US Army Corps
of Engineers
Construction Engineering
Research Laboratories

USACERL Technical Report CRC-94/04
August 1994

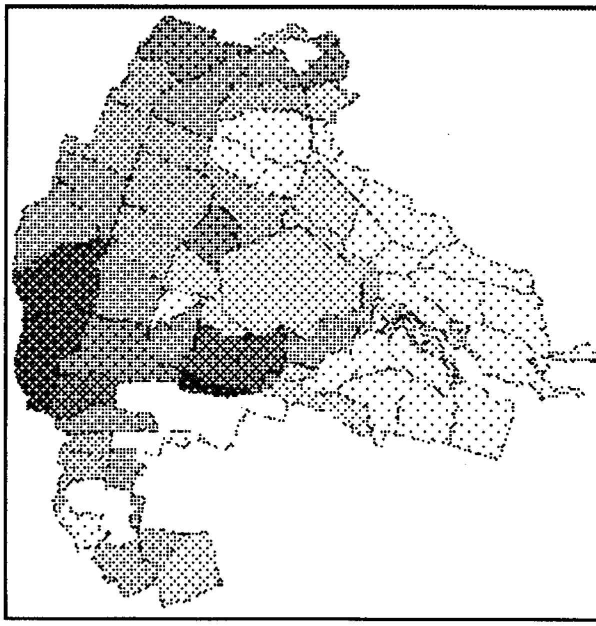
Significance Standards for Prehistoric Cultural Resources: A Case Study From Fort Hood, Texas

by
G. Lain Ellis, Christopher Lintz, W. Nicholas Trierweiler, and Jack M. Jackson

All Federal installations must comply with the National Historic Preservation Act (NHPA) which, in part, requires cultural resources to be evaluated in terms of their eligibility for nomination to the National Register of Historic Places (NRHP). Currently, there is no generalized model to guide such evaluation. Cultural resources are often evaluated on a case-by-case basis using non-explicit evaluation criteria. This approach is arguably inefficient, costly, and scientifically dubious in that it results in non-replicable and non-comparable evaluations. This study attempts to develop a generalized model of evaluation that will produce meaningful, replicable, and defensible evaluations of scientific significance for large numbers of cultural resource properties.

A Cultural Resources Management (CRM) program needs a method to determine what sites merit protection under the NHPA. This study proposes prefacing any such determination effort with a complex, detailed *research design* that is specific to the archaeological data needs of the area. Site significance can then be determined in light of the data needed to answer regional research questions. The goal of the site inventory and testing phases is to find out whether a site has the needed data types. Alternative field tactics for inventory and testing are also discussed in this study.

As an illustrative example, the study presents in some detail a case study from Fort Hood, Texas. The case study attempts to illustrate how a Federal CRM program can go awry, how to fix it, and more importantly, how to design a sound management program from the ground up. The case study reviews the actual history of CRM at Fort Hood, develops an entirely new basis for resource evaluation, and suggests specific methodologies for effective acquisition and evaluation of baseline data. The generalized approach can be used as a model for management of cultural resources at other Federal installations with similar needs for the continuing management of large numbers of cultural resources.



USER EVALUATION OF REPORT

REFERENCE: USACERL Technical Report CRC-94/04, *Significance Standards for Prehistoric Cultural Resources: A Case Study From Fort Hood, Texas*

Please take a few minutes to answer the questions below, tear out this sheet, and return it to USACERL. As user of this report, your customer comments will provide USACERL with information essential for improving future reports.

1. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

2. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)

____

____

3. Has the information in this report led to any quantitative savings as far as manhours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

____

____

4. What is your evaluation of this report in the following areas?

a. Presentation: ___________________________

b. Completeness: ___________________________

c. Easy to Understand: ___________________________

d. Easy to Implement: ___________________________

e. Adequate Reference Material: ___________________________

f. Relates to Area of Interest: ___________________________

g. Did the report meet your expectations? ___________________________

h. Does the report raise unanswered questions? ___________________________

i. General Comments. (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)

____

____

____

____

____

____

5. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name: ______________________________

Telephone Number: ______________________________

Organization Address: ______________________________

6. Please mail the completed form to:

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES
ATTN: CECER-IMT
P.O. Box 9005
Champaign, IL 61826-9005

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
August 1994

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Significance Standards for Prehistoric Cultural Resources: A Case Study From Fort Hood, Texas

5. FUNDING NUMBERS
4A162720
A896
EC-TJ4

6. AUTHOR(S)
G. Lain Ellis, Christopher Lintz, W. Nicholas Trierweiler, and Jack M. Jackson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Mariah Associates, Inc.
3939 Bee Caves Road, Suite C-100
Austin, TX 78746

8. PERFORMING ORGANIZATION REPORT NUMBER
CRC-94/04

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Assistant Chief of Staff for Installation Management (ACSIM)
ATTN: DAIM-ED-N
600 Army, Pentagon
Washington, DC 20310-0600

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Federal installations must comply with the National Historic Preservation Act (NHPA) which, in part, requires cultural resources to be evaluated in terms of their eligibility for the National Register of Historic Places. Currently, no generalized model exists to guide such evaluation. This study attempts to develop a generalized model of evaluation that will produce meaningful, replicable, and defensible evaluations of scientific significance for large numbers of cultural resource properties.

A Cultural Resources Management (CRM) program needs a method to determine what sites merit protection under the NHPA. This study proposes prefacing any such determination effort with a complex, detailed *research design* specific to the archaeological data needs of the area. Site significance can then be determined in light of the data needed to answer regional research questions. The goal of the site inventory and testing phases is to find out whether a site has the needed data types. Alternative field tactics for inventory and testing are also discussed in this study.

The study presents a detailed case study from Fort Hood, Texas, illustrating how a Federal CRM program can go awry, how to fix it, and more importantly, how to design a sound management program from the ground up.

14. SUBJECT TERMS
Fort Hood, TX
prehistoric cultural resources
National Histosric Preservation Acat (NHPA)
Cultural Resources Management program

15. NUMBER OF PAGES
236

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std 239-18
298-102

FOREWORD

This study was conducted for U.S. Army Assistant Chief of Staff for Installation Management (ACSIM) under Project 4A162720A896, "Environmental Quality Technology"; Work Unit EC-TJ4, "Multivariate Analysis for Cultural Resources Baseline Data Recovery." The technical monitor was Dr. Constance Ramirez, DAIM-ED-N.

The work was performed by Mariah Associates, Inc. of Austin, Texas for the Tri-Services Cultural Resources Research Center, Environmental Compliance and Modeling Division (EC), Environmental Sustainment Laboratory (EL), U.S. Army Construction Engineering Research Laboratories (USACERL). Dr. John Bandy is Chief, CECER-EC, and William Goran is Chief, CECER-EL. Dr. Nicholas Trierweiler led the project team at Mariah Associates.

Special acknowledgement is due to Dr. Jack M. Jackson of Fort Hood and Keith Landreth of USACERL. Without their advice and close technical support, this study would not have been possible. In the early stages of development, the content of this volume was influenced by persons both within the Mariah organization and outside it. Charles D. Frederick, Mike Quigg, and other Mariah personnel were frequent participants in discussions that shaped this volume. Steve Black and Mike Collins at the Texas Archeological Research Laboratory provided important, early sounding boards for issues pertaining to the general directions of research. Portions of the theoretical section of Chapter 4 were fleshed out during extended conversations with Linda W. Ellis of the Texas Archeological Research Laboratory. Finally, Kimball Smith of Fort Hood has served as an able devil's advocate throughout the process of generating this document.

A draft of this study was submitted for outside review, and we gratefully acknowledge the incisive and helpful comments and suggestions received from Dr. James Bruseth, Dr. Tim Pertulla, and Nancy Kenmotsu of the Texas Historical Commission (THC) and from Elton Prewitt, Ross Fields, and Steve Tomka of the staff of Prewitt and Associates, Inc. In preparing the final version of this document, we have tried to address these comments within the stipulations of our delivery order. All opinions and errors are of course our own and do not necessarily reflect those of CERL, Fort Hood, or the THC.

Document production was conducted by Debora White and Kim Cooke. Graphics were produced by Carol Mills and Lain Ellis, with technical editing by Dee Ann Campbell of Renaissance Editing. The USACERL technical editor was Audrey Fisher, Information Management Office.

LTC David J. Rehbein is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

Tri-Services Cultural Resources Research Center

The Tri-Services Cultural Resources Research Center is a research and technical support center that assists the U.S. military services in the stewardship of cultural resources located within Department of Defense (DOD) installations or facilities. The Center, located at USACERL, helps installations manage their cultural resources and comply with Federal, State, and DOD preservation mandates.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1 MANAGING CULTURAL RESOURCES ON LARGE MILITARY INSTALLATIONS

Nicholas Trierweiler

All federal installations must comply with the National Historic Preservation Act which, in part, requires evaluation of cultural resources in terms of their eligibility for nomination to the National Register of Historic Places (NRHP). Lacking a generalized model of evaluation, cultural resources are often evaluated on a case-by-case basis using non-explicit evaluation criteria. This approach is arguably inefficient, costly, and scientifically dubious in that it results in non-replicable and non-comparable evaluations. This study attempts to develop a generalized model of evaluation using quantitative methodologies for recovery of baseline data which will produce meaningful, replicable, and defensible evaluations of significance for large numbers of cultural resource properties.

As an illustrative example, the study presents in some detail a case study from Fort Hood, Texas. The case study attempts to illustrate how a federal cultural resources management program can go awry, how to fix it, and more importantly, how to design a sound management program from the ground up. The case study reviews the actual history of Cultural Resources Management (CRM) at Fort Hood, develops an entirely new basis for resource evaluation, and suggests specific methodologies for effective acquisition and evaluation of baseline data. The generalized approach can be used as a model for management of cultural resources at other federal installations with similar needs for the continuing management of large numbers of cultural resources.

Importantly, there is no single process by which to manage cultural resources in compliance with state and federal requirements. An appropriate management process depends on its legal basis, the agency with regulatory jurisdiction, the nature of the proposed action, whether or not a multiple property district approach is involved, as well as the nature and peculiarities of the resources themselves. Accordingly, this document is not intended to address all aspects of regulatory compliance. Rather, it is primarily focused on the management needs of military installations. CRM projects are generally characterized by long-term management needs, as distinct from the immediate and (relatively) short-term needs of destructive projects such as reservoirs or mines.

This document is structured in six major discussions. Chapter 1 consists of a summarized review of an appropriate cultural resources management program. Directed chiefly at the non-archeologist, this chapter identifies and discusses major components of a management program, emphasizing the importance of a focused research design as an effective management tool. Natural environmental context and cultural content are viewed as necessary and complementary components within a successful research design.

Chapters 2 through 5 constitute the case study at Fort Hood, Texas. Chapter 2 introduces and briefly assesses the natural context of the study area, and then synopsizes the history of the cultural resources management program at the base. This discussion includes a critique of previous studies at Fort Hood, and an analysis of the management contexts of previous program directions. The discussion ends with a frank assessment of the consequences of these earlier management decisions.

Chapter 3 begins by discussing the importance of natural context in the Fort Hood program. The geomorphic stability of specific landforms is addressed, as are the variety and intensities of various site disturbance processes at Fort Hood. The articulation between these two contextual considerations is discussed, especially with regard to lithic procurement and/or reduction sites on geomorphically ancient and stable land surfaces.

Chapter 4 further refines the new management program at Fort Hood by developing a theoretical perspective with which to guide the new research design. This section includes a review of the historical development of cultural chronologies in Central Texas, with special attention paid to the problem of interpreting burned rock middens. The chapter also reviews specific studies previously conducted in the general vicinity. Finally, the chapter develops in some detail the cultural, ecological and technological approaches that underlie the research design.

Chapter 5 may in some respects be considered the "heart" of the Fort Hood case study in that it develops and explores specific research questions. The chapter is organized into two major sections. First, a series of very basic research questions are posed. These fundamental questions are generally subsumed in most modern archeological research designs under discussions of "previous research" or "cultural-historical framework." For example, in the present research, an examination of basic space-time parameters is made an explicit component of the testable research questions because our knowledge of prehistory is poorly developed in the Fort Hood region. This section is presented with fully developed explicit research questions, test implications, and data requirements. Secondly, a series of more substantive (and more intellectually satisfying) research domains is developed. These domains comprise the framework within which to construct models of prehistory. The substantive questions are also presented in a hypothetico-deductive framework with explicit research questions, test implications, and data requirements.

The discussion in Chapter 6 attempts to operationalize the new research design at Fort Hood. First, the discussion explores in general the limitations of alternative data collection tactics as they relate to the particular data needs specified in the research design. These data needs and data limitations are then synthesized into a general model of assessing site data potential. Finally, suggestions are made as to how this general model could be applied to the specific case at Fort Hood.

1.1 COMPONENTS OF A MANAGEMENT PROGRAM

This section presents an overview of the cultural resource management process as it may be applied to federal installations. The overview is designed for the installation manager who may be unfamiliar with the process, and it provides a framework within which to plan and implement a sound management program. It is *not* intended as a comprehensive guide to federal statutes and regulations. More rigorous discussions of these may be found in Army Regulation 420-40 (Department of the Army 1984), the Federal Register guidelines (U.S. Department of the Interior 1977, 1983), the handbook of the Advisory Council on Historic Preservation (1980), McGimsey and Davis (1977), and Jackson (1993). Figure 1.1 illustrates the basic structure of a management program.

Under current federal law, archeological properties (i.e., "sites") are legally considered to be environmental "resources" in the same way as are wetlands, timber, or animal species. The fundamental purpose of a management program is to protect the "significant" resources which belong to the public (i.e., those on federal property), or those which may be affected by publicly-funded (or permitted) projects. If a cultural resource is determined to be significant, *and* if it cannot be protected, then its loss or damage must somehow be mitigated.

1.1.1 The Scientific Research Design

This section reviews the scientific method which is used as the mechanism for identifying the significance of cultural resources and evaluating their relative value. The reader already familiar with the scientific method may choose to skip this section.

Within a sound management program, cultural properties are evaluated in relation to particular research problems which have been defined for the surrounding region. Because modern installation boundaries seldom coincide with historically or prehistorically meaningful territories, the cultural properties on a military installation often must be

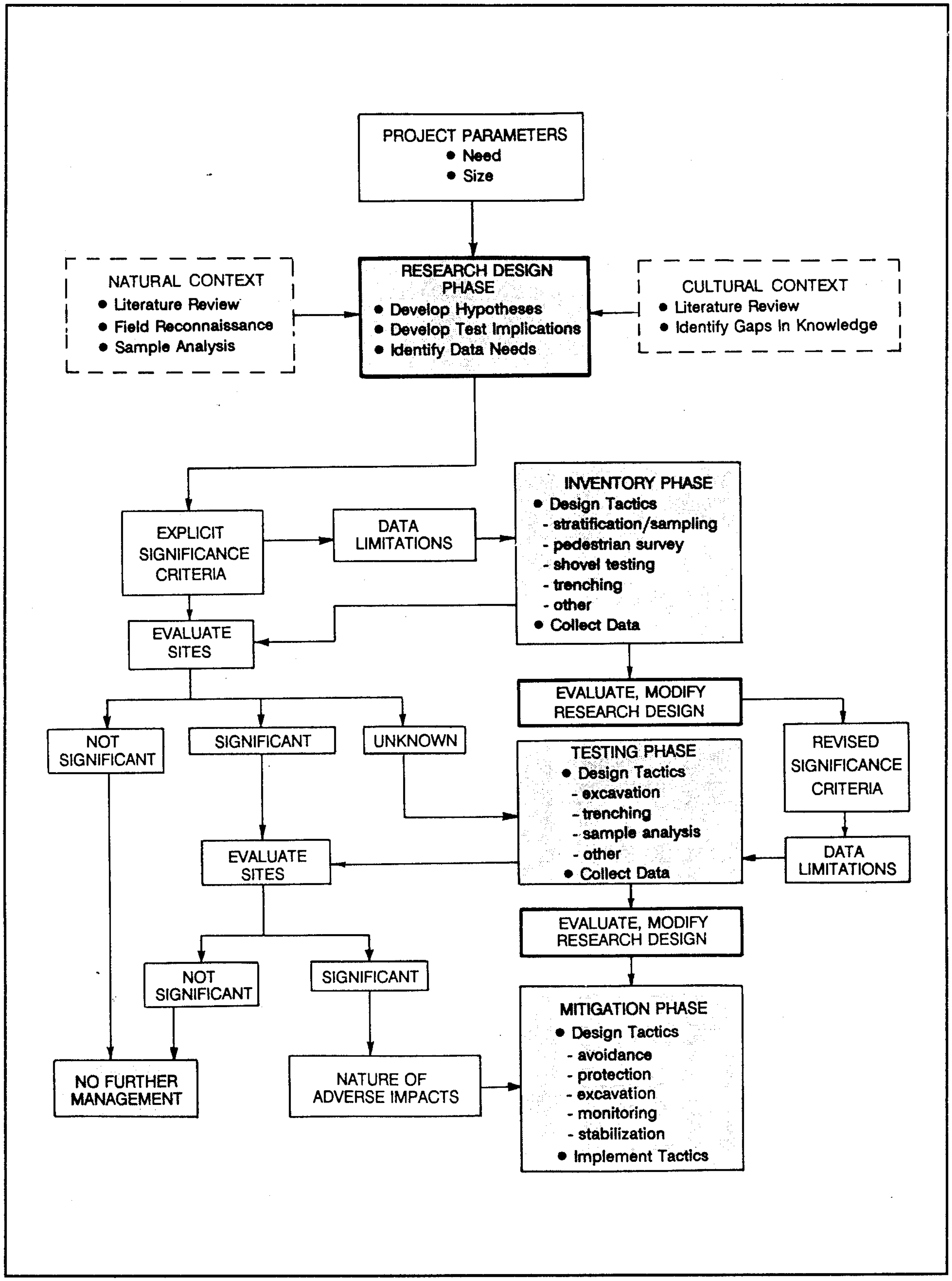


Figure 1.1 Basic Structure of a Cultural Resources Management Program.

assessed in relation to areas beyond the boundaries of the installation itself.

Often, the prehistory and history of a region is known well enough so that some fairly specific topic areas can be addressed. These are the so-called "historic contexts" for research; in order to maximize their contributions, individual properties are managed with respect to one or more of these contexts. Occasionally, regional issues are too poorly defined to permit identification of historic contexts for CRM purposes, and cultural properties are managed (at least initially) with respect to *identifying* the important historic contexts. Chapter 4 of this document argues that Fort Hood is such a case because of the poorly developed status of prehistory in Central Texas. Thus, prior to the implementation of a CRM program, it is necessary either to (1) identify the region and the relevance of cultural properties to that region, or (2) determine that no such region has been adequately defined. In either case, CRM activities within a military reservation take place with respect to issues of regional importance.

Once the relationship between the installation and the region has been identified, the management goal is locating and then determining the "significance" of cultural resource properties. If mismanaged, this determination can be a convoluted, lengthy, and expensive process, especially for large study areas such as military bases which often have hundreds, or even thousands, of cultural resource properties. However, a well designed management program which rigorously evaluates site significance *as soon as possible after initial discovery* can facilitate allocation of scarce management resources (e.g., money, time, personnel) to the significant sites, while identifying those non-significant sites which have no further management needs. Such a well designed management approach can be faster, cheaper, more logical, and more protective of the public's cultural resources.

Importantly, the significance of any given cultural resource property can *not* be determined solely on its own merits. Rather, its significance must be assessed by rigorously comparing it to a currently accepted significance "yardstick." Developing and calibrating such a yardstick is a major purpose of the research design because the research design identifies the specific issues and data to be addressed with cultural properties on a reservation. Thus, the research design is a major link between the reservation and the surrounding region because it identifies the regionally important issues according to which a reservation's cultural properties are "significant."

Research designs vary tremendously in scope and complexity depending on the project parameters (e.g., size and configuration of the study area), but all fundamentally consist of a set of questions and a set of methods needed to obtain reliable answers. However, not all research designs are necessarily *scientific*. Nonscientific research is free-form (i.e., idiosyncratic to the researcher) and non-replicable: any conclusions rely on the weight of the researcher's opinions for credibility. By contrast, scientific research sets up experiments which use data to reach conclusions. In this regard, they are rigorous and replicable, and conclusions may be critically examined by other researchers. Scientific research designs may be either *in*ductive or *de*ductive. Under a deductive approach, very specific predictions are derived from a relevant body of theory, and these predictions are then tested with newly collected empirical data. Inductive research designs can also be scientific and produce useful information. These designs generally collect the data first and later attempt to account for patterns in the data. Unfortunately, inductive designs can often be wasteful of archeological resources. This is because the most that can be learned is information about the theory that was already implicit in the structure for data collection. Consequently, under an inductive design, the first round of research *at best* ends where research begins under a deductive design.

In any scientific research design, the questions must be interesting, or *problematic*, because not all research questions are necessarily equivalent in importance: some questions may be trivial and others may have been adequately answered long ago; other questions remain problematic despite active investigation; still other questions arise with each new advance in theory and method. Problematic research questions are derived from recognized gaps in a current body of scientific knowledge. In cultural sciences (such as archeology), such bodies of knowledge may be highly regional; gaps in one state (or even county) may be sufficiently addressed in an adjoining state. These so-called "data gaps" are topics which have insufficient information to make reliable conclusions. Some gaps may be due to a lack of previous research on the topic. Other gaps may be recognized because the previous research is considered inadequate or outdated. Data gaps can also result simply from scanty information on the topic despite previous intensive and excellent research efforts. For example, knowledge of the Paleoindian period has large gaps, despite much interest and a long history of research about the period. Conversely, well documented, uninteresting, and trivial topics are not considered to be data gaps, and are not targeted by research questions. For example, certain types of sites dating to the early twentieth century are so abundant and have been so well documented that some researchers do not consider these sites to have any potential to make significant new contributions to research.

Each problematic question of a research design targets a recognized data gap and it has one or a related group of associated propositions, or *testable hypotheses*. A hypothesis is merely a very specific question. A very basic hypothesis might propose that "Cultural Group X was present in the study area at Time Z." However, because any given hypothesis can never decisively be demonstrated to be true, hypotheses are usually framed so that they can be rejected by specific observations. For example: "Cultural Group X was present in the study area no earlier than Time Z_1, and no later than time Z_2." If no evidence is found to reject a hypothesis, it is provisionally accepted pending the outcome of future tests. If a large number of tests have been conducted over a long enough period of time by a sufficiently diverse number of independent researchers, and if the hypothesis has still not been rejected, then it may be considered as well confirmed or well corroborated. For example, it is widely accepted that so-called Paleoindian adaptations were widespread throughout North America by 8,000 years B.C. because there is enough secure data to falsify a hypothesis that Paleoindians were not widespread after 8,000 years B.C.

In order to establish criteria for rejection/acceptance, each hypothesis must be associated with specific "no/yes" conditions, or *test implications*. These are statements about the specific conditions which must be met if the hypothesis is to avoid being rejected (i.e., if it is to be provisionally accepted). Test implications must be documented by logical arguments of relevance and generally take the form of "if-then" statements. For example, "If the hypothesis is true, then X should increase in frequency over time." If in fact X does increase, then the hypothesis has avoided rejection. However, if X decreases (or remains constant), then this test has rejected the hypothesis.

Each test implication must specify the actual observations or *data requirements* which are minimally necessary (but not necessarily sufficient) to reject the hypothesis. For example, in order to detect any change in X, it may be necessary to collect very specific kinds of artifacts, and then measure these in precise ways. Data requirements must be spelled out so that the field work will be sure to collect these kinds of data (if they are available). The same type of data may be simultaneously needed by more than one test implication/hypothesis. For example, reliable indicators of the time period of a site, such as diagnostic projectile points or radiometrically datable charcoal, are commonly needed in order to test many questions dealing with changes over time in prehistoric economy, social structure, population size, and other questions. Similarly, biological data is necessary to describe the prehistoric environment and diet.

1.1.2 The Research Design as a Management Tool

The goal of a sound cultural resources management program is to find significant cultural resources so that they can be avoided and protected. The problem domains, hypotheses, test implications, and data requirements are all needed so as to construct a "yardstick" against which to measure the significance of any cultural resource. Resources which meet many of the data requirements are judged to be significant; resources which meet few of them are judged not significant. Importantly, the yardstick (research design) must be constructed in advance, so that all resources are evaluated fairly and in a comparable manner. This is not to say that any research design is static and unchanging; ideally, it is reviewed and revised periodically as new information fills in previous gaps and as new problematic questions arise. Indeed, changes in the current state of the research art could transform sites that previously were judged to be insignificant into sites that are significant and vice versa. For example, the historical development of methods for obtaining pollen and other small botanical materials revolutionized the capacity to obtain significant data sets from small sites that otherwise had meager stone tool assemblages.

Implementing the process can be thought of as having four primary components: developing the research design, finding the resources, evaluating them, and protecting them (or mitigating their damage if they can not be protected). The last three components are sometimes operationalized into discrete work phases (i.e., "survey," "testing," or "mitigation"), but there can actually be considerable overlap between process components and work phases. For example, all sites should be evaluated for significance immediately upon their discovery, if this is possible. This evaluation should not necessarily be postponed until a later formalized testing phase. Similarly, new sites may be discovered during a phase primarily designed to evaluate previously located sites.

Within the context of a research design, the significance of any resource can (at least, theoretically) be determined by means of a records search followed by a single, well planned field visit. In practice, however, the full assessment of significance for some sites must proceed through additional work phases. This is primarily for cost-effective tactical reasons: different kinds of sites require widely varying levels of investigation to reach the same significance assessment, and it is usually more cost-effective to conduct the fieldwork in a staged approach. In cultural resources management, two sequential and complementary phases of significance evaluation are often referred to as "inventory" and "testing." Each phase focuses in on a prioritized hierarchy of data requirements. The focus and data limitations of each phase are summarized below and are discussed more fully in section 6.1.

During the inventory phase, cultural resources are first located ("inventoried") and then observations of data potential are made to allow a significance assessment (if possible). The kinds of observations made during the inventory phase are generally *limited to the surface of the site*. Sometimes these surface observations are complemented with subsurface shovel probes or, more rarely, with geomorphological assessments of landform and depositional potential. Shovel probes conducted during the inventory phase are often limited in their number, depth, and precision. While some sites can be fully assessed during this phase, other sites require more intensive field effort than is typically expended during this phase; in many cases, significance cannot be determined in the absence of more subsurface data.

Based on these inventory phase observations, three outcomes are possible in assessing significance. Some sites may be determined to have no potential with which to address the hypotheses (and hence, the data gaps) and consequently, no further management action is recommended beyond recording what was observed. Some sites may have clear potential and must be protected. Finally, the limited kinds of observations made during the inventory may not permit a full evaluation of data potential for some sites, and these sites must be "tested" to determine their data potential and significance. Because the additional observations needed in order to test the site often require detailed subsurface excavations, an additional phase of field work is usually necessary. However, by the end of a testing phase, all sites should be fully assessed (with concurrence by the regulatory authority) as either significant or not significant.

From the perspective of the cultural resources manager, there is an economic trade-off between investing effort in the inventory and the testing phases. A greater effort expended during the inventory phase will certainly require greater up-front funding but may well allow significance evaluation of a greater proportion of all sites. For example, inventories *with* subsurface shovel testing generally fully evaluate a greater proportion of sites than similar inventories *without* shovel testing. Conversely, a lower level of effort expended during the inventory phase may well be cheaper initially, but this option will almost certainly require that more sites receive the labor intensive test excavations at a later point. Part of the greater cost of this alternative is that at least two rounds of site visitation may be involved (as has been the case at Fort Hood). In such an event, the persons actually conducting the testing during a second round of visitation may *not* be the same persons who conducted the original inventory, thus requiring more time to become familiar with any given site.

This tactical trade-off is different for each project, and depends heavily on geomorphological context coupled with the kinds of actual questions posed by the research design. In general though, it is more cost-effective *in the long run* to conduct a higher level of effort during the inventory phase in an attempt to fully evaluate as many sites as possible and reduce the pool of sites which must be formally tested. As indicated, the higher level of effort during an inventory phase may include subsurface shovel testing of sites coupled with a site-specific geomorphological evaluation of depositional context and potential for intact cultural deposits.

Perhaps not as obvious however, is that a higher level of effort expended early in the program may include a field reconnaissance of some intensity during development of the research design, prior to the actual field inventory. This point is discussed in some depth in the next section. The effort to front-load a program so as to reduce the necessary effort later should also assure a very close articulation between theory and method, that is, between the data needs of the research design and the actual observations made during inventory.

1.2 ASSESSING NATURAL CONTEXT

The fundamental components of a research design were discussed in section 1.1, but to repeat, the scope and complexity of any given research design is tied directly to the scale of the study area. For example, very small proposed actions are likely to have simpler and more highly focused research designs than those for extensive impacts or large tracts (i.e., military bases) which must be managed as a single unit over a long period of time. As a general rule, when the scale of the study area increases, so should the effort invested in development of the research design.

Currently, many large research designs identify data gaps by reference to the existing archeological literature only. This section discusses the need to integrate natural context considerations into the initial development of any comprehensive research design, prior to the inventory phase. Regardless of the overall scope and scale of the project, many, if not most, of the important archeological research questions will articulate closely with environmental or natural variables. This is to say that a meaningful archeological research design cannot be divorced from environmental context: the identification of the research design's "data gaps" must be viewed through an environmental filter.

At the same time, an understanding of natural context can greatly facilitate the design of optimal data collection strategies. For example, a meaningful stratification of the study area based on natural environmental variables can identify areas with high potential to yield significant sites. This approach, coupled with management priorities, can help identify specific field tactics for different environmental strata. While for a given project the ultimate goal of inventory may well be 100 percent coverage of the study area, most inventory tactics generally divide the study area into manageable units. Sometimes these are arbitrary in size and configuration (e.g., 1.0 mile by 0.1 mile transects within a township, range, and section system; 1 km^2 quadrants within a universal transverse mercator [UTM] system). Alternatively, sampling units can be of irregular size and configuration based on natural phenomena such as landform, geology, or elevation, or a synthetic variable such as potential to yield significant sites, as defined by explicit criteria.

Natural context may be assessed during the initial development of a research design through two closely linked and supplementary, but methodologically different, avenues of approach: geomorphological and paleoenvironmental data, and other types of natural environmental data. These are discussed below.

1.2.1 Geomorphological and Paleoenvironmental Variables

Geomorphology and paleoenvironmental studies can greatly aid the understanding of the physical processes, such as deposition and erosion, which are responsible for creating the modern landscape. They are essential to understand the processes responsible for creating, preserving, eroding, or exposing sites. Therefore, an understanding of these processes is critical in order to design an inventory program that optimally focuses on key data requirements. For example, if a research design identifies a certain time period as of special interest, then an understanding of the geomorphological history of the study area can target those portions of the study area which have a high probability of yielding cultural deposits of the appropriate age. Conversely, certain portions of the study area may be identified as having little to no chance of yielding deposits of relevant age, intact deposits, and/or stratified deposits. For this reason, a clear understanding of geomorphology and paleoenvironment is necessary to *develop* a comprehensive research design. Because the specific tactics of an inventory phase are driven by the research design, it is essential that geomorphology and paleoenvironment be integrated into the research design prior to conducting the actual field inventory.

Unfortunately in the past, many archeological inventories in the United States were conducted in the absence of any meaningful assessment of geomorphological context, causing all inventoried sites to be viewed similarly without respect to differential processes of formation, preservation, exposure, and erosion. For example, during the 1980s, over 1,200 prehistoric sites were inventoried at Fort Hood prior to any geomorphological studies. None of these sites could be fully evaluated for NRHP significance until a remedial program of site specific geomorphological context had been conducted. The delay resulted in a significant increase in the total cost to complete the inventory program. Perhaps more seriously, because many of the sites could not be fully evaluated, few were protected, and by the time the sites were evaluated within a geomorphological context, some ultimately judged to be significant had been adversely impacted.

Consequently, it is highly recommended that a geomorphological and paleoenvironmental context for any study area be developed *prior* to conducting archeological inventories. The context will allow identification within the study area of areas of deposition and erosion which could bias the observable archeological record. The context will allow development of a local paleoecological sequence which may alter significance determinations relative to established research priorities. The context will allow the study area to be stratified based on criteria deemed important by the research design. Finally, the context will allow identification of specific inventory tactics which should be used in different geomorphic situations. For example, shovel testing may be suggested on all lower terraces and in aeolian deposits but not on stable Pleistocene surfaces with minimal soil depth and/or low potential for buried cultural deposits.

While many archeologists are skilled in geology, the context study should be conducted only by a qualified geomorphologist, preferably one specializing in post-Pleistocene processes. A well designed geomorphological study may be structured into five largely sequential components. First, the actual "study area" must be clearly defined. Usually this is based on modern political boundaries such as military bases and rarely on natural phenomena such as watersheds or drainages.

Next, a review of the available geologic and geomorphological literature should be conducted, both for the study area and for the surrounding region. Sources should include local soil and geologic maps, theses, and dissertations, as well as published geological literature. This literature review is directly comparable to that conducted for the archeological literature in that it should develop a framework for the overall research design by identifying major gaps in current knowledge. For example, the review may suggest that a major erosional period has biased the existing population of sites by destroying many of the earlier sites. If the historic context for CRM activities has identified data gaps which only early sites can fill, the significance of early sites may thus be increased because of their relative rarity can be predicted on the basis of geomorphic data. Similarly, the literature review may identify a major climatic shift in prehistory, thus suggesting specific questions for the overall research design. A review may also suggest that specific portions of the study area have been geologically stable for long periods of time, resulting in opportunities for readily visible, albeit palimpsest, archeological sites. Alternatively, the review may suggest that portions of the study area have the potential for buried archeological sites which may not be visible during surface inventory except in fortuitous erosional or man-made cuts. These suggestions should call for different inventory tactics.

Following the literature review should be a field reconnaissance designed to verify the conclusions of the literature review. The field reconnaissance should include inspections by the geomorphologist of each major geologic component within the study area. The purpose of this reconnaissance is to evaluate the conclusions of the current literature, to add detail and refine the scale of the conclusions, and to serve as a basis for formulating specific follow-up tactics.

If major alluvial systems or aeolian deposits are present, then a radiometrically dated stratigraphic framework should be developed for any Holocene and late Pleistocene deposits. This framework should be based on multiple radiocarbon dates from several locations throughout the study area. Stratigraphic locations should be described in detail and profiled, and additional samples should be collected for non-chronometric tests. While this component should focus on the alluvial/aeolian deposits, colluvial deposits capable of containing cultural deposits also are of interest. If the reconnaissance identifies surfaces considered to have a high probability of Holocene sedimentation but which currently have insufficient exposures with which to evaluate the potential for buried cultural deposits, then a program of subsurface investigation should be initiated. Using a backhoe or similar mechanical trenching tool, multiple deep trenches should be excavated in these contexts to obtain a more detailed perspective on depositional and erosional processes and how these might affect site formation and site visibility. Trenches should be profiled and described in detail and samples should be taken as appropriate.

Finally, additional and highly detailed data should be collected by means of laboratory analyses of the collected samples. These analyses should include physical, chemical, as well as biological assays. The physical and chemical composition of the soils and sediments should be determined by means of soil texture, carbonate content, organic matter, salt content, pH, radiocarbon, and other similar tests. The biotic components may be analyzed by testing for phytoliths, pollen, and ostracodes, as well as possible other remains such as macrofaunal mollusks and/or vertebrates. Because some sediments are not conducive to preserving these types of biotic indicators, their analysis should be structured in a staged approach to determine presence and distribution of the targeted indicators.

This model of a geomorphic and paleoenvironmental program should permit optimal design and implementation of a subsequent program of archeological inventory. However, it should be emphasized that the informational feedback between geomorphology and archeology should continue past the inventory phase. Once individual sites are located, they should be integrated into the geomorphic context with additional site-specific studies, both during testing and data recovery phases.

1.2.2 Other Natural Context Variables

As argued above, the natural context of archeological sites must be an integrated component of any comprehensive research design so as to design optimal data collection strategies and make informed management decisions with regard to site significance. While remarkably productive from a cost-benefit perspective, geomorphic investigations clearly cannot collect all of the relevant natural context information. Other strategies are needed to collect other kinds of natural context information such as climatic, biological, and hydrological data. Furthermore, geomorphic studies are limited because they are largely locality specific. While they can obtain detailed and intensive information about certain localities, these data must be somehow extrapolated to other localities within the study area which were not directly observed. For example, a geomorphic field reconnaissance can precisely determine the slope and aspect (direction of slope) at any locality, but overall *trends* of slope and aspect (especially in areas with no recorded archeological sites) must be determined by reference to another source of information. Similarly, modern climatic conditions (i.e., precipitation, temperature) may be called for in the research design in order to reconstruct past conditions.

Physical variables may include among others: landform, elevation, slope, aspect, topographic relief, sediment origin, sediment depth, soil development, lithology, active erosion, and active deposition. Hydrological variables may include among others: surface water source, distance to surface water, drainage size, aquifer type, and aquifer depth. Climatic variables may include among others: precipitation (annual/monthly mean, minimum, maximum, range; seasonality), and air temperature (annual/monthly mean, minimum, maximum, range; frost-free period). Biotic variables may include among others: fauna present, flora present, canopy cover, and denudation. Some of these types of natural context data are occasionally collected during inventory using intuitive, non-replicable, and/or imprecise methods. Other types can be collected using maps, photographs, and other records. Occasionally the data are used to develop context with which to evaluate site significance; more often, the data are not used at all in any meaningful inter-site analysis (at least during inventory and testing phases).

Alternatively, many of these types of data can be obtained prior to inventory in a more explicit, replicable, and precise manner from existing databases. The data can be obtained not only for specific localities, but also for extensive areas. Using appropriate research questions as a filter to identify which kinds of natural context data are meaningful, the data can be used to stratify the study area prior to inventory. In this regard, computerized geographic information systems (GIS) can be extraordinarily useful in the recognition of natural context within archeological research designs. Facilitated by recent and rapid high-technological advances in computer devices and software, GIS systems can be difficult to understand and operate. However, the immense potential offered by these spatially-referenced databases strongly argues for their early integration into comprehensive research designs.

Natural context information can be made available to a GIS through four sources of data input: manual digitizing, automatic scanning, and previously digitized data bases (Stine and Decker 1990:135). Any type of information from any type of graphic image, such as maps or aerial photographs, can be manually digitized for access by a GIS. In this approach, a grid (or cell) size must be defined as the spatial resolution of the GIS. For example, elevation may be digitized from US Geological Survey (USGS) quadrangles using a 100-m cell. This resolution would result in 100 data points per km^2 (or 256 per mi^2). Alternatively, graphic images can be automatically scanned using a preprogrammed device. Manual digitization is most useful for highly specific types of data which are not commercially available or which are deeply embedded in complex graphics. For example, the locations (and other attributes) of archeological sites are usually manually digitized.

However, previously digitized data bases are arguably the most cost effective approach, especially in the early phases of a project. The federal government currently is the largest consumer of GIS data. At least 45 different federal agencies use, create, and/or supply GIS data (Zubrow 1990, Table 16.2), ranging from the Bureau of Land Management (BLM) to National Aeronautics and Space Administration (NASA) to the Central Intelligence Agency (CIA). Appropriately, the federal government is also the largest supplier of existing digitized data bases. Some of these with environmentally relevant data include the Soil Geographic Data Base (Soil Conservation Service), the National Wetlands Inventory Database (US Fish and Wildlife Service), and the National Digital Cartographic Data Base (US Geological Survey), and others from the Defense Mapping Agency, the National Geophysical Data Center, the Bureau of the Census, and the National Archives. While the types of available data which are relevant to natural context are limited, the GIS can manipulate these to create new natural context variables. For example, for any cell, a GIS can mathematically transform the primary elevation data into secondary slope, relief, and aspect data by reference to nearby cells.

It is important to note that different types of data (e.g., elevation, number of days per year with a mean temperature above 32° F) can be stored and accessed as if they were multiple overlays. Complex combinations of these variables (i.e., slope less than 5° *and* frost free period greater than 120 days *and* distance to water less than 200 m *and* elevation less than 7,500 ft) can be similarly created and accessed. Likewise, various sources of data (e.g., manual digitization and commercial digitized tapes) can be combined in multiple data overlays. However, mixing data sources can be tricky if they have different degrees of resolution, accuracy, or precision.

1.2.3 Integrating Natural Context into the Program

Natural context information, including both field-derived geo/paleoenvironmental data and GIS data, can be productively used at two key points in implementing the cultural resources management process. The first is during initial development of the research design. Recognizing patterns in natural context within a large study area can identify data gaps, can suggest specific research questions, and can indicate specific data acquisition tactics. The second useful point to integrate natural context information is during site evaluation. Site specific natural context data, not obtainable during the archeological field work, can enhance (or limit) the data potential and significance of any site.

At both stages of the process, the concept of a "red flag" site can be a useful management tool. Red flags are sites which have a high probability of requiring further management attention. Red flags are anomalous sites which do not fit predicted patterns. "Sites in anomalous settings by definition must be the result of behaviors that do not fit current models of why prehistoric inhabitants settled where they did" (Altschul 1990:227). Because they cannot be easily predicted, red flag sites *may* contain differentially high research potential and are especially likely to require additional management effort (i.e., time, personnel, money). Deductive predictions must of course be verified by empirical field observations (Warren 1990:91). Not every flagged site will ultimately be assessed as significant; upon closer inspection, some will simply not conform to the red flag parameters and others may lack physical integrity such that their data content is unacceptably compromised. Alternatively, a red flag analysis of natural context variables will never be sufficient to identify *all* significant sites. Nevertheless, the ability to identify red flag sites early in the management process is an advantage because it allows strategic allocation of management resources to the optimal protection of the cultural resources.

The concept of red flag *sites* may be extended to red flag *contexts*. These are specific natural contexts (defined as combinations of environmental variables) which are likely to contain one or more sites with high data potential. For example, if a geomorphic reconnaissance suggests that deposits earlier than 5,000 years BP have been largely stripped from the study area, then sites older than this may be correspondingly rare, and any such remaining deposits might be considered to be a red flag context. Special inventory tactics (e.g., prospective backhoe trenching or ground penetrating radar) could be used in these contexts. Conversely, once a field inventory has empirically located sites and collected site-specific data, their information potential under the overall research design may be filtered through their natural environmental context. For example, if analysis of GIS elevation and temperature data suggest that prehistoric agriculture should be possible only in certain localities, then a structural site found elsewhere in the study area could have unusually high research potential and therefore be judged significant.

2 THE FORT HOOD PROJECT

Christopher Lintz and Jack M. Jackson

This chapter introduces the case study at Fort Hood, Texas. The first section defines, identifies, and assesses the study area, focusing on natural context variables of geology and geomorphology, climate, hydrology, vegetation, and fauna. This is followed by a critical synopsis of the history of archaeological management at the base, including a historical review of previous investigations and an analysis of the context and consequences of earlier management decisions.

2.1 DEFINING THE NATURAL REGION

Fort Hood Military Reservation encompasses approximately 878 km^2 (339 mi^2; 217,300 acres) in Bell and Coryell counties of Central Texas. The installation surrounds and extends north of the city of Killeen, and is 20 mi (32 km) west of the Bell County seat of Belton, 43 mi (70 km) southwest of Waco, 120 mi (190 km) south of Dallas, and 65 mi (105 km) north of Austin (Figure 2.1). The reservation developed from an amalgamation of military-oriented facilities, including the Blue Bonnet Ordnance Plant, and Camp Hood (1941) along with base expansions (1943, 1953) and incorporation of the Robert Gray Army Airfield in 1963. The main mission of the installation during the past 50 years has been the training of armored and supporting units. The reservation remains the nation's largest armored training facility (Guderjan et al. 1980:57). Cultural resource studies at Fort Hood have been conducted since 1978 in order to comply with the National Historical Preservation Act of 1966 (PL 89-665) and its various amendments (PL 91-234, 93-54, 94-422, 94-458), the Archaeological and Historical Preservation Act of 1974 (PL 93-291), and the Archaeological Resources Protection Act of 1979 (PL 96-95). These laws charge federal agencies to inventory their properties for cultural resources, identify which resources contain important or significant information, and ensure proper management of these significant resources, either through preservation (avoidance or stabilization) or through data recovery.

This section locates the Fort Hood installation and briefly characterizes its environmental setting and diversity. Considerable information on the environmental diversity of Fort Hood is derived primarily from Espey Huston and Associates (EHA) 1979; Guderjan et al. 1980; and Nordt 1992. One primary goal of this section is to indicate that despite small-scale topographic and vegetational differentiation of the reservation, from a regional scale it occurs completely within a region classified by geologists and biologists as a single environmental unit.

2.1.1 Geology and Landforms

Fort Hood is located within a region traversed by the Balcones Escarpment and Balcones Fault, which defines the eastern boundary of the Edwards Plateau. The series of faults extends from the Red River valley of North-Central Texas, passes through the modern cities of Dallas, Waco, Austin, and San Antonio, and veers westward across the Rio Grande into the State of Coahuila in northern Mexico. The fault zone is indistinct north of Waco and becomes more prominent towards the south. The Balcones fault system is relatively indistinct in the Fort Hood region and is manifest as a seven-mile-wide zone in the vicinity of the city of Belton, east of the military reservation. The elevation of the military installation ranges from 1,230 ft (374 m) above sea level to 590 ft (179 m) along drainages in the eastern edge of the base. With the exception of the flat-topped mountains in the northern and eastern portions of the base, most of the installation has elevations below 850 ft (260 m).

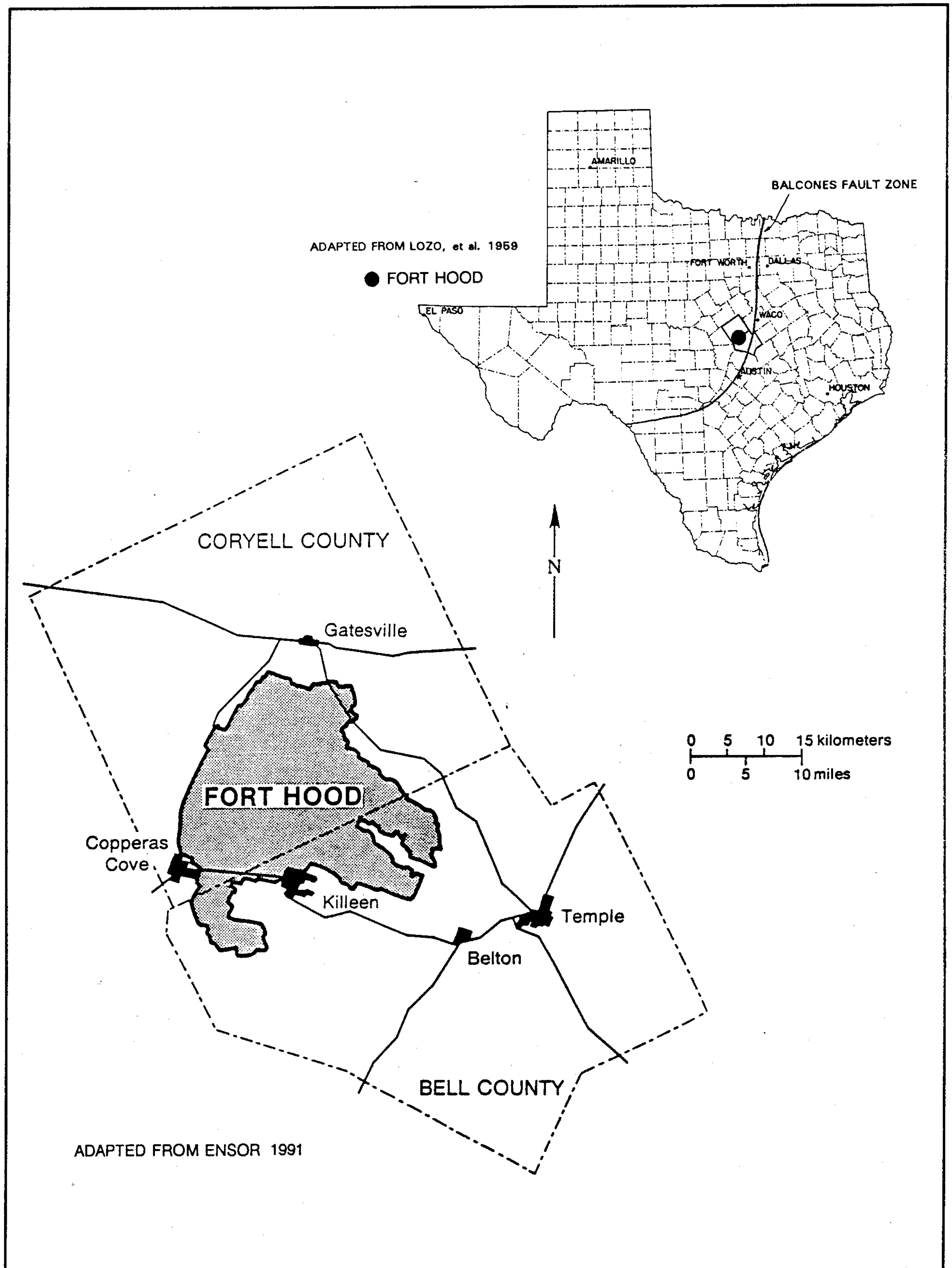


Figure 2.1 Location of Fort Hood.

The Balcones escarpment also defines the eastern edge of the Lampasas Cut Plain, which is physiographically intermediate between the Great Plains and the Gulf Coastal Plain (Hill 1900; Fenneman 1938:101). Fenneman (1931, 1938) classifies the region as part of the Central Plains Section of the Great Plains Province of North America, primarily on the basis of its up-lifted, higher elevation compared to the adjacent Gulf Coastal Plains, even though the region is described as a plateau of marine deposits in mature and later stages of erosion.

The bedrock geology of the reservation consists of Lower Cretaceous marine shoreline sediments from the receding waters over a broad, shallow marine shelf (Nordt 1992). Abundant marine fossils indicate the presence of ancient reefs. The dominance of limestones, marls, shales, and clays reflects deposition along the shore in a low energy environment; sand deposits are relatively rare in this area. The geology of the military base is dominated by five formations, from lower to upper: (1) the Glen Rose Formation, consisting of fine-grained chalky to hard limestone interbedded with dark gray clay and marl; (2) the Paluxy Sand Formation, a light gray to red, very fine-grained quartz sand which may be interbedded with minor amounts of shales and limestones; (3) the Walnut Clay Formation, consisting of chalky clay, limestones and shale; (4) the Comanche Peak Limestone Formation, a hard and nodular gray to white limestone with numerous shale partings; and (5) the Edwards Limestone/Kiamichi Clay, a massive limestone with abundant chert, nodular clay, limestone, and shale. Some studies recognize the Fort Worth and Duck Creek Formations as related to the Edwards Limestone.

Following up-lifting along the Balcones escarpment, these relatively level deposits have been eroding at least since the Miocene. Differential hardness of the Edwards Limestone/Kiamichi clays coupled with back-wearing of slopes have resulted in a distinctive series of buttes/mesas and steep-sloped, flat-topped "mountains." Two distinctive erosional surfaces are present on the reservation. The higher Manning Surface represents nearly level remnants of the chert-bearing Edwards and Comanche Peak Limestones which dominate the higher elevations in the northern, eastern, and a minor amount of the southern portion of the installation (Figure 2.2). In general, the extent of Manning Surface erosion is more pronounced in the southern parts of the reservation, where the hills tend to be more rounded than in the north. Erosion of the softer Comanche Peak Limestones beneath the more resilient Edwards Limestone created numerous bluff shelters and shallow rockshelters around the perimeter of the flat-top mountains, and occasional karst sink holes in the overlying Edwards Formation.

The lower Killeen Surface undulates slightly, but co-incides with the chert-poor Walnut Clay formation, which is abundant along the central-western portions and the northern margins of the military base. The Paluxy Formation is a minor expression barely documented on the geological maps. It occurs mainly as relatively narrow areas in the west-central portions of the reservation. The chert-poor Glen Rose Formation is exposed in the main incised tributaries across the central and southern portions of the installation.

Pliocene and Pleistocene alluvial terraces are relatively common bordering higher elevations of the modern rivers. Many of these alluvial deposits contain chert cobbles in the Uvalde Gravels from nonlocal sources beyond the limits of the current river systems (Guderjan et al. 1980:8).

2.1.2 Climate

The military reservation is near the boundary of the zone of semi-arid steppe climate to the west and the zone of warm, temperate, rainy climate with hot summers to the east. The moist, humid maritime tropical air mass dominates the climate during the spring, summer and fall (Huckabee et al. 1977). Advances of polar air from Canada cause rapid plunges in temperature during winter and early spring. The yearly average temperature is 68.1° F, with the mean summer to winter temperatures ranging from 94° F

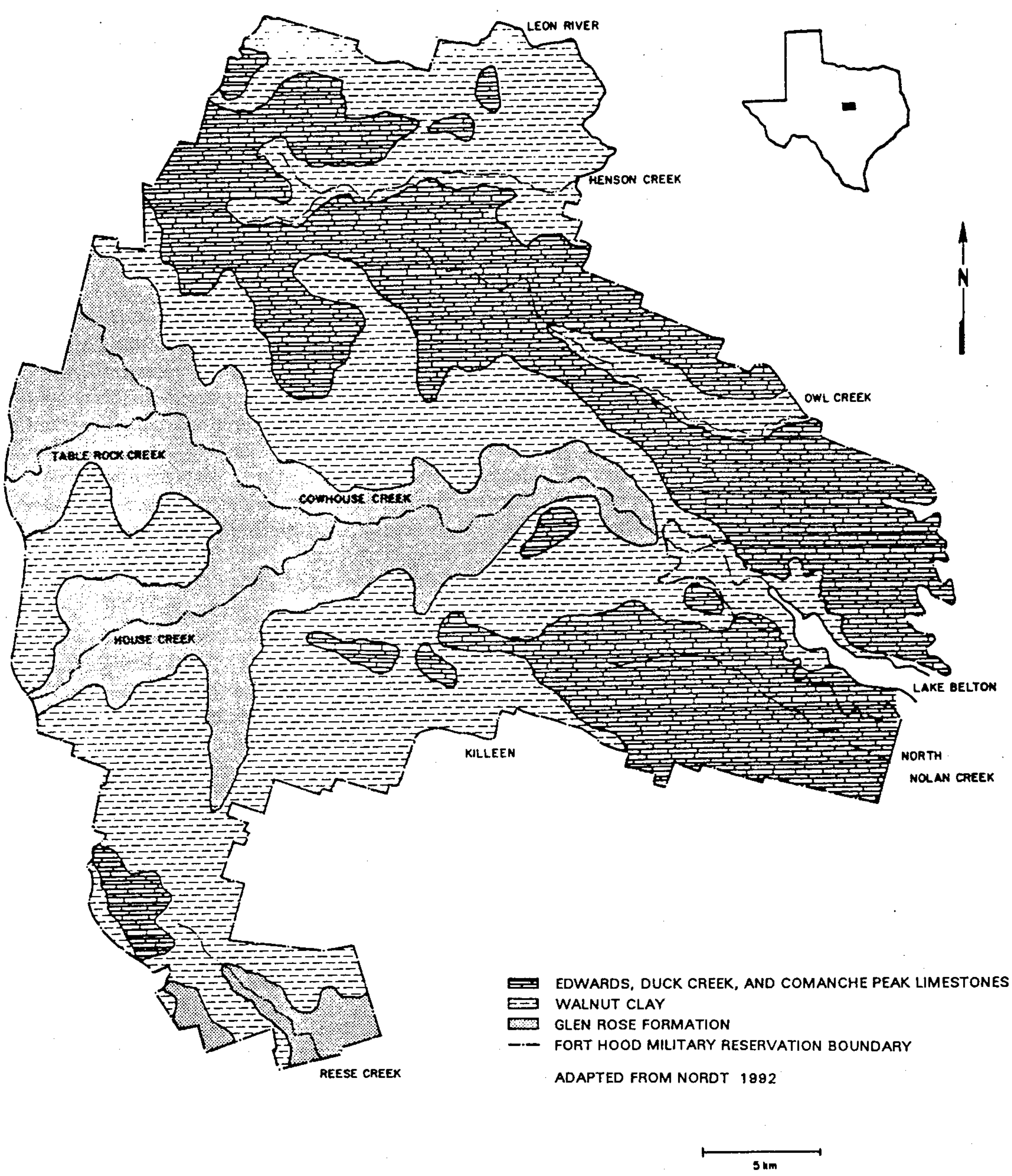


Figure 2.2 Geological Formations on Fort Hood.

to 38° F, respectively. The average length of freeze-free period is 260 days a year.

The average annual precipitation is 33.4 inches. Measurable snowfall is rare since it often melts as rapidly as it falls. Most rainfall comes during the winter months when measurable amounts fall an average of five days a month during September to May. The driest months are July and August. Prevailing winds are southerly with the most persistent and strongest occurring during March and April. The evaporation rate is nearly 1.5 times the amount of yearly precipitation.

2.1.3 Hydrology

All of drainages within Bell and Coryell Counties are within the Little River tributary of the Brazos River drainage. The major drainage orientations are toward the east or southeast (Figure 2.3). The Leon River, along the northern perimeter of the reservation and the Lampasas River, south of the base, are the major tributaries of the Little River. The overall drainage pattern is dendritic and is more angularly defined in the northern portions of the installation. The tributaries of the Leon River which drain the northern edge of the base include Shoal Creek, Henson Creek, and Owl Creek. Cowhouse Creek is a main tributary of the Leon River which bisects the reservation. Cowhouse Creek has two major tributaries, Table Rock and House Creeks, which enter from the south. Other minor tributaries to Cowhouse Creek from the north include Taylor Branch, Stephenson Branch, Wolf Creek, Browns Creek, and Stampede Creek. The minor southern tributaries include Cottonwood, Bull Run, Riggs Run, and Oak Branch. South of the Cowhouse drainage is North Nolan Creek, another tributary of the Leon River. The southern-most area of the reservation is drained by Reese Creek, a tributary of the Lampasas River. Belton Dam spans the Leon River east of the military installation and has created Lake Belton, which inundates the lower portions of Cowhouse Creek. No significant impoundments occur along Cowhouse Creek or streams on or above the reservation. Springs and seeps occur in relatively great abundance on Fort Hood, especially in association with rockshelters in the Comanche Peak Limestone (Brune 1981:65-67).

Some of the historic flood events on the installation have been spectacular. Flood records for Cowhouse Creek (drainage basin of 455 mi^2; 1180 km^2) indicate that the river rose 37.5 ft (11.25 m) in 1900, and again in 1944; 38.76 ft (11.65 m) in 1956; and 40.1 ft (12 m) in 1959. The El Nino event of December 20, 1991 left flotsam at an elevation of 44.3 ft (13.3 m) above normal flow, and was estimated to have a maximum discharge of 110,000 ft^3 per second.

Geomorphic studies by Nordt (1992) indicate the presence of a high Pleistocene terrace (T-3, designated the Reserve alluvium) along the Leon River. Elsewhere, several of the other rivers on the installation have lower Pleistocene terraces (T-2, the Jackson alluvium). The Holocene terrace (T-1) deposits reflect a complex series of cut and fill episodes which eventually filled some river valleys to heights of 10 m before the rivers incised to bedrock during the historic period. The four recognized Holocene fills include the Georgetown Alluvium (ca. 11000 to 8200 B.P.), the Fort Hood Alluvium (ca. 8000 to 6800 B.P.), the lower West Range Alluvium (ca. 4300 to 2800 B.P.), and the upper West Range Alluvium (ca. 2400 to 600 B.P.). The modern overbank alluvium (T-0) has been designated the Ford Alluvium (ca. 600/400 to present), which has formed draped deposits several meters up the sides of the modern streams.

2.1.4 Vegetation

The reservation is located within the southern portion of the Cross Timbers and Prairies Vegetation Area as defined by Gould (1975). Others have classified the vegetation of the region encompassing the military base as within the Hill Country Savannah (Allred and Mitchell 1955) or the Juniper-Oak Savannah (Kuchler 1964). All of these studies characterize the vegetation zones as being relatively narrow (east-west) extending considerable distances north-south (Figure 2.4). Gould (1975) recognizes the dominant vegetation as Ashe juniper (*Juniperus ashei*), live oak (*Quercus*

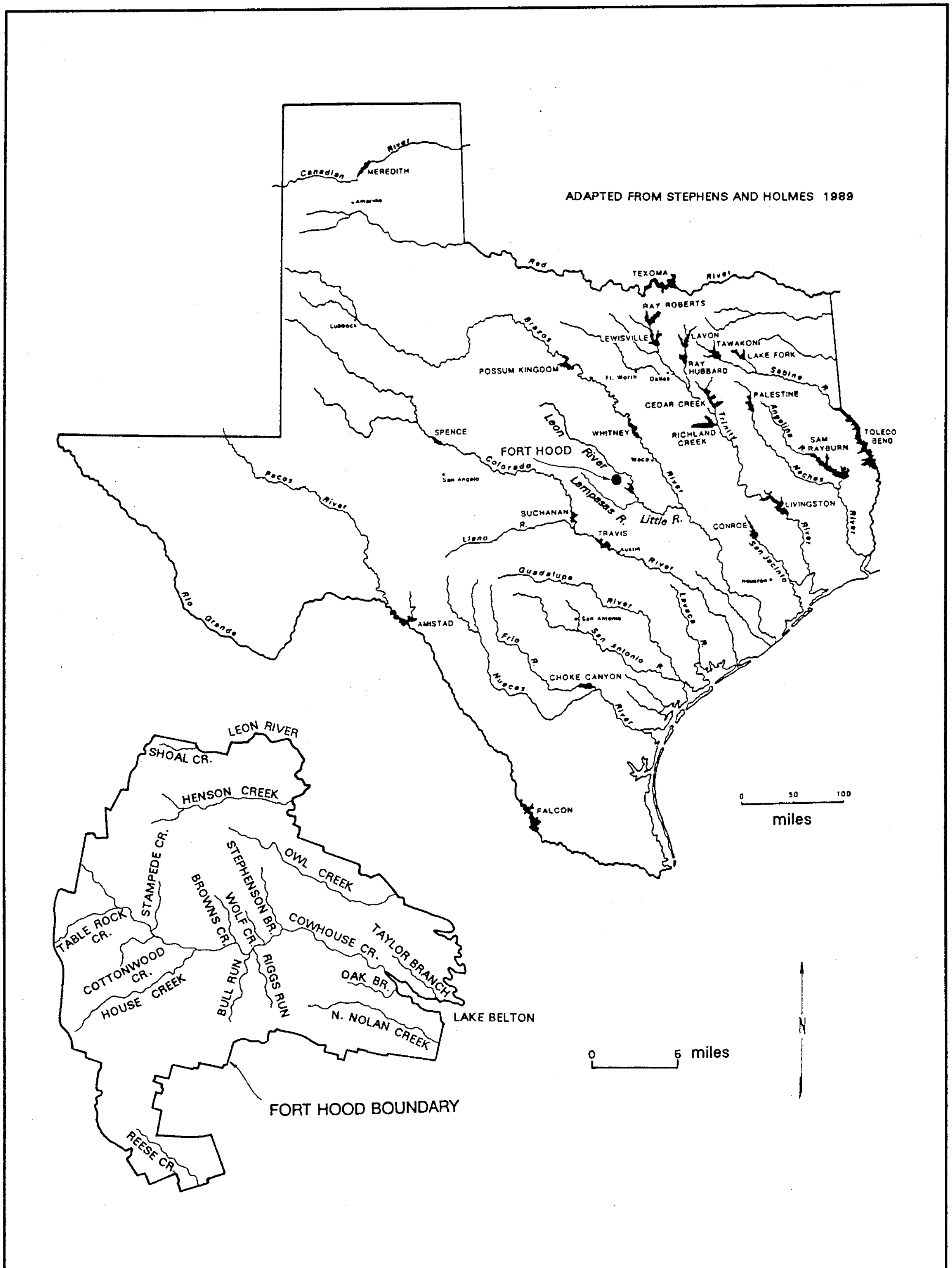


Figure 2.3 Hydrology of Fort Hood.

virginiana), Texas red oak (*Quercus texana*), cedar elm (*Ulmus crassifolia*), and Texas persimmon (*Diospyros texana*), with minor inclusions of post oak (*Quercus stellata var. mararetta*), and blackjack oak. Allred and Mitchell (1955:13) note that the trees of the savannah are mostly live oak, Spanish oak and shinnery oak, whereas the understory is dominated by a "true Prairie grasses" with hairy grama as a minor constituent. No mention is made of the juniper which is abundant on the installation. Kuchler (1964:86) describes the region as a savanna with dense to very open synusia of broadleaf and evergreen low trees and shrubs which are dominated by little bluestem, Ashe juniper, and live oak.

A generalized vegetation map of Fort Hood was prepared based on the terrain analysis maps developed by the Army Engineer Topographic Laboratory in 1977 (EHA 1979:Figure 2.3-1, A-1). A total of 15 vegetation categories were delineated based on composition and densities, including four categories of coniferous woodland and scrub, four of mixed woodland and scrub, four of deciduous woodland and scrub, two of grasslands, and one where vegetation was not a significant factor. Distributional classification indicated that the installation was composed of about 38 percent grassland and savanna, 57 percent woodland and scrub, and about 5 percent developed urban areas. Plant inventories indicated that the woodlands were dominated by Ashe juniper, live oak, and Texas oak. A total of 267 species or varieties of plants representing 72 families were documented, including a few relict species, such as the big-tooth maple (*Acer grandidentatum*). Mixed woodlands (cedar/oak) dominate the base with the greatest density along the higher Manning surface--especially in the northern and eastern portions of the base. Coniferous (Cedar) Woodlands have limited areal extent and occur as stands, mostly in the southern portion of the installation. The greatest density of deciduous (oak) woodlands occurs in the southeastern portion of the base along North Nolan Creek. The grasslands and savannas generally correspond to the lower Killeen Surfaces and are mostly present in the central and western portions of the installation. Some grassland areas may have been expanded since the establishment of the reservation due to range fires in the live-fire impact zone as well as impacts from the armored vehicle training areas.

2.1.5 Fauna

Terrestrial wildlife classification has placed the Fort Hood region within the Balconian Biotic Province, which includes the Edwards Plateau (Blair 1950). The terrestrial vertebrate fauna contains a mixture of species from the surrounding Australoriparian, Tamaulipan, Chihuahuan, and Kansan Biotic Province. A summary of faunal remains potentially present at Fort Hood has been prepared (EHA 1979). Several wildlife habitats were delineated on the installation. These included three terrestrial habitats (Upland Woodlands, Deciduous (Riparian) Woodlands, and Grasslands) and a single aquatic habitat.

A total of 57 mammalian species are present in this widespread province, including deer (*Cervidae* fam.), peccary (*Tayassuidae* fam.), bobcat (*Lynx rufus*), mountain lion, coyote, two kinds of foxes, two kinds of rabbits, beavers, 14 kinds of rats and mice, gophers, three kinds of squirrels, badger, two kinds of skunks, mink, weasels, raccoon, ringtails, seven kinds of bats, opossum, armadillo, shrews, and moles. Other terrestrial vertebrates include one terrapin, 16 species of lizards, 36 species of snakes, 15 frogs/toads, and two salamanders. Approximately 322 birds have been documented in this biotic province, although many are visitors. Some of the larger and more economically-important birds include the turkey, herons, spoonbill, several varieties of ducks and geese. In addition, 64 fish are potentially listed as being present. Some of the larger species of fish include gar, carp, catfish, bass, crappie, drum, and shad. Several species of freshwater clams and crustaceans are also present in creeks and rivers. In addition, a wide range of terrestrial and aquatic insects are also present.

2.1.6 Summary

The foregoing summary of the project area serves as an introduction to the locational setting and local

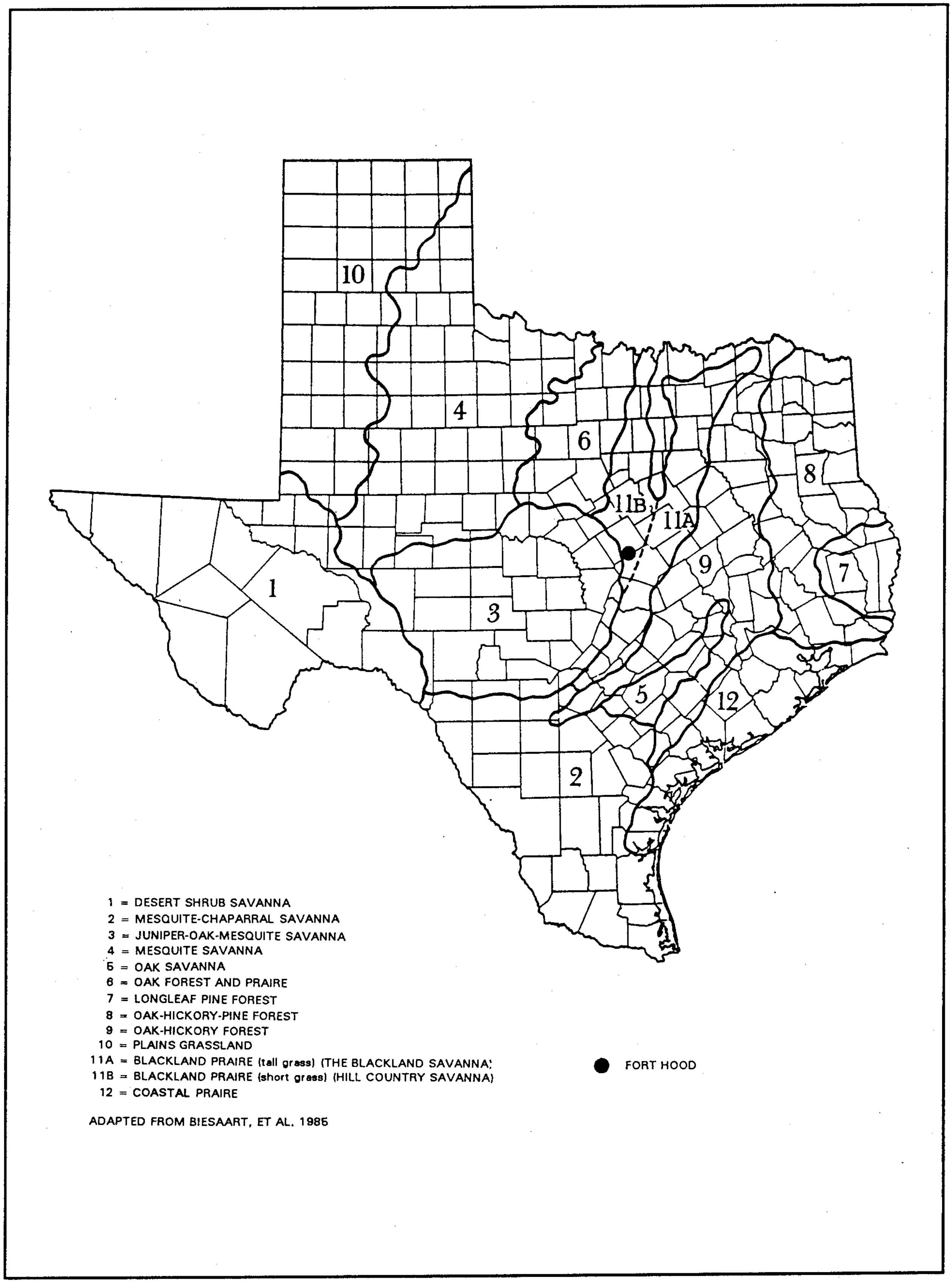


Figure 2.4 Vegetational Regions around Fort Hood.

variability in physiographic and biotic provinces encompassing Fort Hood.

The proximity of the Balcones escarpment provides an important contrastive boundary between the resources found on Fort Hood and the adjacent Gulf Coastal Plain. Although nodules and outcrops of chert are locally abundant on Fort Hood, this resource is very rare further east, except in the form of outwash gravels. Similarly, the dissected uplands provide ample springs and seeps, which tend to be less common on the Gulf Coastal Plain.

Although the spatial limits of the Lampasas Cut Plain are not especially large, the area is considerably more than the area of the military installation. None of the various detailed classification system of plants, animals, or landforms straddle or cross cut the base. The long-narrow vegetation zones identified by Gould (1975), Kuchler (1964) and Allred and Mitchell (1955), completely encompass the base; however, mobile groups of hunters-gathers would not have to travel great distances to access resources from adjacent zones. The floral and faunal resources are relatively abundant, although they are not ubiquitous. The challenges facing hunters and gatherers were to develop sufficient familiarity with resource distributions to anticipate resources, and to recognize during daily activities subtle changes in the environmental setting so that alternative fall-back strategies could be implemented if primary subsistence strategies were perceived to be inadequate.

2.2 HISTORY OF THE PROJECT

Jack M. Jackson

Fort Hood was among the first large military installations to attempt a complete cultural resource inventory. The complete inventory of 339 mi^2 of land was a major undertaking and represented a considerable expenditure of funds. Not surprisingly, there were several early efforts to devise way in which the Army could comply with the National Historic Preservation Act as inexpensively as possible. The first such effort was the formation of the Fort Hood Archeological Society (FHAS). This was an unofficial organization of soldiers and civilians interested in archeology who in December 1971 were given a building in which to meet and store their artifacts and records. In return, the organization undertook the survey of the Fort for archeological sites. The society flourished for a few years, finding 105 sites (Thomas 1978) even after a professional archeologist was hired in 1977, but made only the faintest progress toward the completion of an inventory. At the rate of site recording accomplished during that six-year period, it would have taken 125 years to reach the current level of inventory.

Dr. Frederick Briuer was hired to be the Staff Archeologist at Fort Hood in 1977. Some other major Army installations hired professional archeologists at the same time. Early policy guidance for these professionals and for the officers who funded their projects and oversaw their work was sparse. Funding was modest. During the first five years of the program, funds were available for the salary of Dr. Briuer and later for an assistant. Funds for contract survey averaged slightly more than $150 thousand per year. During the next five-year period (fiscal years 1983 to 1987), the funding was only slightly more generous. Two full time archeologists were retained on staff and funds for contract surveys averaged just under $200 thousand per year. During this period, the design of survey procedures which would yield the maximum data for the minimum cost per acre was a primary goal of the program. To his credit, Dr. Briuer devised a standard survey operating procedure, site definitions, and other conventions which a succession of contractors followed.

The operational concept of these survey projects was based on the fact that much of the land at Fort Hood is geomorphically stable. The survey crews were normally composed of six persons who swept a 1 km square at 30 m intervals to locate surface sites, then recorded the sites. This work was nominally accomplished in a single working day. No shovel testing was accomplished, although subsurface deposits were examined in cutbanks and gullies but only within the survey unit. No systematic survey of stream cut banks was done.

Most of the early surveys were done at a cost to the government of under $8.00 per acre. The cover of each survey report published for these years depicted a map of the Fort with the previously surveyed areas lightly shaded, and the areas included in the report darkly shaded. With a maximum area of some 217,000 acres to survey, the total cost of this surface inventory would have been about $1.7 million. During the first ten years, about half that amount was actually expended toward the survey effort. Other efforts included a pioneering study of the impacts of military maneuvers on archeological sites, experiments with various forms of site protection, and detailed studies of some larger historic sites on the post.

2.2.1 Sequencing of Investigations

True to the prevailing survey paradigm of the era, the initial survey was accomplished on a randomly selected series of 1 km squares. Science Applications, Inc. (SAI) was the prime contractor for these early surveys with first Southern Methodist University (SMU) and subsequently the University of Texas at Austin (UT) as the subcontractors who actually furnished the equipment and survey crews. From 1979 onward, the idealized random sample survey was interrupted by project-oriented surveys connected with various construction and pipeline projects. In 1981, the last of the random sample quadrants was surveyed. Dr. David Dibble, the Principal Investigator for UT, questioned the basic assumptions of the surface survey and introduced the idea of acute geomorphological variation (Dibble and Briuer 1989). Disagreements over the content and phrasing of sections of *Research Report Number 3* delayed final publication until 1989. UT withdrew from the project after 1981 and SAI negotiated a subcontracting agreement with Texas A&M University (A&M). A&M continued as the primary contractor for the next ten years. Surface survey continued to be the primary means of site detection and evaluation of sites for NRHP eligibility was put off until after the completion of the surface survey.

Dr. Briuer introduced a novel idea during this period. The reader should recall that most archeologists in the middle 1980s were much taken with the power of computers and mathematics. Fort Hood was among the pioneers in the use of GIS. Dr. Briuer thought that it might be feasible to use the computer and various special GIS techniques to cluster sites in a sophisticated manner and to select for preservation a "statistically representative sample" of the site inventory. Through this method, sites would be selected and the normally expensive and time-consuming subsurface testing tasks avoided, while maximum preservation of in situ deposits would be achieved by avoiding excavations. It was an intriguing idea. The State Historical Preservation Office (SHPO) expressed polite interest, a major university agreed to do the pilot study, and the surface survey work continued.

This innovative approach to site significance proved to be abortive for several reasons. First, there was no formal Programmatic Agreement (PA) among the Army, the SHPO, and the Advisory Council on Historic Preservation (ACHP) allowing for this departure from NRHP criteria as the basis of significance. Indeed the ACHP had not been consulted. A personnel change at the office of the SHPO changed polite interest to open skepticism. Secondly, the results of the pilot study were less productive than hoped. A major conclusion of the pilot study pointed to the need for additional information, largely excavation data, before satisfactory clustering could be attained. Thus, for both technical and legal reasons, the approach had to be abandoned.

Dr. Briuer left Fort Hood to work elsewhere during the winter of 1988. He had been the Staff Archeologist at Fort Hood for almost a dozen years and the surface survey had covered about 95% of the areas where survey was practical. Not surveyed were large areas of the Fort which had been covered by paving and heavy construction in 1943 and an even larger area was in use as an artillery impact area. Pedestrian survey would have been fruitless in one area and very dangerous in the other. More than 2,000 sites had been discovered and mapped.

2.2.2 Field and Analytical Methods

A series of written and detailed Standard Operating Procedures were developed with contributions by several individuals. These informal documents were codified and published in 1986 (Briuer and Thomas 1986). The 1 km^2 quadrant remained the basic unit of survey throughout the life of the project. Analytical methods called for the collection of temporally-diagnostic artifacts from both historic and prehistoric sites. In practice, this involved the collection of projectile points from the surface of prehistoric sites and a wide variety of artifacts ranging from tableware sherds to used automobile license plates from historic sites. The practice of dating prehistoric sites by this means was generally accepted, but has proved to be troublesome when applied in a naive fashion. Because the historic sites needed to be dated in units of a quarter century, rather than a quarter of a millennium, dating by artifacts proved to be less satisfactory. A method of providing field crews with a preliminary property map of each quadrant showing the dates of land claims and the locations of residences and other features from historic maps was developed in 1980 to supplement artifact dating of historic sites. This was often done after the field survey was complete in later surveys. Clearly, a large number of sites could not be well dated using these methods.

From the very beginning of the project, efforts were made to obtain more accurate maps and to refine methods of recording map data. There were many areas on Fort Hood where standard 7.5 minute USGS maps and ordinary map orientation techniques were difficult to use. Archeologists working on private land can usually rely on such features as roads, utility lines, and fences as aids even on the most featureless landscapes. At the Fort, there are few utility lines, no internal fences, and a road network where only those that are paved remain static from year to year. After many experiences with attempts to use Army tactical maps, 1 to 400 scale aerial photographs became the standard mapping medium. At that scale, a 1 km grid square fit nicely on a surveyor's clipboard and small erosional cuts and even individual trees could be used as orientation features. Once the aerial photographs came into use, it became quickly apparent that the locational data on many of the early site forms might be less than reliable. An effort was mounted to monitor and relocate sites from the early surveys both to verify their locations and to reassess their condition over time. Some sites, particularly those recorded by the Fort Hood Archeological Society, have proven to be elusive.

2.3 CRITIQUE OF PREVIOUS RESOURCE MANAGEMENT WORK

Trying to get by inexpensively has proven to be an expensive strategy for CRM work. Efforts to relocate and remap sites from the early FHAS survey work have more often than not cost ten times as much as a professional survey crew would have cost. Once a site which could be eligible for the National Register is recorded, it becomes an object of further management. A site poorly recorded by non-professionals and located almost a mile from where they actually were at the time can cost the program hundreds of man hours. Many of these sites could have been located, recorded, and evaluated as not eligible for the National Register in a matter of a few extra hours when they were first discovered. Instead, many have been relocated and revisited many times to verify simple location and areal extent data. Other hours have been expended processing digging permits to avoid these sites for as long as 15 years.

2.3.1 Context of Management Decisions

The ruling context of all of these decisions was always the desire to show maximum progress while expending minimal funds. Dr. Briuer did know that a geomorphology study would be helpful, but his experience had convinced him that he would not be able to obtain funds to support such a study (Briuer, personal communication 1988). His last two years (fiscal years 1987 and 1988) were the leanest on record in terms of contract funds and he lost the civil service slot for an assistant. To cope with the work load of processing hundreds of digging permits, Dr. J. M. Jackson was brought in under an Intergovernmental Personnel Agreement with UT to assist Dr. Briuer. Dr. Jackson began work in October 1988. Drafting a PA and a Historic Preservation Plan (HPP) were among his first tasks. Placing the entire long-term plan in writing and showing the relationship between the work that needed to be done and the funds required to do it proved to be quite fruitful. Funds available to the program during the four years Dr. Jackson has been the staff archeologist have been almost equal to the total funds expended on the program during the 12 years of Dr. Briuer's service. A geomorphology study and surveys with shovel testing were begun, as was a program of sub-surface evaluation of previously located prehistoric sites.

In this context, it is clear that, like a starving child, the Fort Hood cultural resource management program managed to stay alive, but was badly malnourished. However well fed the child has been between his 12th and 16th birthday, some evidence of malnourishment during the formative years is still evident. Examining those consequences may provide lessons from which others may learn.

2.3.2 Consequences of Management Decisions

Perhaps the most obvious and least desirable consequence of these early management decisions has been the effect on site security and protection. If one is attempting to patrol and check for vandalism on 150 to 200 sites within 339 mi^2, the job is difficult, but not impossible. Attempting to spread the net of protection to cover over 2,000 sites in effect removes adequate protection from the 200 which would have been eligible for the NRHP. During the Environmental Compliance Inspection held in the fall of 1992, Fort Hood was commended for an active and effective anti-vandalism law enforcement program. That program would have been ten times as effective if it only had to cover ten percent of the sites.

Another serious shortcoming has been the lack of an explicit and detailed research design with NRHP criteria clearly spelled out. There were research designs of various stripes written for individual projects, but not one of these, nor indeed the whole body of them, filled the void. A state plan for Central Texas would have helped fill the void, but the planned series has not yet gotten beyond East Texas. A previous project with a major university failed to produce such a document. This volume, produced some 16 years after the first professional archeologist began work at Fort Hood, is at least ten years late. On the other hand, this volume is a far better document for having been written with full knowledge of the types and numbers of sites and the general geomorphic setting in which they are found, and can serve as a model for other projects.

Earlier efforts to economize have also produced a series of very large conglomerate sites. These sites are all larger than 75,000 m^2. As a general rule, they encompass a number of features in generally stable upland settings united by an ubiquitous scatter of broken and chipped chert. Most of them include an outcrop of primary lithic material. As a class of sites, they came to be known as "lithic resource procurement areas" or LRPAs. Unfortunately, when such general language is put into a contract, definitions must be very concrete. What emerged from an effort to make such a generalization concrete enough for contract purposes makes less than perfect sense. In the contract, LRPAs are defined as sites larger in surface area than 75,000 m^2, regardless of other characteristics. Thus, the exceptions to the general rule are now found on both sides of this arbitrary size marker. There are true quarry/procurement sites that are smaller, and sites without any primary outcrops which are larger. This problem of nomenclature is discussed at some length in section 5.3 of this volume.

These large sites were largely an artifact of another attempt to write a contract definition of how many sites were to be recorded per survey quadrant. It was cheaper, easier, and less time consuming to record a single large site than to record the rock shelters, middens, and other features found inside its boundary. The result, however, was not a useful management unit. Those in a position to benefit from our hindsight should avoid the practice of lumping sites into such agglomerations. Consider for a moment the problem of a well preserved rock shelter covering perhaps a quarter acre that has been recorded as one component of a fifty-acre site. If the shelter itself is eligible for the NRHP, how do you manage the other 49.75 acres? That is a problem we will have to solve at Fort Hood, and yet it could have been avoided.

Perhaps the most serious consequence of the strictly CRM surface survey approach is that we have accumulated a wealth of data, but we have very little information. It is, indeed, rather embarrassing that we have discovered so many sites and know so little about the prehistory of the area. This document seeks a specific theoretical solution to that basic problem.

3 CONTEXTUAL CONSIDERATIONS

Christopher Lintz

This chapter is concerned with the issue of context in the archeological record. Initial discussions distinguish between research context and stratigraphic context. Section 3.2 then focuses on the stratigraphic context at Fort Hood. The results of the geomorphic studies along major streams are summarized and the archeological potential for the preservation of in situ archeological remains on each landform is discussed. The special contextual problems associated with the upland lithic procurement sites are discussed in section 3.3. Finally, the nature and extent of impacts and the potential for sites to survive these impacts on Fort Hood are addressed in section 3.4.

3.1 NATURE OF CONTEXT

Although context is often used by archeologists to mean the ascriptive/descriptive provenience and the partitioning of materials by association to features or other artifacts into interpretable units (see Todd 1992), the term actually has a much broader and more flexible meaning depending upon its intended use. In its most generalized sense, *context is the environment within which things (artifacts, sites, and even cultures) are found or within which they operate* (Hole and Heizer 1973:134). It is the crux of anthropological studies of both the present ethnographic and prehistoric archeological societies. Three generic variables for studying context are *time, space*, and *human activities* (behavior). These variables are used in different combinations to make inferences about historical problems. Most archeological studies of technological changes primarily utilize the elements of time and space. However, ethnographic and archeological studies of artifact functions primarily utilize human behavior and space for examining the context of material remains, whereas the study of cultural adaptation may be derived from the cumulative body of evidence amassed from the study of behavior and time.

Distinct from the material notion of context as a function of time and space is the concept of research context. This pertains to the relationship and organization of information about fundamental research topics. Unlike contexts involving spatial dimensions, research context need not be tied to a specific cultural entity or related to clearly delineated time periods or site locations. Indeed, in cases where temporal or spatial considerations are germane, the research contexts are apt to relate to a larger scale of analysis, such as regional or area-wide concerns. Research contexts may include accumulation of data furthering middle range theories which link archeological observations to behavioral activities, or to a growing body of information about adaptive processes. Although the contributions of research contexts are incredibly important for extracting new kinds of data applicable to older problems, this notion of research context is not typically used in archeological "field studies."

The kinds of problems being addressed clearly influence the priority of the context variables that need to be studied. Some research problems may not strictly require detailed spatial control to make significant contributions as long as tight chronometric control over absolute time is maintained. Three archeological examples from the study area are offered which contribute to the research problem of prehistoric subsistence but which use non-spatial data.

First, it can be argued that recovery of charred macrobotanical remains from burned rock features have rarely been effectively analyzed for their use. In addition, vandalism and training activities have extensively impacted the deposits in many (but not all) burned rock middens on Fort Hood. While some such impacted features may still have intact deposits, others may be thoroughly mixed. Consequently, a viable strategy for quickly amassing economic data from such sites involves: (1) using fine-mesh water screen or flotation tactics to recover very small charred plant remains from focused excavation; (2) identifying the botanical remains recovered from mixed deposits to obtain data on subsistence and seasonality; and then (3) using AMS radiocarbon dating on individual specimens to establish an absolute chronology of the economically useful plants. If applied to a large enough sample or micro-remains, such an approach could contribute insights into the decisions of resource selection and how these change over time.

The second example also addresses prehistoric subsistence data and has the additional benefit of providing reliable ages of human skeletal remains. Such chronometric information may be of assistance in the repatriation of human remains to the proper ethnic groups, where this is required by law. This tactic uses carbon and oxygen isotopes coupled with radiocarbon dates on surface collected human bones from vandalized sites. The results obtain paleoenvironment and dietary information directly on human remains which can be chronologically ordered and assigned to cultural periods/phases. In addition, even though the isotope and dating methods are destructive forms of analyses, only a minute quantity of bone is needed; other portions of the elements can be repatriated to appropriate Native American groups. However, the absolute date can help establish which Native American groups were regionally present during the time of the burial and who can rightfully claim the remains for reinterment.

The third example contributes paleoenvironmental information derived from employing oxygen and carbon isotopic data and acceleration carbon or epimerization dating on micro-fauna (e.g., *Rhabdotus* sp. or extracted samples of ostracodes) to begin the compilation of paleo-temperature and vegetation covers at dated points in time.

The relatively high cost of accelerator mass spectography (AMS) radiocarbon dating in all three examples is partially off/set by the relatively short field effort needed to extract the samples or remains. Similar approaches can be used to establish the age of rare and uniquely preserved organic artifacts (e.g., sandals, cordage, bags) that occasionally may be found strewn inside vandalized sites. The strategies outlined above utilize the non-traditional notions of archeological context as a ready means for quickly and cost-effectively amassing a body of important information toward addressing specific research issues; the method should be viewed as an initial step applicable for regional perspectives and not site-specific comparisons. These strategies should not necessarily be considered as the primary means of compiling information for research issues, but it is a quick way to accumulate a valuable chronometrically-fixed data base on subsistence and paleo-environmental issues. Limitations to the approach involve the inability of extending the radiocarbon results to other materials, since no spatial associations can be drawn from the vandalized contexts. This limitation is not overwhelmingly fatal, since previous methods to address research issues have expended tremendous efforts at collecting "diagnostic" projectile points and ceramics from mixed archeological contexts.

In addition, some kinds of cultural resources are so rare that the recovery of recognizable materials from sites with poor spatial archeological context contributes important information to cultural affiliation, technology, stylistic, or movement/exchange based merely on the evidence of diagnostic objects, manufacturing patterns, shape, and identifiable material sourcing. This is especially true for Paleoindian and Early Archaic sites which have rarely been studied, or areas containing abundant exotic artifact forms or materials. Thus, preservation or investigation of sites which have been plowed or adversely impacted by mechanized vehicles may be warranted if sufficient distinctive artifacts are documented from the site, even though spatial provenience has been lost.

More traditionally, archeological contexts refer to the predominately spatial provenience of artifacts from prehistoric or historic sites. Schiffer (1987:3-4) has emphasized two forms of context: systemic context and archeological context. Systemic context refers to artifacts when they are participating in behavioral systems, whereas archeological context refers to artifacts that interact with the natural environment.

Clearly, artifacts can move back and forth between systemic and archeological contexts, especially if they are re-used by later people. Studies of ethnographic hunter-gatherer groups not only suggest that people cache newly made tools for anticipated future use, but also that they are keenly aware of previously made (i.e., archeological) tools as an exploitable resource (Binford 1983b:224). Thus, tool recycling may involve either short- or long-term participation in the archeological context before they reenter the systemic context. The distribution and association of artifacts from a site reflect the end product from a wide range of cultural and natural taphonomy factors. Cultural factors can include artifact use, reshaping, resharpening, recycling, and reuse of tools as different implements, which are left, lost, or discarded. In contrast, the natural taphonomy factors relate to depositional and post-depositional processes, such as artifact redistribution by eolian, alluvial, colluvial processes, and displacement by floral turbation (plant roots, tree falls, cradle-knolls), faunal turbation (burrowing mammals, crayfish, insects), and various forms of pedoturbation (frost actions, freeze-thaw, solifluction, shrink-swell factors of clays) (Wood and Johnson 1978). The interpretation of "patterned" spatial distribution of artifacts can yield behaviorally relevant information only after the natural influences have been considered.

The conceptual use of context has often been abused in archeology. In some portions of the United States, context is an ascribed manner of grouping or partitioning artifacts by predetermined a priori "meaningful" provenience units. For example, many pithouse and puebloan sites in the Southwest are frequently excavated by descriptive stratigraphic units which are presumed to have cultural relevance (e.g., structure fill/overburden, roof fall, floor associations). Once so designated, analyses often treat materials from different contexts without understanding the processes of site formation. Todd (1992) rightfully indicates that this procedure of assigning descriptive/ascriptive labels to the archeological context diminishes the possibility that subsequent studies can progress through a range of analytical scales and reach alternative conclusions.

Clearly, artifacts can have simultaneous relevance to different contextual relationships. For example, a specific bifacial knife may have simultaneous interpretable systemic contextual relevance to an adjacent hearth, to other implements of a tool kit, to adjacent lithic and faunal debitage, all within "work areas," within stratigraphic lenses, within rooms, within structures, and so on. Thus, Todd argues, spatial provenience and orientations of artifacts are the appropriate primary levels of field recording, but the descriptive-documentary-interpretative components of ascribing systemic context and material associations should be relegated to the analytical domain of archeological investigations. This position is well founded provided that provenience observations are made within natural stratigraphic limits, wherever it is discernable.

3.2 LANDSCAPE STABILITY AND CONTEXTUAL INTEGRITY

If the spatial segregation of archeological materials is crucial for defining artifact associations which underlie the delineation of behavioral units, then determining the *rate* of deposition is the key. Knowing the rate of deposition allows for identification of different occupations with clearly definable contextual integrity which are apt to differently preserve prehistoric activities. As Binford (1982) notes, the rate of artifact deposition is governed by human behavioral processes, whereas the rate of artifact burial is usually governed by natural landscape processes. Geomorphologically, land forms can be characterized as degradational, stable, or aggradational environments. Depending upon topography, in some settings, such as alluvial valley, fills can periodically alternate between these three environments.

The clarity of occupations located on geomorphologically stable (or degrading) land surfaces are often masked, since temporally-associated features, artifacts, and residues can often not be successfully segregated. The recovery of select diagnostic artifacts may provide insights into select periods represented, but many more such activities from different adaptive systems may also be undetectably present. Thus, it may be appropriate to treat assemblages on geologically ancient, degrading, or stable land surfaces as accumulations of indecipherable materials from palimpsest activities; such assemblages are rarely interpretable or comprehensible for addressing many research domains (Binford 1981c, 1982, 1983a). In general, the older and more stable the land surface, the more likely that mixed palimpsest materials are present. Nonetheless, artifacts from palimpsest (or *possibly* palimpsest) assemblages may be useful for some research questions. For example, the mere presence of diagnostic Paleoindian artifacts is extremely useful information, regardless of geologic context, simply because such artifacts are so rare.

At Fort Hood, the land surfaces with the poorest potential for isolatable archeological materials consist of pre-Holocene age surfaces, including so-called "uplands" and Pleistocene terraces. However, even some alluvial settings may be stable terrace surfaces that were exposed and available for the accumulation of artifacts for several thousand years before being buried by subsequent aggradational processes. Thus, the presence of artifacts exposed in buried alluvial contexts can also represent palimpsest materials with limited segregatable value for addressing many culture-historical research issues. Geomorphological studies of pedogenic development within the alluvial terrace should provide, in most instances, a ready means for identifying whether the context represents a rapidly or slowly aggrading environment.

The best environmental contexts for retrieving isolatable archeological materials, and hence behavioral information, are from rapidly aggrading sediments on geomorphologically active areas. These contexts tend to bury, seal, and segregate materials from discrete behavioral episodes. In addition to alluvial settings, other forms of aggradational environments consist of fill inside rockshelters, materials within eolian dunes, the base of colluvial slopes, and even the formation of anthropogenically-derived mound features on top of ancient, stable landscapes (Butzer 1971).

Although Paleoindian materials may occur on stable or even degradational upland settings, the detection and investigation of remains of comparable ages imbedded in aggrading alluvial terraces provide greater clarity of associated materials. Thus, a detailed geomorphological study of the region permits the stratification of the landscape into areas with greater or lesser potential for single component sites with "intact deposits." This is not to claim that all sites of a comparable age constitute the same behavioral patterns on any landform, for clearly differential resource distributions dictate differences in settlement and subsistence patterns. (Indeed, the nature of hunter-gatherer adaptations concentrates on specific seasonally available resource(s) influenced by the nature of their distributions-- point source, linear or areally extensive; however, these groups also spread other routine activities across the landscape surrounding targeted resources at select settings). Instead, the above stated claim for focusing research activities on relatively intact deposits is an acknowledgement that archeological remains from some landforms may rarely, if ever, contain preserved and unmixed materials that can be segregated and used to address many research issues about temporally-specific time periods or prehistoric societies, except inferentially, from the recovery of known resources transported to other settings with better preservation. It may eventually be possible to delineate some intelligible contextual aspects of prehistoric activities from the palimpsests accumulated on stable upland surfaces after the association of distinct suites of artifacts from discrete contexts or advances in chert patination rates allows for the interpretation of the more over-printed upland deposits. However, the palimpsests sites are probably never going to approach full intelligibility because many items are likely to have non-diagnostic forms.

For some research issues, survey data can be used to correlate functionally diagnostic artifact types (i.e. grinding stones, gouges, etc.) to landform settings to delineate generalized exploitation patterns, even if these artifacts can not be initially attributable to specific time periods or culture complexes. Eventually, the morphology or technology of some tools recovered from upland settings may be linked to items recovered from discretely datable assemblages in aggradational settings to permit complementary behavioral information from non-aggrading environments. However, the absence of stratigraphic segregation on some landforms presents severe analytical limitations. The benefits from intensively investigating palimpsest materials from upland settings diminish quickly, and limited funds can be applied more efficiently to other landforms with higher potential for preserved intact deposits. Such analytical tactics can employ survey data, which otherwise might be ignored. In other words, it is necessary to recognize that palimpsest sites are valuable for some specific purposes, but not for other research purposes.

3.2.1 Geomorphology and Age of Landscapes

Geomorphological studies of landforms on Fort Hood have concentrated on delineating the depositional (mostly alluvial) sequences near the main rivers and tributaries (Nordt 1992) and have only recently shifted to lateral tributaries and other settings. The following sections discuss four types of landforms found on Fort Hood: (1) Ancient Stable Surfaces and Upland Settings; (2) Steep Slope Settings including rockshelters; (3) Minor Lateral Tributary Settings; and (4) River Terrace Settings. Discussions for each setting type focus on the genesis of sediments and potential for intact deposits.

3.2.1.1 Ancient Stable Surfaces and Upland Settings

Most of Fort Hood consists of Tertiary period materials on two distinct surfaces: the Manning and Killeen. Both of these surfaces typically have flat to slightly rolling topography with prominent escarpment edges. Limestone bedrock is exposed or shallowly buried by organic and/or rich organic-clay soils derived mostly from in situ limestone bedrock deterioration and weathering. Soil development in the western portion of the base tends to be shallower than on the eastern portion of the base, where deposits may reach depths of 60 cm. Loose, residual cobbles-to-tabular, blocky boulders of "Edwards chert" are common in upland soils found in select areas of the base--principally the Fort Worth-Duck Creek and Edwards formations in the northwestern third, the eastern third, and a minute area in the southern portion of the base. However, vast areas in the western third are covered by the Glen Rose, Paluxy Walnut and Comanche formations which are devoid of the Edwards Chert. Many of the chert cobbles have been fractured by thermal, cultural, and mechanical processes.

Two distinct Pleistocene terraces have been recognized only along the Leon River, which forms the northern boundary of the base (Nordt 1992). Both terraces the may include subrounded water-worn cobbles of limestone and some chert. The fill from the older T-3 Pleistocene terrace has been designated the Reserve alluvial unit and is manifested as a 20-m-tall terrace along the Leon River. The antiquity of this terrace is not directly dated, but is older than the 15,000 years B.P. age established for the more recent T-2 terrace.

Elsewhere on Fort Hood, the creeks and major tributaries have a prominent T-2 Pleistocene terrace, whose fill is designated the Jackson alluvium. Pedogenic development in the upper part of the Jackson alluvium has been named the Lewisville soils (Nordt 1992). Some terrace segments are mantled with finer sediments. The Pleistocene terrace has a relatively level tread, which is apt to be dissected with steep slopes along the margins. Carbonates have formed a duracrust or hardpan cap in portions of the Jackson alluvium; most of these sediments probably pre-date human occupations; bulk sediments have yielded humate dates of 15270 ± 260 years B.P. (Beta-38694) as a minimum age. Nevertheless, colluvial transport of fines above the duracrust may have covered features and occupational debris in gently sloping areas on Pleistocene terraces.

Fine-grained materials (principally residual soils) predating demonstrated human existence on the Manning surface, the Killeen surface, and possibly the Pleistocene terrace(s) are not considered to qualify as having the potential for buried, intact "culture-bearing" deposits in light of the antiquity of the deposits, the general absence of alluvial or eolian accumulations, and the potential accumulation of multiple palimpsests in surficial, or very shallow, deposits. Unless the survey or reconnaissance data has demonstrated a single component, through the recovery of multiple examples of a single chronometric artifact type, then the presence of multiple, nonsegregatable palimpsests is assumed. Thus, while it may be worthwhile to pursue the collection of Paleoindian or Early Archaic materials even from these stable upland surfaces, targeted sites should contain repetitive examples of diagnostic materials (i.e. multiple Clovis or Folsom points), to increase the likelihood that the associated materials represent Paleoindian materials and not more recent artifacts mixed with a reused early points. However, any upland areas with Holocene alluvial or eolian accumulations on these Pleistocene or older surfaces should be investigated as if a potential for intact deposits exist.

It is conceivable that Holocene cultural activities on the Manning and Killeen surfaces, as well as on the Pleistocene terrace(s), may have created anthropogenic deposits which may be intact (mostly in the form of subterranean or mounded features). The feature types standing the best chance of having intact deposits include those features excavated into the ancient surface (i.e. basin hearths, or slab-lined pits), or massive accumulations of materials on top of the surfaces (i.e. burned rock middens, or mounds). An additional locus with good potential for the preservation of intact Holocene paleoenvironmental and perhaps cultural remains occurs in karstic depressions or sink-holes that recently have been recognized in upland settings. Another intriguing kind of prehistoric activity recognized on the upland setting is an association of accumulated burned rock hearths/mounds and minor quantities of stone debris with the fine sands of the Paluxy formation at relatively great distances from present water sources. In some instances, sizable quantities of burned rocks occur several hundred meters from the nearest source of limestone. Investigation of these kinds of features potentially may yield relevant information about the activities responsible for their formation, since the likelihood of palimpsests is low at these settings far from water. These sites are excellent candidates for conducting the dated macrobotanical studies advocated in section 3.1, above. The results from these relatively unique site settings have a very high potential for distinguishing forager-collector behavioral strategies and prehistoric land use in the upland settings.

Features on all these ancient surfaces have some chance of becoming buried if (1) they occur on slightly inclined surfaces and are sealed by colluvially-moved sediments; or (2) features near major river escarpments (especially the Pleistocene terraces) have been covered by alluvium, especially during high energy flood episodes when river channels were not as deeply incised into the valley as they are at present.

3.2.1.2 Steep Slope Settings

The steep slopes occur along the margins of the Manning, Killeen, and Pleistocene terraces. Modern degradation through the Holocene alluvial terraces are discussed separately below. The height and steepness of the slopes may vary; however, much of the margins of the Manning and Killeen surfaces are marked by pronounced escarpments and long, steep valley walls littered by exfoliated limestone and chert boulders, to pebbles from the escarpment and finer sediments that may have washed in from the uplands. Nodules of Edwards Plateau chert may be locally embedded in the limestone bedrock, the escarpment, or in the rocks along the talus, especially in the northwestern and eastern portions of the base. Cultural remains on the steep slopes are likely to be colluvially displaced, although talus deposits associated with shelters may contain stratified layers of discarded debris.

Rockshelters often occur beneath the escarpments circumscribing the Manning and Killeen surfaces. The shelters may have formed by groundwater and range from slight overhangs to large caves; these were often sought as habitation loci for various lengths of time and/or cemetery sites. Fill inside the shelters consists of decomposed limestone "flour" or exfoliated wall/ceiling sediments and cobbles possibly mixed with sediments washed in from the uplands and often anthropogenically modified lenses (ash, decomposed organic remains, etc.). Groundwater seeps in some shelters have precipitated tufa-like deposits which may have cemented in situ cultural and paleoenvironmental materials into a rock-like matrix. Cultural materials (and features) are apt to occur inside and in front of the shelters. Artifacts and cultural debris may occur within stratified lenses on the talus below the shelters. Fills developing during lengthy gaps in shelter habitation may completely bury surficial evidence of occupations. However, prehistoric levelling of living surfaces and the excavation of pits may have mixed some sediments, and extensive vandalism inside some shelters has disrupted spatial contexts. Nevertheless, spatial context potential may be preserved in the solidified tufa matrix shunned by the vandals, and within the stratified talus deposits.

3.2.1.3 Minor Lateral Tributary Settings

The depositional situations along lateral tributaries and ephemeral drainages are probably the most complex. The alluvial sequences are poorly dated and their relationships to the cut/fill sequences of the major river terraces have not been geomorphologically studied and thus remain effectively unknown. In one case, large burned rock hearths associated with late Archaic points were found 1.5-m deep within 500 m from the tributary head. Along the base of the steep slopes, there may be a tremendous potential for burial of lowland surfaces and archeological deposits by colluvium. Once sealed by colluvium, features and living surfaces may exhibit a high degree of preservation and stratigraphic integrity. There is also a relatively high potential for extensive and thick middens to occur at minor confluences of lateral tributaries. This is especially the case at valley heads above minor confluences at the bottom of steep slope areas. Middens at several sites have been identified primarily by the abundance of fire-cracked rock, charcoal, bone, shell, and flint tools exposed in vandal's pits and in backdirt piles; the middens are minimally evidenced outside of the vandalized areas.

3.2.1.4 River Terrace Settings

Several river and major tributary valleys on Fort Hood have not been geomorphologically studied by Nordt (1992) to delineate the presence and age of cut-fill sequences. The major rivers and tributaries include the Leon River, Cowhouse Creek, Henson Creek, Owl Creek, Nolan Creek, House Creek, Table Rock Creek, and Reese Creek. Over 10 m of Holocene alluvium occurs along the river valleys of the T-1 terrace, consisting of a complex series of three cut and fill episodes and three soils have developed along the narrow river valleys between 10,000 and 600 B.P. The modern channel (T-0) developed in the past 600 to 400 years, but overbank deposits up to 7.5m thick have been deposited along the incised valley walls. Subdivisions of the Pleistocene T-3, T-2; Holocene T-1; and Modern T-0 fills, ages, and defined soils are shown in Table 3.1.

Unlike the stable upland settings, alluvial sediments along major streams have a relatively great potential for containing intact buried cultural remains. Inseparable palimpsests may have developed on stable terrace treads until the incised valley filled and covered the tread with subsequent fill sequences. Occasional overbank floods may have caused minor separation of occupations on higher terrace settings.

The occupations on aggrading alluvial surfaces stand an excellent chance to contain maximum integrity of tool distributions, features and activity areas.

Considerable problems exist in the recognition of sites on the alluvial terraces. Early survey teams did not systematically examine terrace faces and cutbanks to find the buried occupations; most documented site boundaries coincide with the limits or erosion exposures on the terrace tread. Most likely, the number and size of alluvial terrace sites are under represented.

We have also noticed that some sites (along Table Rock Creek) have extensive burned rock middens on the intersecting colluvial and alluvial portion, near the distal portion of the terrace. This area of interfingering sediments may present ideal situations, segregating otherwise palimpsest materials on stable terrace surfaces by examining a number of intact occupations that became segregated during their burial by colluvial deposits.

3.3 THE LITHIC RESOURCE PROCUREMENT AREA PROBLEM

The areal extent of palimpsest artifacts on stable surfaces create methodological, analytical, and management problems. The case of lithic procurement sites at Fort Hood provide a clear example of the taxonomic and contextual issues surrounding large, seemingly undifferentiated sites.

The methods for identifying and recording sites during the previous 15 years have not been extremely successful at delineating boundaries, internal site structure, or meaningful subdivisions of large sites based on surface data only. As indicated above, most surveys conducted on Fort Hood have been conducted on parcels subdivided on 1-km quadrants (Briuer and Thomas 1986). Each square kilometer was covered by pedestrian surveyors spaced at 30-m intervals, each of whom would note artifacts and features on a topographic map. After the quadrants were covered, tentative locations sites would be identified from the compilation of information, and teams would return to the "sites" to formally document the resource. Site recordation involved establishing a site datum, walking six to eight radii from the datum to establish site boundaries, completing site forms, site maps, and photographic documentation of the site, and recording artifact and vegetation densities at 5-m intervals along a single "bead line" through the long axis of the site. The only artifacts systematically collected were temporally-diagnostic arrow or dart points. The basis for defining site limits is discussed by Ensor (1991:23).

> Site boundaries were defined on the basis of artifact scatter and topography of the site. Site definitions tend to include a fairly large area within which there were several spots containing a concentration of artifacts or debitage. This is particularly true of areas in which chert outcrops are present at the surface and thousands of square meters contain chert nodules and flakes. Since it is not always readily apparent which flakes are natural and which are the result of human activity, the entire chert field is often designated as a site. These 'sites' obviously represent a complex situation in which human use of the chert field has been repeated over a long period of time. . . Identifying the entire chert field as a site is an interim strategy to provide the entire area with some protection until a more detailed survey can be conducted. Such a strategy is only possible in situations where sites are not slated for imminent destruction by some construction activity, but will instead be the basis for a site protection program. . . While this approach to site boundaries makes sense from a cultural resources protection perspective, it makes the analysis of the data more complicated, since nearly all of the sites probably represent multiple occupations. (Ensor 1991:23)

The problems of distinguishing natural from cultural flakes was especially difficult under limited time constraints, especially in regions containing abundant chert nodules subjected to 35 years of armored vehicle training before federal laws required the inventory and management of cultural resources. However, the recognition of problems associated with such sites created a subtle yet interesting conceptual and semantic shift which had ramifications for the survey methodology, and subsequent classification and management of large sites.

The passage from Ensor (1991:23) cited above methodologically acknowledges a shift in site definition from linear or areally extensive chert resource areas to large multicomponent cultural re-

Table 3.1 Terraces, Alluvial Fills, Ages, and Named Soils at Fort Hood.

Terrace	Named Alluvial Unit	Age (Years B.P.)	Named Soil
T0 (recent)	Ford Alluvium	600 to present	none
T1 (Holocene)	upper West Range Alluvium	2400 to 600	Bosque
	lower West Range Alluvium	4300 to 2800	unnamed
	Fort Hood Alluvium	8000 to 6800	Lewisville
	Georgetown Alluvium	11,000 to 8200	Royalty
T2 (Pleistocene)	Jackson Alluvium	17,000 to 13,500	Minwells
T3 (Pleistocene)	Reserve Alluvium	older than 15,000	not defined

source sites requiring management purposes. The methods for distinguishing and documenting such large sites is also interesting. Because the surveys were constrained by 1-km parcel units and because sites often extended beyond the limits of a given parcel, complete site documentation was delayed until adjacent parcels were examined, in some cases for several years.

Semantically, the correlation of site boundary to resource distribution created a new class of large and heterogenous site areas. In trying to capture the nature of this variability, the Fort Hood cultural resource management program defined a class of cultural resources as Lithic Resource Procurement Areas (LRPA). These areas "reflect the lumping of many discrete remains of lithic resource procurement activities into huge upland sites or human activity localities, encompassing many isolated and discrete temporal and spatial events. . . (which) as a general rule have a surface areas greater than 75,000 square meters" (Solicitation DAKF48-90-R-0053:C9-10). In practice, the LRPA resources merely referred to large sites or site clusters which required special attention and which merited different evaluation tactics than those employed on smaller, more discretely defined sites.

This extension of LRPA to any very large site cluster or resource area containing sites has conceptually undermined the utility of the term, in much the same way that the burned rock midden concept has historically inhibited our communication and formulation of a research objective which can effectively handle the resource. In some instances, LRPAs referred to areally extensive distributions of lithic debitage on upland settings which were far from actual chert bedrock or nodular resource areas. At the other extreme, many sites less than 75,000 m^2 in area occur within chert resource areas and contain seemingly high ratios of cores, large decortication flakes, and few formal tools, but may not be considered as a formal lithic resource procurement activity loci because they fail to meet the size criterion.

Ensor is explicit that the problem relates to chipped stone artifacts; however, the designation of these sites as lithic resource procurement sites may also apply to extensive areas of thermally-altered or fire-cracked rock, which may or may not have been caused by cultural activities. If resource size and setting are the only criteria for LRPA classification, then the behavioral and functional implications of lithic procurement sites becomes meaningless.

Contextual associations and tightly defined explicit empirical criteria for identifying fabricator implements and debitage classes at chert resource sites should be the basis for identifying the functional relationship of sites in the settlement and adaptive systems. Clearly, lithic procurement sites should be at or very near lithic resources. In addition, empirical evidence of behavior should be documentable. Such evidence of procurement should include: (1) a relatively high incidence of tested cobbles; (2) debitage which reflect a dominance of knapping efforts used to test the knapping characteristics and/or search for natural flaws in the nodules; (3) a relatively high ratio of hard-hammer fabricator tools as compared to other tool forms; and (4) abandoned cores and failed flakes.

If the lithic resource sites also contain bifaces in any stage of reduction, then evidence can be mustered to argue that lithic procurement and processing was being conducted at the site. Currently, insufficient documentation exists on these sites to ascertain whether cobble testing and procurement were the purpose of a specialized foray to the lithic procurement site, whether the procurement was embedded in other foraging activities, or whether the entire camp briefly resettled near the chert resources during the procurement activities. Similarly, we do not currently know whether quality nodules were tested at their sources and then removed and processed at camps in other settings for subsequent reduction; if cobble processing and reduction which yielded readily transportable large biface/flake blank packages occurred at the resource outcrop areas; or if complete processing (tool manufacture) took place at these areas. The presence of large bifacial caches of Edwards Plateau chert in sites east of Fort Hood clearly indicates that the study of chert exploitation practices near source occurrences is important. Due to the palimpsest nature of many of these sites, combinations of these alternatives may have occurred at various times in these upland settings. However, the methods of identifying diagnostic materials coupled with patination studies may help render these sites more intelligible.

3.4 IMPACTS AND DISTURBANCES

This section discusses previous considerations of natural and cultural impacts that have potentially affected the archeological remains on Fort Hood. In addition, the anticipated impacts on various land form settings are also briefly examined.

3.4.1 Range and Nature of Impacts

Previous considerations of impacts on cultural resource at Fort Hood have identified 22 agents (Moncure 1989:Table 5.2). Few of these agents were individually discussed and some (e.g. roof fall, plowing) were not mentioned beyond their listing. Additional impacts were also identified in the narrative discussions, but were not formally listed as identified impacts. Moncure organizes these impacts on the basis of four dominant themes (Table 3.2):

(1) *Historic Site Impact Agents*, including salvage or deterioration of historic buildings since Army acquisition;

(2) *Limited Effect Impact Agents*, including planned Army construction projects impacts (such as roads, pipelines, earth moving, land clearing, vegetation cutting) and activities related to Combat Engineer training;

(3) *Limited Control Impacts*, including non-planned impacts chiefly from erosion, cattle grazing, rodent disturbances, and vegetation burning; and finally

(4) *Other Impacts*, including ordnance, tracked and wheeled vehicles, and vandalism.

Moncure's organization is convoluted for two reasons. First, some impact agencies, such as burning, erosion, earth moving or wheeled vehicles, are attributable to more than one time period and/or general group of agents. Second, the areal extent of an Army planned project is not reflected under the rubric "Limited Effect Impact Agents."

Furthermore, this systems fails to monitor changes in the intensity or areal extent of the direct and indirect impacts due to activities at various historical periods in the past. An alternate manner of identifying and classifying impacts is to recognize the cumulative nature of impacts with changes in the land-use of the region and to acknowledge that activities conducted during different periods engender differential rates of impact. For example, sheet erosion accelerated after early historic settlers instigated land clearing/plowing, and even more so after the vegetation clearing and vehicular use which accompanied the introduction of

Table 3.2 Impacts to Cultural Resources According to Moncure (1989).

Class of Impacts	Listed Impacts	Other Impacts Discussed
Historic Site Impact Agents	Historic Habitation Collapsed Structure	Structure Salvage Structure Deterioration
Limited Effect Impact Agents	Earth Moving Vegetation Pushing Vegetation Cutting Burning Misc. Military Railroads Land Clearing Cultivation Borrow Pits Roads Pipelines	Power Lines
Limited Control Impacts	Cattle Burning Wild Animals Erosion	(none)
Other Impacts	Tracked Vehicles Ordnance Wheeled Vehicles Vandalism	Pedestrian Coverage Dedudding
Unclassified Impacts	Plowing Roof Fall	(none)

mechanized training over broad areas after Army acquisition. Accordingly, the types of land use and the intensity and/or extent of impacts should be jointly considered. Differential land forms are also subjected to different degrees of impacts, but this variability is not easily accommodated.

In Table 3.3, the types of primary impacts are cross-grouped by origin and by time period, noting both intensity and areal extent. Origin of impact is classified as either natural or cultural, and time of impact is classified as the pre-settlement period, the early historic settlement period, and the military period. Intensity of impact is noted as minimal, moderate, or severe, and areal extent of impact is noted as extensive (shaded cells) or localized (unshaded cells). The identified impacts have been subjectively rated for intensity and extent based primarily on intensity of land usage (inferred from population size) during the three defined periods.

The pre-settlement period (before about A.D. 1860) covers the period when the area was utilized by aboriginal Indians and Euro-American explorers who were involved with transitory use of the resources. Most of the impacts were primarily natural events, and include vegetation burning, channel erosions, perhaps limited sheet erosion, and roof falls.

The early historic period (about A.D. 1860-1942) pertains to the period of the establishment of rural ranch and farmsteads and their associated support

Table 3.3 Intensity and Extent of Impacts by Temporal Period. Shaded cells indicate areally extensive impacts; unshaded cells indicate areally localized impacts.

Type of Process	Impacting Agent	Pre-settlement (before 1860)	Early Historic (1860 - 1942)	Military (1942 - present)
Natural	burning	minimal to moderate	minimal to moderate	moderate
	gully erosion	minimal to moderate	minimal to moderate	moderate to severe
	sheet erosion	minimal	minimal to moderate	moderate to severe
	burrowing animals	moderate	moderate	moderate
	roof fall	not applicable	minimal	minimal
Cultural	land clearing	not applicable	moderate to severe	severe
	vegetation cutting	not applicable	moderate	minimal to moderate
	vegetation pushing	not applicable	minimal	moderate
	plowing	not applicable	moderate	minimal
	cultivation	not applicable	moderate	not applicable
	earth moving	not applicable	moderate	moderate to severe
	borrow pits	not applicable	moderate	moderate
	grazing	minimal	moderate to severe	moderate to severe
	historic habitation	not applicable	minimal to moderate	minimal
	structure salvage	not applicable	moderate to severe	minimal
	structure deterioration	not applicable	minimal	minimal to moderate
	pipelines/powerlines	not applicable	minimal	minimal
	roads/railroads	not applicable	minimal	moderate to severe
	wheeled vehicles	not applicable	minimal	severe
	tracked vehicles	not applicable	not applicable	severe
	ordnance	not applicable	not applicable	minimal to severe
	pedestrian coverage	minimal	moderate	severe
	vandalism	not applicable	moderate to severe	severe

communities (Jackson and Briuer 1989; Mueller-Wille and Carlson 1990). During this century-long period, major impacts are related to early attempts at settlement following the pacification of the Indian "problem" in Bell County (1841). Land clearing and farming/ranching, involved the fencing of lands, construction of masonry walls around fields, excavation of channels to control slope wash away from fields, the clearing land/plowing fields, and the introduction of livestock.

Other primary forms of direct impacts included the establishment of ranch and farm complexes and the development of roads, railroad, electric lines, and support communities. Indirect impacts resulting from a shift to a more sedentary pattern included increased erosion, increased pedestrian coverage of the terrain, and increased access for vandalism.

The military period (after A.D. 1942) witnessed the removal and/or salvage of select historic structures; deterioration of other abandoned structures; increased development of roads, pipelines, power lines, and training facilities; clearing of lands; maneuvers by tracked and wheeled vehicles; increased pedestrian traffic by troops on maneuvers; close-order coverage for "dedudding" of ordnance and "brass pickers" in and adjacent to the impact area; churning of sediments mostly by heavy tracked vehicles during wet weather conditions; occasional plowing and reseeding of heavily rutted areas; and increased vandalism.

Two other studies have been specifically undertaken to assess damage and impacts to the environmental resources of the base. One study examined the effectiveness of various protective measures from primarily tracked and wheeled vehicle impacts to a sample of 47 prehistoric and 34 historic cultural resource sites on Fort Hood (Carlson and Briuer 1986). The protective measures included the use of wire, brush, perimeter barricades, site burial under earth, the posting of "off limits" and "hazardous" signs, as well as the use of no protective measures. The measure of impact protection was based on a comparison of qualitative notations on four observations:

(1) general site condition (destroyed to excellent);

(2) estimated percent of site disturbance;

(3) source of disturbance; and

(4) estimated change in site condition (inferred from photographs of the 81 sites taken 12 to 17 months apart).

In lieu of discrete and objective criteria for observations (such as documenting the displacement of shallowly buried metal washers resulting from vehicle maneuvers) the estimated percentage of surface impacts on sites ultimately reflected only judgmental and intuitive impressions gained from surficial appearance of the site. The design of the project also failed to understand that vehicular impacts in moist sediments cause permanent disruption of the fragile integrity of the subsurface context. Such disruption is often masked by the surficial "recovery" of renewed surface vegetation and filling of deep vehicular ruts. This is especially true at Fort Hood where disc-plowing and reseeding programs are implemented to "restore" the landscape (Sedlak and Brown 1992:13). As may be anticipated, the results were inconclusive.

> Firm conclusions on the success or failure of the site protection measures are hampered by small sample sizes and the artificiality of lumping the various protection measures into few categories or very unequal size. Of greater concern is the lack of comparability between the original survey crew and the monitoring crew in their evaluation of site damage. The high percentage of sites evaluated as being in (sic) 'Better' suggests that the monitoring crew was more conservative in their damage estimates. (Carlson and Briuer 1986:14)

Elsewhere (Carlson and Briuer 1986:26) the report acknowledges that problems with the damage assessment methodology makes it impossible to reliably indicate the exact amount of damage a site has suffered; further it was not possible to demonstrate severity of the damage. Despite these serious admissions raising concerns about the validity of the study, the report suggests that only the "Off Limits" signs and the no protection strategy provided noticeably poorer protection (Carlson and Briuer 1986:14). Furthermore, no significant relationship could be found between the intensity of military training and the proportion of sites in a "worse" condition (Carlson and Briuer 1986:26).

The report acknowledges that problems exist in the project design due to budgetary and schedule considerations, and recommends that aerial photography may be helpful in recognizing the processes of site damage on various portions of the base. One surprising aspect about the analysis of site impacts in this document is the complete avoidance of any discussion of geological or archeological context, as well as a consideration of how to measure context disruption from the various impact agents.

The second study is concerned with modeling maneuver activity damage assessment based on comparisons of aerial photography over a 16-year period (1975-1991; Sedlak and Brown 1992). The intent of the modeling was to assess impacts to the environment (specifically, denuded vegetation) within defined management areas; the study was not specifically directed at cultural resources. Landsat images were used to generate 16 stages of vegetation cover from the yearly photographs; these data were correlated with rainfall and intensity of maneuver training to delineate the amount of environmental degradation for 73 management areas on the base. The scale of impacts ranged from less than five percent to more than 35 percent. Only in a few cases were large numbers of training areas badly damaged, and these correlated with wet conditions. For example, the study documented that in 1979, a wet year, nine of the 73 management areas (12%) had more than 25 percent disturbance, but during the following dry year, only three areas (4%) were comparably impacted. Furthermore, vegetation loss regenerated within 13 to 24 months.

This study provided a relatively good model for projecting some of the environmental effects from the arrival in 1992 of the 5th Infantry Division. However, the study arguably can not be extended to cultural resources for two reasons. First, the study does not consider terrain, geomorphology, soils, or other locational variables smaller than the generalized training unit in classifying impacts. Hence, the study units are overly generalized. More importantly, unlike vegetation, cultural resources are non-renewable and their contexts can not be "regenerated" or healed.

3.4.2 Extent of Impacts

This section briefly discusses the nature of impacts identified by land form. Specific discussions briefly focus on the ancient surfaces, steep slope surfaces, lateral tributary surfaces, and river terrace surfaces interms of the range of impacts and expectations to cultural resources in the various settings.

3.4.2.1 Impacts to Ancient Surface Sites

Much of the upland settings have been impacted by historic brush clearing, plowing, sheet erosion, and tracked/wheeled vehicles. Given the palimpsest nature of shallow cultural materials anticipated on these stable, ancient surfaces, a considerable amount of mixing and loss of integrity may be expected. Vast areas of the base may not contain intact deposits from these various kinds of activities. Vegetation and topography may provide clues as to the locations of intense impacts. For example, tracked vehicles may not have severely impacted the juniper thickets on the east range uplands, especially near escarpments. Other impacts include range fires which thermally alter limestone and the other activities associated with Army training, including the construction of "hulldowns," bivouac pits, walls, hearths, and other features. Recent aerial photographic studies on the intensity of mechanical impacts in various maneuver areas do not provide sufficient resolution to evaluate specific sites cases (Sedlak and Brown 1992).

3.4.2.2 Impacts to Steep Slope Settings and Rockshelters

Major impacts to steep slope settings occur in three forms: (1) sediment creep from gravity and slope wash; (2) tracked roads across the slopes; and (3) vandalism, especially in shelters. A wide range of minor impacts include the temporary use of shelters for shade by hunters and military personnel, and ancillary tree and brush clearing activities which are usually accomplished by hand. Range fires may have thermally fractured rocks on slopes and could have created pockets of ash in depressions.

3.4.2.3 Impacts to Minor Lateral Tributary Settings

Major impacts to sites in these settings include: (1) vandalism; (2) early historic agricultural activities; and (3) military-related activities. Many sites with thick burned rock middens at lateral tributary heads have been extensively vandalized. Exposed backdirt seems to attract attention and encourage even further destruction. Early historic agricultural activities along lateral tributaries include such forms of disturbances as field clearing, plowing, and water control. Water control activities included the improvement of seeps and springs, construction of dams across tributary heads, and excavation of ditches and channels at steep slope margins to divert run-off and lessen erosion in the field and field border walls. Military-related impacts include tracked vehicle roads and occasionally "hulldown pit," bivouac, and special task (tree cutting, and possibly range fires, etc.) activities.

3.4.2.4 Impacts to River Terrace Settings

Occupations in terraces along the major streams are apt to occur near the surface to depths in excess of 10 m. The depths of some of these occupations tend to naturally preserve their integrity, with the exception of shifts in the incised river meanders and perhaps exfoliation of the terrace side walls.

Major impacts to the upper portion of river terrace settings include early agricultural activities, lateral gully erosion, vandalism, and the excavation of "hulldown" pits and tracked vehicle accesses to ford major rivers and tributaries. Given the current lack of geomorphological understanding of the region during survey, military excavations on the terraces may impact undetected sites.

3.4.2.5 Summary

Each kind of landform has experienced various degrees of natural and human-induced impacts which have variously affected the archeological contexts of deposits. In general, substantial portions of the uplands have shallow archeological contexts representing palimpsest materials which tend to be more fragile than deposits in other settings. Previous attempts to consider and measure the nature of impacts have not included either archeological or research context into the design of the program. The results have been difficult to interpret. Similarly, the generalized characterizations of military vehicle impacts based on aerial photographs may document vegetation restoration and recovery, but have little bearing on the nature of archeological resources. Whereas considerably more research potential is afforded to sites with discrete archeological context, this chapter suggests that if the state of knowledge changes, so does the nature of research context and, by extension, the need for a periodic reassessment of site significance.

4 ARCHEOLOGICAL OVERVIEW AND THEORETICAL PERSPECTIVES

G. Lain Ellis

Chapter 4 begins the process of developing a research design for archeological research at Fort Hood. Because a research design is a proposed course of action for future activities, the process of developing one necessarily involves assessing the current state of archeological knowledge and practice and then devising a way to proceed further. However, archeological knowledge and practice are closely linked to the theoretical perspectives that shape research. This chapter therefore provides an assessment of the current state of Central Texas archeology and outlines the theoretical perspectives upon which we hope to advance archeology at Fort Hood.

Accomplishing these tasks is a necessary prerequisite for developing a research design because there are close links between current knowledge, theoretical perspectives, research designs, and the regulatory requirements that govern the CRM process. As noted in Chapter 1, the Section 106 regulations governing CRM activities at military bases stipulate that archeological research shall be conducted within a framework of well defined historic contexts. Pursuit of research within well defined historic contexts assures that public resources spent on archeology will be devoted to issues that genuinely deserve attention rather than being frittered away pursuing research directions that follow well worn paths through well known territory. However, the Section 106 regulations also recognize the possibility that there may be circumstances where regional archeological knowledge is too poorly developed to provide a basis for defining specific historic contexts. In such cases, the regulations stipulate that a goal of archeological research is to establish the foundations upon which to build historic contexts.

Regardless of the state of development of historic contexts for CRM activities for any given military base, attempts to advance research always occur under circumstances where previous results largely define what remains to be done. Furthermore, previous results always have been achieved from within a particular theoretical perspective. Theoretical perspectives are broad, high-level conceptual structures which do not automatically translate into procedural guides that govern the details of research activities. To apply a theoretical perspective to archeological research in a given area for a given set of historic contexts, it is necessary to have a research design that specifies the procedures to be used to advance research goals. Thus, the *current* state of development of historic contexts is always a product of *previous* applications of theoretical perspectives and research designs to the advancement of previously developed archeological knowledge. However, to say that the current development of historic contexts is a product of previous efforts is not to say anything about the soundness or productivity of those efforts. Indeed, two major purposes of this chapter are (1) to demonstrate that Fort Hood is a case where regional archeological knowledge is not sufficiently advanced to allow for the definition of specific historic contexts, and (2) to delineate the general theoretical parameters within which we intend to remedy this deficiency. Thus, another major purpose of this chapter is to lay the foundations for proposing a "back to basics" research design in Chapter 5. To fulfill its purposes, this chapter is structured in two major sections.

Section 4.1 is an extended argument which concludes that archeology in Central Texas has not been very successful at fulfilling the goals established within the traditional theoretical perspective employed by Texas archeologists. Another conclusion of the argument is that the traditional theoretical perspective does not provide a basis for advancing research in alternative, ecologically oriented directions that have emerged in Central Texas in recent years. Many researchers familiar with Central Texas archeology would agree with these conclusions. However, some archeologists might have different reasons than ours for agreeing, and others may believe that the state of the archeological art is well developed in Central Texas. Thus, the argument is long and detailed in order to persuade the archeologically informed reader that we have a well founded rationale for developing the research design delineated in Chapter 5. By default, the argument also leaves us open to detailed critique. Although section 4.1 is intended primarily for an archeological audience, the argument serves the nonarcheological reader as an example of the kind of critical assessment that should be applied to current archeological knowledge whenever it is necessary to define or modify the historic contexts that govern CRM activities at a military installation. We believe that such critiques should be carried out on a periodic basis in order to assure as much as possible that ongoing research is meeting its goals. Indeed, in the absence of periodic critique, there is no way to determine the current value of particular cultural properties, which in turn means that there is no basis for determining how to manage them rationally.

Section 4.2 of this chapter is an extended discussion of the theoretical perspectives we propose to guide the research at Fort Hood. The perspectives delineated in section 4.2 establish a basic ecological direction for research at Fort Hood and outline specific theories of technology and adaptation to accompany the ecological approach. These theoretical perspectives diverge broadly from traditional approaches applied in Central Texas. They also differ at least in some details from other ecological approaches currently used in Central Texas and elsewhere. Although this section is directed primarily toward archeologists, it also has value for nonarcheologists. For the archeological reader, this section establishes the theoretical framework upon which is based the research design in Chapter 5.0. The theoretical discussions that typically accompany research designs for Central Texas (including many of our own) are short on detail and, as such, may fail to explicitly communicate the content of the general approach that is to be applied in research. The extended nature of the discussion in this section enables the archeological reader not only to evaluate our general approach in considerable detail, but also to determine whether the research design is capable of implementing our theoretical perspectives. For the nonarcheological reader, the discussion serves as an example of the effort and complexity that go into articulating the theoretical foundations of an archeological research program. The discussion therefore also serves as an illustration of the effort that goes into the articulation of the theoretical components of historic contexts.

4.1 CENTRAL TEXAS ARCHEOLOGY AND HOW IT GOT THAT WAY

This section of the chapter reviews the development of archeological knowledge in Central Texas. The review begins with an examination of the historical development of culture chronologies in Central Texas. It identifies major trends in the ongoing attempt to build culture chronologies, concentrating on isolating methodological features in order to disclose the relationships between goals and theory that have characterized research. The primary conclusion of this discussion is that the traditional culture-history focus in Central Texas has been largely unproductive with respect to achieving its goals, and that this focus is not facilitating research by archeologists who are more interested in problems of hunter-gatherer adaptation than in the histories of specific groups that inhabited Central Texas. The discussion then focuses on the burned rock midden problem as an area of inquiry within which developmental trends relevant to the conduct of archeological research in general in Central Texas are currently being discussed. This section then turns to a brief summary of Central Texas prehistory that highlights the gaps and conflicts which have emerged. The section concludes with a discussion of the poor state of development of archeology in the Fort Hood area in order to show that there currently are insufficient grounds for defining specific historic contexts at Fort Hood, and to demonstrate the need for a "back to basics" approach for Fort Hood.

4.1.1 Culture-Chronology Building in Central Texas

The delineation of, and debate over, cultural taxonomies applicable to Central Texas has been time consuming and often heated. The following will not attempt to summarize all of the various schemes presented for the region, but rather refers to historical and procedural aspects of regional syntheses and overviews developed by Suhm et al. (1954), Suhm (1960), Johnson (1967), Weir (1976), Jelks (1978), and Prewitt (1981, 1985). The discussion also focuses on critiques of chronology-building in Central Texas.

4.1.1.1 Initial Developments of Culture Chronology

The earliest attempts at cultural taxonomies were based primarily on data from informal multi-county surveys and limited excavations. Chronology-building consisted of noting cultural differences based on regional/areal variability of artifacts and features and on generalized hypotheses of subsistence practices. Even though some stratigraphic or "progressive" developments were incorporated into chronology-building, most of these early schemes (e.g., Pearce 1932; Ray 1929; Ray and Sayles 1941) had limited utility that led to their abandonment by the 1950s (Suhm 1960:76-79; cf. Hofman 1989:58).

Extensive archeological research took place in the 1930s, much of it under the University of Texas and WPA auspices, and continued in the late 1940s and 1950s after a hiatus during World War II (Guy 1990). The artifact assemblages from these extensive excavations, coupled with the acceptance of the Midwest taxonomic system, promoted research on cultural classification and chronology for Central Texas (Kelley 1947b; Jelks 1951; Suhm et al. 1954). Although this research proceeded largely without substantial contributions from deeply stratified sites or radiocarbon dates, progress was made in the delineation of temporal variation in artifact assemblages. In the late 1940s, Kelley (1947a, 1947b) proposed a chronological framework that would become the basis for subsequent developments in the 1950s (cf. Suhm 1960). By 1960, the regional sequence was recognized as consisting of five foci assigned to two aspects defined under Midwest taxonomic criteria (Black 1989:22). The Edwards Plateau Aspect represented the Archaic Period and consisted of the Uvalde, Round Rock, and Clear Fork foci. The post-Archaic materials were assigned to the Central Texas Aspect and consisted of the Austin and Toyah foci. Assemblage comparisons were often based on material differences (especially between projectile points). The excavations on which chronology was based, however, often suffered from a certain naiveté with respect to site formation processes (cf. Johnson 1967:8-10). Although many of these excavations targeted deeply stratified sites, few incorporated geomorphological or chronometrical studies which would establish the age or stability of land surfaces. As a result, archeologists frequently relied on analytical zones which bore little resemblance to culturally significant stratigraphic units so that the effects of palimpsest accumulation and assemblage mixing were largely ignored.

4.1.1.2 Culture Chronology in the 1960s and 1970s

Attempts were made to refine the Central Texas cultural sequence during the 1960s and 1970s (Black 1989:22-25; Guy 1990). The studies advanced on two fronts. Considerable reservoir studies in Central Texas and the Rio Grande Valley below the Pecos River focused on extracting assemblages from a series of deeply stratified terrace sites and rockshelters throughout the "crescent" that defines the escarpment around the edge of the Edwards Plateau from the northeast (above Waco) to the southern Pecos River area. Thus, the first advance consisted of the accumulation of a large data base for Central Texas (cf. Black 1989:35). In many cases, these investigations succeeded in sorting out relative chronological relationships between projectile point types (e.g., Jelks 1962) and identifying new projectile point types that could be associated with radiocarbon dates (e.g., Shafer 1963).

The second advance, represented by Johnson (1967) and Weir (1976), involved performing intersite assemblage comparisons on a regional basis (Black

1989:22). Johnson (1967:*iii*) attempted to establish a preliminary chronological framework which he hoped would serve eventually as a basis for identifying "culture units [that] should represent given groups of people" (1967:3). Broad regional research had brought to light strong (if also intuitive) projectile point similarities between sites along the Balcones Escarpment and sites along the Rio Grande River near the mouth of the Pecos River. However, Johnson (1967:10) also noted that the evidence was too sketchy to establish cultural phases according to widely accepted principles developed by Willey and Phillips (1958).

Johnson statistically ordered 20 regional assemblages from nine stratified sites to identify a series of six morphological tool clusters. The stratigraphic distributions of diagnostic projectile points served as a basis for defining cultural strata from which assemblages of associated tool forms were developed. Next, using 59 radiocarbon dates, he defined five loosely construed temporal periods (I-V) ordered around the central tendencies of dates associated with diagnostic points. Armed with a rough chronology and a set of cultural diagnostics that could be associated with other elements of the assemblages, Johnson then conducted a statistical analysis of assemblage-to-assemblage similarity indexes which he placed in an index-ordered matrix table. The temporal and spatial parameters of the matrix table were interpreted to indicate periods of assemblage similarity between Central and Southwest Texas. Since half of the tool clusters were restricted to sites in Southwest Texas, Johnson concluded that the two areas constitute separate and distinct archeological provinces with linked or shared tool assemblages during Periods I (8050-5950 B.C.), IV (A.D. 260-770), and V (A.D. 1030-1561).

Limitations of the study (which Johnson acknowledged at the time) included problems in defining the stratigraphic basis for assemblage definition, the use of thick stratigraphic zones to define gross assemblages, asymmetry in the frequency of radiocarbon dates from the periods in the two regions, and the method of using central tendencies to establish the ages of the tool clusters. Despite its shortcomings, the study served to identify strong relationships between the cultures of Central Texas and the Lower Pecos region, relationships which have continued to influence constructions of cultural sequences for Central Texas (e.g., Weir 1976; Prewitt 1981) at least to the extent that the Lower Pecos data base often provides many of the radiocarbon dates that figure into Central Texas chronology (cf. Turpin 1991). Furthermore, by characterizing his study as preliminary with respect to identifying groups of socioculturally related people, Johnson reinforced both an existing goal for Central Texas archeology and the influence of Willey and Phillips (1958) as a primary theoretical approach to the definition of culture-historical units.

Between 1967 and 1976, several attempts were made to improve culture chronology for Central Texas. An especially problematic issue was the transition from the Paleoindian to the Archaic stage. There was a general (but unformalized) understanding of temporal variation within the Paleoindian stage, and a general (but only slightly more formalized) understanding that the Archaic stage followed closely after. However, by the late 1960s, stratigraphic excavations (e.g., Shafer 1963; Sorrow et al. 1967) had recognized the existence of projectile points that were too early to qualify for the early portion of the Archaic stage, but too dissimilar to Paleoindian styles to qualify for the later portion of the Paleoindian stage (as these stages were then understood). By the early 1970s, enough of this early material had emerged to lead Sollberger and Hester (1972) to postulate the existence of a long-term "Pre-Archaic" transitional period between the end of the Paleoindian stage (ca. 6000 B.C.) and the emergence of a full-blown Archaic structure (ca. 3500 B.C.).

At approximately the same time (ca. 1973), Jelks (1978) worked on a chronological overview of what he called the Diablo Range, an area including not only Central Texas, but regions of approximately equivalent size surrounding Central Texas. As the basis for his chronology, Jelks grouped projectile points into chronologically sensitive "series" composed of morphological types that shared general technological traits (e.g., contracting stems). On the basis of the sequence of point series, he traced broad diachronic patterns of culture change throughout the Diablo Range. However, Jelks' scheme never got much attention in Central Texas archeology despite its novel approach (Prewitt 1981:66), probably because by the time Jelks' chronology appeared in print in 1978, Weir's (1976) dissertation had already provided a workable chronology that achieved more or less instantaneous application by Central Texas archeologists.

4.1.1.3 Weir's Chronology

Weir's (1976) dissertation, although it was restricted to the Archaic stage, marks a watershed event in the development of chronology in Central Texas archeology (cf. Black 1989:22). Unlike Johnson's (1967) study, which included a substantial amount of Lower Pecos materials, Weir used only artifacts from sites along the Balcones Escarpment between Waco and San Antonio. His sample consisted primarily of materials from 17 sites, of which "five were determined to contain one or more components that were structurally intact and which contained artifacts that were thought to be temporally associated" (Weir 1976:48). Using four types of sites (rockshelters, campsites, quarry sites, kill sites) 18 types of features, 21 diagnostic point types, 7 debitage types, 12 biface types, 12 uniface types, 5 core types, and 4 burin types, Weir characterized differences in assemblages among five temporal phases (Figure 4.1).

Although he recognized 50 point types, Weir regarded only 21 as culturally diagnostic since they were found at four or more of the sites in this study sample: these artifacts apparently formed the basis for assemblage assignment to five phases (*sensu lato* Willey and Phillips 1958) which roughly corresponded to already widely-accepted period designations within the Archaic. Since most tool forms occurred in multiple periods, changes in the Central Texas Archaic were documented by variations in the relative frequency of occurrences. The five temporal phases were chronometrically anchored using 46 radiocarbon dates, of which at least 35 were from the Lower Pecos region outside the study area. The five temporal phases are the San Geronimo phase (8,000-4,500 B.P.), the Clear Fork phase (5,000-4,000 B.P.), the Round Rock phase (4,200-2,600 B.P.), the San Marcos phase (2,800-1,800 B.P.), and the Twin Sisters phase (2,000-700 B.P.). Weir used correlation coefficient statistics on non-projectile-point artifacts to delineate patterns of tool associations, and statistical comparisons of assemblage diversity and intensity for the various phases to characterize temporal changes in tool assemblages. Thus, as a result of identifying distinct assemblages belonging to different time periods, Weir's phases (to the extent they were supported by data) replaced previous chronological periods with phases denoting specific temporally-bound cultural phenomena.

Weir's (1976) dissertation is also historically remarkable in Central Texas archeology because it coupled an explicit theoretical framework to its chronological-assemblage foundations and to climate- and population-based interpretations (cf. Peter et al. 1982:21.2). In laying out his course of action, Weir (1976:7) adopted elements of Birdsell's (1968) and Maruyama's (1963) systems theories as a framework within which he would interpret and explain periods of stability and change. This marked one of the few times in Central Texas archeology up to 1976 that a major effort at cultural chronology-building was explicitly accompanied by a discussion of the middle-range theory (cf. Kosso 1991) to be used to flesh out the significance of the results. (For notable exceptions, see Troike [1955] and Skinner [1971].) Within this framework, Weir noted general patterns of assemblage differences between phases and related them to general trends in paleoenvironmental and population conditions. Although his treatment of the causal relations between assemblages, climate, and demographics was impressionistic (cf. Prewitt 1985:216), his use of systems theory nonetheless allowed him to lay out an explicit, if also insufficiently documented, argument for the specific conditions that would account for stability and changes in cultural patterning over time.

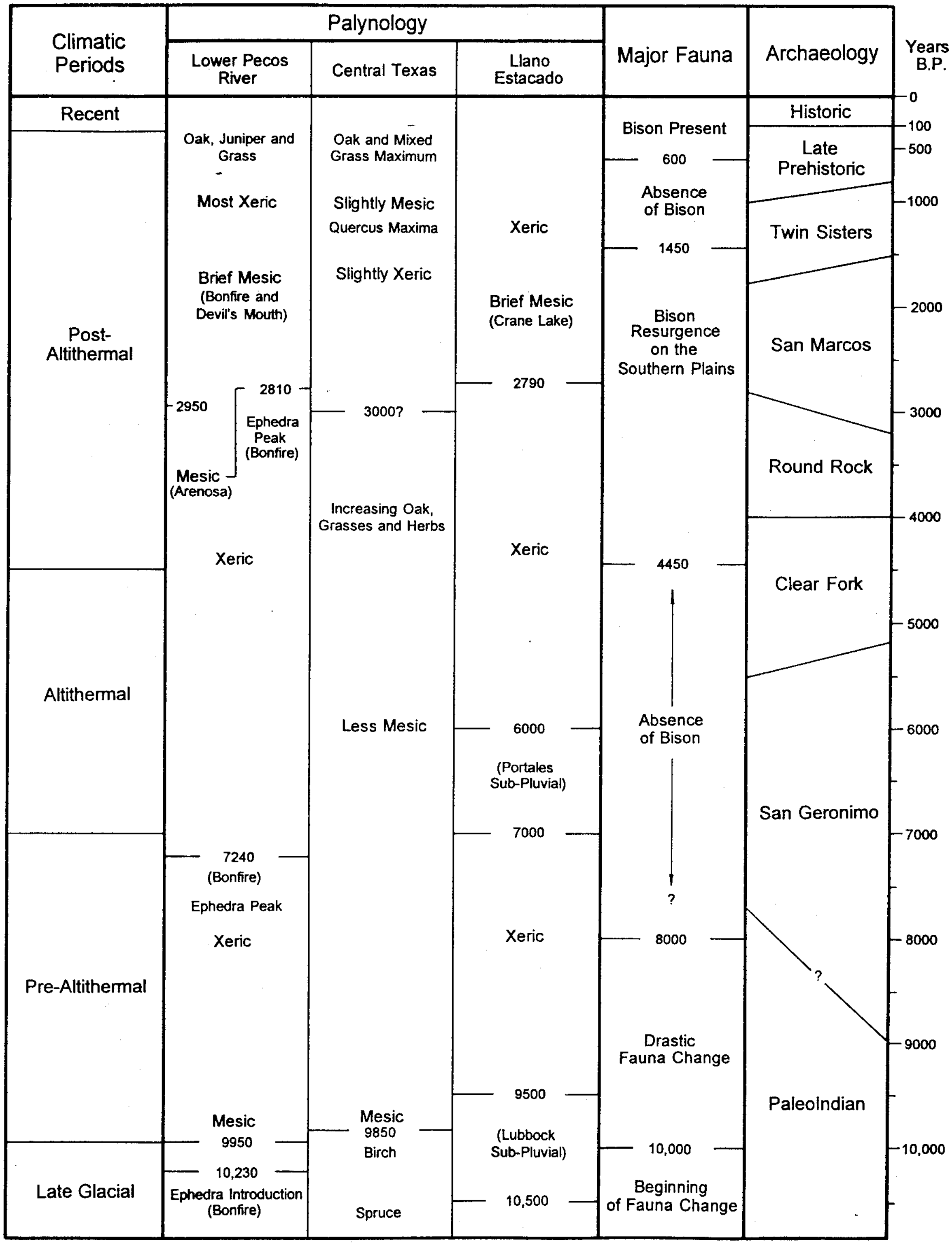


Figure 4.1 Weir's Chronology (after Weir 1976:28)

Significant problems with Weir's Central Texas Archaic sequence included: (1) the lack of any contextual (mixed or multicomponent) evaluation for mixed assemblages at the 17 sites (cf. Johnson 1987:8); (2) the absence of site-specific stratigraphic documentation to support the assemblage segregation for the postulated phase sequences (cf. Johnson 1987:7-8); (3) the predominant use of radiocarbon dates extrapolated from outside the study area (cf. Turpin 1991); and (4) an absence of basic data presentation that would enable other researchers to replicate his study and hence substantiate his conclusions (cf. Guderjan et al. 1980:26-27). Despite these problems, Weir (1976) "represent[ed] the state-of-the-art knowledge of the cultural stratigraphy of the Central Texas Archaic" (Guderjan et al. 1980:26), and established the basic temporal units that have underlaid Central Texas chronology ever since (Black 1989:22). However, by 1980, there was considerable controversy over how to interpret relationships between similar materials in different parts of the region (Henry et al. 1980).

4.1.1.4 Prewitt's Chronology

Prewitt (1981, 1985) has attempted to refine Central Texas cultural chronology. Prewitt's (1981:65) project was to produce a temporal sequence of cultures which would "provide a basis for the logical discussion and comparison of successive cultural manifestations in the Central Texas archaeological region." Within this larger project, Prewitt's major goal (1981:67) was to produce phases with finer temporal resolution than the relatively gross phases previously identified by Weir (1976).

In accordance with well established Central Texas practice, Prewitt (1981:68-70) adapted a chronology-building method that distinguishes (*per* Willey and Phillips [1958] and Krieger [1946, 1953]) between atemporal developmental stages and temporal divisions or phases within a given developmental stage. Thus, for Prewitt, the Paleoindian and Archaic stages denote very general kinds of adaptation, whereas phases identified for a given stage denote chronological periods during which a specific variant of a given developmental stage characterizes a particular region. Given the absence of Formative and "more developed" stages (*per* Willey and Phillips' [1958] evolutionary schema; cf. Story 1990:211), and given sparse information on Paleoindian stage cultures, Prewitt focused his chronology building efforts on the Archaic stage in Central Texas.

Relying on reports published between 1948 and 1980 and on some of his own unpublished manuscripts, Prewitt (1981) constructed his chronology on data from 39 sites in 18 counties in Central Texas. The resulting chronology (Figure 4.2) identified a series of 13 phases that represented distinct temporally-bound divisions of the Archaic stage in Central Texas. Prewitt (1981:Figure 4) provided a summary of key index markers (mostly projectile points,) which were diagnostic of their respective phases, and a brief description of the cultural and adaptive characteristics (1981:77-84) that corresponded with the index markers. Prewitt (1985), responding to criticism, published the radiocarbon dates for the original chronology, and added sites and dates to the chronology. The later paper both fine-tuned the original and offered an explanation for certain anomalies in Austin and Toyah phase radiocarbon dates. Unlike Jelks' (1978) attempt to synthesize Central Texas chronology, Prewitt's chronology was fairly widely used as a period structure within a short time of its appearance (Black 1989:24-25), although it has not gone without criticism as a culture chronology (Peter et al. 1982; Johnson 1987:23-24). Much of the criticism has focused on the issue of whether or not the chronology is anything more than a chronology of projectile points (cf. Peter et al. 1982:21.2).It is, therefore, worthwhile to critique Prewitt's chronology in some detail in order to see the his stated goals as a culture chronology. In fairness to Prewitt, we should note that we are not criticizing sense(s) in which it meets him in what follows. Because he had the courage to make a bold, high-profile proposal in 1981 and to follow it up in 1985 with enough data to allow for a public critique that has conveniently taken place, he has just as conveniently set the stage for raising interesting issues for the future of archeology in Central Texas. In other words, the critique below regards Prewitt as a representative of

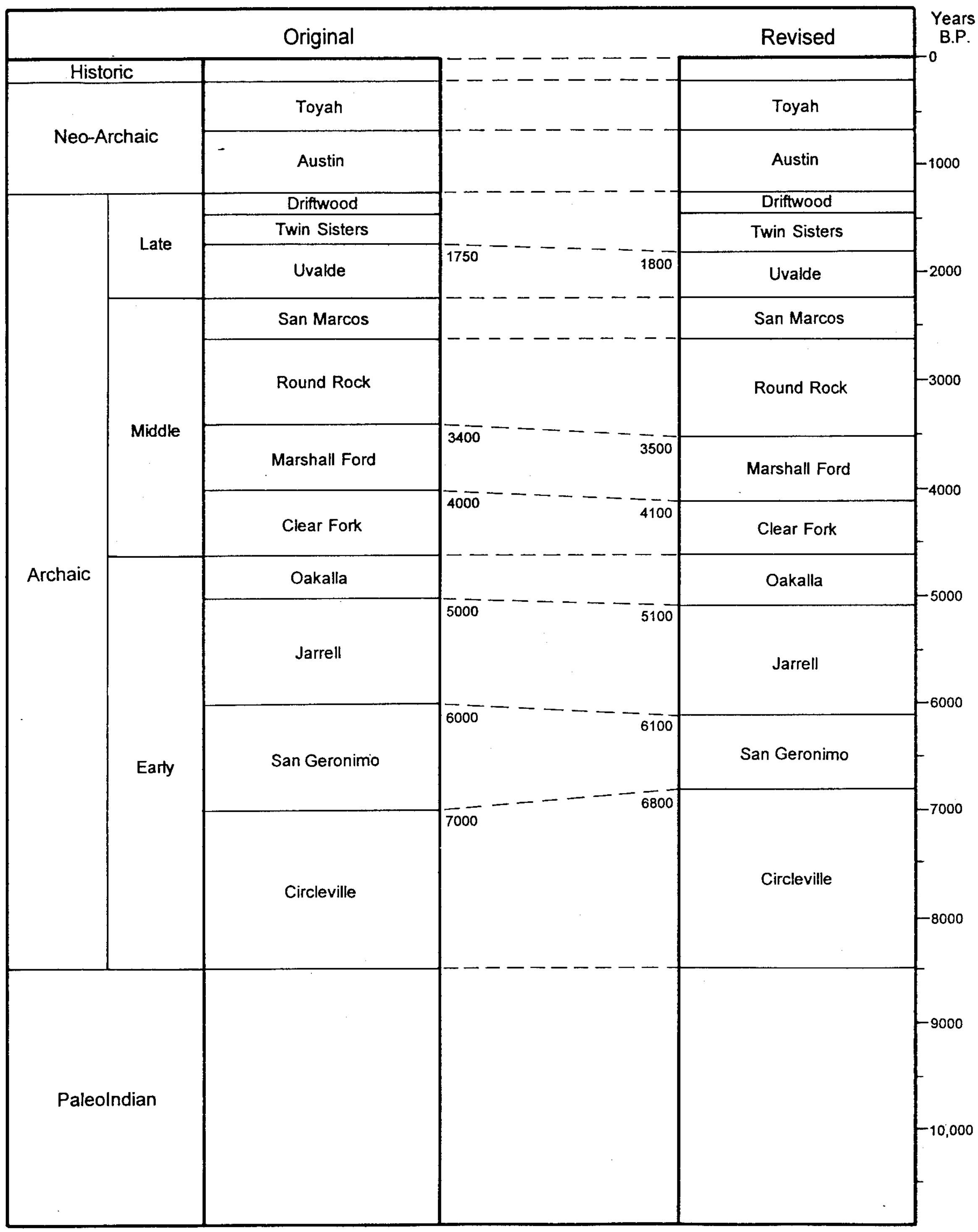


Figure 4.2 Prewitt's Original and Revised Chronology (Prewitt 1985:215).

broader trends in which most Texas archeologists (ourselves included) have participated.

4.1.1.5 The Nature of Prewitt's Chronology

Prewitt (1981:70) refers to his chronology as a description (the content of which is something to be explained in the Willey/Phillips progression from observation to description to explanation) and as a chronological "system of controls from which such explanations may be achieved." These suggestions seem to be at least partially mutually self-defeating in the following sense. If the cultural content represented by the phase descriptions is *both* the object of explanation *and* the set of controls which governs explanation, then it follows that the set of controls is also the object of explanation since the same thing (namely, the cultural content) occupies both positions in the scheme. Thus, although Prewitt (1981:70) is undoubtedly correct in asserting that "chronological control is merely a necessary step which is required before explanation is possible," the chronological controls themselves must be independent of the object to be explained in order to serve their function (cf. Peter et al. 1982:21.2; Dean 1978). This problem, however, probably is nothing more than a semantic one resulting from glossing over some material in order to address meatier problems in limited space. If so, it still remains to be seen whether Prewitt's proposed chronology is capable in its own terms of accomplishing its stated goal: providing a sequence of distinctive phases to serve as a basis for explanation of process. In other words, it remains to be seen just exactly what the chronology is a chronology of, and what range of problems the defined phases can serve as a basis for testing.

It is useful first to examine the nature of the phases described in the chronology in the terms available to Prewitt in 1981. If the chronology is more than a chronology of projectile points, phase boundaries should demarcate other differences in cultural phenomena. Table 4.1 is a list of the items (other than projectile points) Prewitt assigns to each phase to constitute the description of cultural units in his chronology. Each item in each description presumably represents a series of observations of the same phenomenon. The sum of observations in each time period constitutes a description of "a cultural manifestation" according to the phase-definition methods Prewitt (1981:68-70) adapts from Willey and Phillips (1958). The succession of cultural units represented by each description presumably constitutes the object to be explained, namely, a pattern of change of cultural manifestations for which reasons must be found to account for change from one manifestation to the next. However, it is difficult to see how Prewitt has accomplished his stated goal because it is difficult to see just exactly where any identifiable processual boundaries exist to justify distinguishing between phases. It is correspondingly difficult to see what there is that needs explaining. For example, consider site-location characteristics. On the basis of the kinds of places chosen, there are five different basic patterns if we assume that the references from which Prewitt has derived his data are representative of the Central Texas pattern. If the trait list is representative, then the changes in site-location criteria are something to be explained. Since site-location changes are highly likely to correspond to changes in adaptation because they represent major departures in land use, site-location could change along with other elements of an adaptive system. Using the pattern of site-location shifts in Table 4.1 as a phase-definition criterion would produce a chronology equivalent to phases comprised of:

- the Circleville phase (6550-5050 B.C.), with rockshelter, point-bar, bluff-top, and terrace sites;
- a combination of the San Geronimo, Jarrell, and Oakalla phases (5050-2650 B.C.), with terrace and bluff-top sites;
- the Clear Fork phase (2650-2050 B.C.), with terrace and upland sites;
- a combination of the Marshall Ford, Round Rock, San Marcos, and Uvalde phases (2050 B.C.-A.D. 200), with rockshelters, terrace, and upland sites; and

- the Twin Sisters through Toyah phases (200-1750 A.D.), with rockshelters and terrace sites.

To the extent that site-location criteria constitute a significant part of the cultural processes to which phase definitions refer as objects to be explained, then Prewitt's phases do not coincide very well with change in that aspect of cultural process. Note that to the extent site-location criteria are biased by a data base drawn largely from reservoir studies and/or by geomorphic change that has obscured large portions of the archeological record, it is likely that site-location is diachronically more homogenous than is apparent in Table 4.1. Thus, site-location criteria may fail even worse as an index of cultural manifestation because even greater phase-to-phase site-location homogeneity would produce even fewer phases, negating efforts to increase the resolution of the chronology.

The immediate and correct objection to this line of critique is that it is overly simplistic because there is much more to a phase than site-location criteria. However, the question emerges: What traits in Table 4.1 would allow for a better discrimination of cultural manifestations and, hence, for phase definitions that reflect distinct adaptations?

Another approach might be plant-processing equipment integrated into the overall adaptive strategy, but it does not work very well either. Grinding stones (which Prewitt invokes as evidence of plant processing) are present in all phases except the Oakalla (which Prewitt regards as the least well-defined phase because of sparse evidence), so phases cannot be discriminated on that basis. Burned rock middens (which Prewitt also invokes as evidence of plant processing) might serve as another basis, but the known temporal occurrence of middens (as of 1981) only allows for division into three phases: Circleville through Jarrell (6550-3050 B.C.), Oakalla through San Marcos (3050-300 B.C.), and Uvalde or Twin Sisters through Toyah (300 B.C. or A.D. 200 to A.D. 1750). Thus, burned rock middens could not be much of a basis for distinguishing phases in 1981, even if combined with grinding stones. Consequently, if there is a processual basis to the phase definitions, it must be elsewhere, perhaps along the lines of basic subsistence strategy.

If Prewitt's (1981) interpretation is correct, the pattern of change in basic subsistence strategy appears to be characterized by an early phase during which gathering was more important than hunting,a middle phase in which hunting and gathering were equally important, a late phase in which gathering again was more important, and a final phase (Toyah) which was more or less mysterious in 1981 because of the unique combination of a possible dependence on agriculture and one of three episodes of dependence on bison. If phase definition corresponds to major shifts in subsistence strategy, then depending on how one treats the episodic appearance of bison, there are either three phase changes if bison do not count (after or before Oakalla, after Round Rock, and after Austin) or seven phase changes if bison do count (after San Geronimo, after Jarrell, after or before Oakalla, after Round Rock, after San Marcos, after Uvalde, and after Austin). Thus, only if one is willing to take the appearance or disappearance of bison as an index of change in cultural manifestation does anything that remotely approximates Prewitt's chronology hold up as a basic chronology of diverse subsistence strategies. Of course, Prewitt may not intend the chronology to reflect *adaptively* diverse cultural manifestations.

There is reason to believe that an alternative intent underlies Prewitt's chronology. For example, he claims "that projectile points are indeed sensitive and reliable chronological indicators" (Prewitt 1981:65). This implies that a change in point style corresponds to a change of cultural manifestation. However, in most cases of phase-to-phase change, there is little obvious general change in adaptation that coincides with the introduction of new point styles. Thus, even though points may be sensitive, reliable chronological markers, they are not markers of particularly broad adaptive change. Indeed, Prewitt (1981:74) explicitly acknowledges the absence of significant adaptive change following the introduction of bows and arrow points in the NeoArchaic. Consequently, points must be markers of "cultural manifestations" that do not

Table 4.1 Basic Traits for Phase Descriptions Listed in Prewitt (1981). Shaded cells indicate presence.

		C	SG	J	O	CF	MF	RR	SM	U	TS	D	A	T
Site Locations	Rockshelter	X					X	X	X	X	X	X	X	X
	Point bar	X												
	Bluff top	X	X	X	X									
	Terrace	X	X	X	X	X	X	X	X	X	X	X	X	X
	Upland					X	X	X	X	X				
Tools	Clear Fork gouges	X	X	X	X	X					X		X	
	Guadalupe gouges		X											
	Perforators										X			
	Bifaces	X	X	X		X	X	X	X	X			X	
	Covington bifaces													X
	Four-bevel bifaces													X
	Hare bifaces											X		
	Friday bifaces												X	
	Unifaces						X	X	X	X	X	X	X	
	Strangulated bifaces					X								
	Drills	X												X
	Scrapers	X	X	X		X			X		X		X	
	End scrapers													X
	Gravers	X									X	X		
	Hammerstones	X		X									X	
	Lithic debris concentrations							X	X			X		
	Grooved stones (?)	X												
	Grinding stones	X	X	X		X	X	X	X	X	X	X	X	X
	Crushers										X			
	Bone awls	X										X	X	X
	Carved bones	X											X	
	Ulna flakers									X				X
	Marine shell ornaments								X				X	
	Freshwater shell pendants										X	X		
	Stone/marine shell gorgets										X			
	Boatstones										X			
	Bone beads											X	X	
	Painted pebbles												X	
Hearths	Arcuate										X			
	Large basin stone lined	X	?							?				
	Medium basin stone lined	X	?							?				
	Large basin										X		X	X
	Medium basin				X			X	X	?	X	X	X	X
	Small basin							X	X	?	X	X	X	X
	Large Flat			X	X				X	?				
	Clay/charcoal pits	X						X		?	X	X	X	X
Other	Burned rock middens				X	X	X	X	X					
	Atlatl	X	X	X	X	X	X	X	X	X	X	X		
	Bow												X	X
	Ceramics													X
Subsistence	Gathering > hunting	X	?	X	?				X	X	X	X	X	
	Gathering < hunting		?		?									?
	Hunting = gathering		?		?	X	X	X						?
	Agriculture													?
	Mussels	X	?	X	X		X	X	X	X	X			
	Bison				X					X				X

KEY: C = Circleville; SG = San Geronimo; J = Jarrell; O = Oakalla; CF = Clear Fork; MF = Marshall Ford; RR = Round Rock; SM = San Marcos; U = Uvalde; TS = Twin Sisters; D = Driftwood; A = Austin; T = Toyah refer directly to adaptation if they are to serve as markers for phase boundaries.

Prewitt hints at the alternative: he apparently believes that specific projectile point styles correspond to specific social (perhaps ethnic) groups so that each group is characterized by a particular style. For example, Prewitt claims that in the early phases of the Archaic stage and in the Uvalde phase, a "proliferation of projectile point styles suggests small dispersed bands which roamed over relatively large geographical areas" (Prewitt 1981:73; see p. 74 for the Uvalde reference). This implies an assumption on Prewitt's part that the presence of more than one style at a given time indicates the presence of more than one group at a time. If this is Prewitt's intent, then the importance of the failure of diagnostic points to coincide with adaptive change is negated by the appearance of shifts in stylistic communities which qualify under Prewitt's phase-definition criteria as distinct cultural manifestations by virtue of sharing distinct ways of making projectile points (and, in later phases, a few other stylistically distinct artifacts). To the extent that a one-style/one-group assumption underlies Prewitt's chronology, the assumption functions as a middle-range theory in terms of which the appearance of stylistically distinct points *must* be interpreted as the appearance of distinct groups whose members make points according to culturally transmitted norms shared by group members (cf. Kosso 1991; Binford and Sabloff 1982).

Thus, Prewitt's phases apparently refer not to the appearance of distinct adaptive modes in Central Texas, but rather to the appearance of distinct sociocultural groups. Prewitt's chronology, therefore, apparently is a construct of a hypothetical sequence of contemporaneous sociocultural groups for which the object of explanation must be presumed to be changes of sociocultural groups. In this case, then, the study of adaptation is subsidiary to the explanation of sociocultural change in the sense that if what one wishes to explain is spatial and temporal change in the composition of sociocultural groups inhabiting Central Texas, then adaptive shifts made by members of those groups may account at least partly for change in sociocultural composition. (This also would be the case if Prewitt's interpretation follows from a several-style/one-group assumption.) Furthermore, this approach avoids having the chronology be both the object and the controls of explanation because the content of the phase descriptions (namely, the technological and subsistence content) is not the object to be explained, but rather the chronologically controlled evidence that may prove to have explanatory significance relative to changes in the sociocultural groups proposed by the chronology.

Thus, a critique of Prewitt's chronology should focus on its value as an indicator of change in sociocultural groups because it is this sort of change that Prewitt apparently intends to represent. In other words, the value of Prewitt's chronology as something more than a chronology of projectile points is directly contingent on how well it identifies the presence or absence of groups at different times: to critique it on other grounds would be unfair because no classification should be criticized for not being able to perform functions it was not designed to perform (cf. Dunnell 1971).

4.1.1.6 Johnson's Critique

The most widely known criticism of Prewitt's chronology is Johnson's (1987; cf. Peter et al. 1982 for an early critique) evaluation of culture-chronology-building in Central Texas, among other areas of Texas. In addition to noting that there are a number of discrepancies between Prewitt's radiocarbon data and index markers (Johnson 1987:12-17; cf. Black 1989:23-24), Johnson (1987:8-12) raises more basic, theoretical issues of the chronology's status as a culture chronology.

Willey and Phillips (1958) has served as the procedural guide for chronology building in Central Texas. However, the Willey/Phillips approach establishes identities between archeological assemblages and specific groups of people presumed to be equivalent to the ethnic groups or emically-identified cultures documented by ethnographers (cf. Binford and Sabloff 1982). The approach establishes such identities under the assumption that artistic (or, at least, stylistic) themes generally are specific to sociocultural groups. Thus, according to Willey/Phillips procedures, an accurately defined phase represents a socioculturally integrated group of people who share an artistic or stylistic tradition by virtue of their sociocultural integration. A phase, therefore, is a representation of a single group of people who occupied a given geographic area for a given length of time. By extension, when building chronologies under Willey/Phillips procedures, "we are mainly building taxonomies--social taxonomies" (Johnson 1987:20)--that place a chronological sequence of particular societies within known spatial and temporal boundaries. Consequently, Johnson (1987) criticizes Prewitt for violating the Willey/Phillips procedures by establishing phases which refer not to single, identified sociocultural groups, but rather to contemporaneous *arrays* of sociocultural groups who occupy the same geographic area, each of which deserves to be characterized by its own specific phase designation. Johnson assails Weir's chronology (among others) along the same lines, and rejects it too as a culture chronology.

Johnson's critique, to be relevant and fair, must be predicated on three assumptions that Prewitt apparently shares: (1) identifying sociocultural groups and explaining what happened to them is an (if not the) appropriate object of archeology, (2) the Willey/Phillips method is an (if not the) appropriate way to identify sociocultural groups, and (3) different projectile point styles denote different sociocultural groups. Indeed, Johnson is fairly straightforward about these assumptions. Johnson's criticism that "Prewitt is dealing not with sociocultural groups, but rather with historical time periods" (Johnson 1987:11) would be no criticism at all if Johnson had not laid out the Willey/Phillips procedures under a section titled "The *Proper* Method of Recognizing Phases" (Johnson 1987:3, emphasis added). Furthermore, he finds it "incredible to ask us to believe that all those [different diagnostic Circleville dart points] were the residue of one society and worthy of being encompassed within a single phase" (Johnson 1987:11). Thus, Johnson's (1987) critique of Prewitt's and Weir's chronologies amounts to an "in-house" dispute among Central Texas archeologists whose primary goal is to identify sociocultural groups equivalent to the ethnic or self-identified groups studied by ethnographers, and whose primary middle-range theory for identifying such groups is the presence of stylistically unified artifacts or artifact assemblages. However, this is not the only legitimate approach to studying hunter-gatherers in Central Texas, as a second line of critique illustrates.

4.1.1.7 A Shift Away from Culture History

It follows from the foregoing discussion that if Prewitt's chronology is a hypothetical model of the succession of sociocultural groups, then the chronology itself is not a model of a succession of adaptations, despite the fact that each of the hypothetical groups certainly had one. Furthermore, by being more or less independent of adaptive change, Prewitt's chronology does not by extension address issues of whether one relatively localized subdivision of any sociocultural group in Central Texas had the same adaptation as other subdivisions (cf. Black and McGraw 1985:320-321; Peter et al. 1982:21.3). Consequently, to the extent that one is interested in explaining adaptive change rather than sociocultural change in Central Texas, the chronology does not demarcate a succession of appropriate units for which phase-to-phase change in adaptive process is the object to be explained. Hence, Prewitt's chronology obscures the possibility of addressing the issue of what sense it makes to talk about Central Texas prehistory if one's primary interest is understanding hunter-gatherer adaptations.

Since attempting to understand the nature of hunter-gatherer adaptive processes is a legitimate research aim, recognizing the limitation that Prewitt's chronology (and similarly motivated ones) places on research into the history of hunter-gatherer adaptation processes warrants abandoning it as a framework for cultural analysis. This limitation does not follow from some profound error on Prewitt's part, but rather from the apparent fact that Prewitt's (among others', e.g., Johnson's [1987]) theoretical assumptions and archeological interests focus primarily on the "who" and secondarily on the "how" of hunter-gatherer adaptation in Central Texas. Thus, the crucial issue with respect to Prewitt's chronology is not whether it is right or wrong, but whether even a perfectly refined version of it which overcomes Johnson's criticisms can serve research interests with different emphases. There is no reason to expect that a perfect Prewitt-like chronology will serve other interests because the relevance of classifications is perspective- and problem-dependent, and different research interests can expect to require their own classifications (Dunnell 1971). Indeed, it is not at all clear that culture chronologies are even necessary for some alternative approaches (cf. Johnson 1987:20). There are at least two reasons for bringing up the issue of the relevance of the concept of "Central Texas archeology."

The first reason is that if one has a sociocultural orientation like Prewitt's and Johnson's, then Central Texas culture chronology (construed along more or less strict Willey/Phillips lines) is not much further advanced in 1992 than it was 15 to 20 years ago because no sociocultural groups have been described successfully in terms that would qualify as phases (Black 1989:24). Furthermore, even if chronometric and contextual problems (such as those noted by Johnson [1987]) can be overcome to produce a very well dated sequence of cultural patterns, a "Central Texas" culture chronology that purports to reflect a meaningful culture area may frequently fail to identify appropriate spatial boundaries for phases. For example, if Prewitt (1985) is correct in postulating a wave-like, north-to-south introduction of Toyah phase people into Central Texas (a phenomenon for which Johnson [1990:485-486] finds some support), then much of what is relevant about the first several hundred years of Toyah culture may not be in Texas, let alone Central Texas. If so, then either a Central Texas Toyah phase deals with a cultural phenomenon in terms of a culturally meaningless boundary, or a Toyah phase defined in a Central Texas culture area violates culture-chronology procedure by violating the spatial criterion for phase definition. Still further, it is common to refer to Cabeza de Vaca's reports (and other Spanish colonial documents) when speculating about seasonal, long-distance aboriginal movements to take advantage of food resources. To the extent that such migrations occurred, then a chronology of Central Texas cultures could violate phase-definition procedure on spatial grounds for almost any time period. On the other hand, if Prewitt (1985) is correct about the timing of Toyah expansion (or, in the absence of extraregional integration, is it migration or acculturation?), then Cabeza de Vaca (and other Spaniards) may have encountered Native Americans in the throes of significant adaptive and/or sociocultural upheaval (Figure 4.3), in which case seasonal transhumance may have been a relatively recent development. Thus, even within a sociocultural orientation, the notion of Central Texas archeology may tend to obscure the fact that the distribution of groups at any given time is an empirical problem to be resolved by research in and out of Central Texas. Hence, even if sociocultural groups are the primary object of investigation, a focus on Central Texas chronology may easily hinder progress by leading archeologists to look for phenomena of interest in an area defined on arbitrary grounds perhaps bearing no relationship at all to sociocultural territories by virtue of a geographic focus that could be either too broad or too narrow. Just as Johnson (1967) has noted that natural stratigraphy is no a priori guarantor of temporal cultural association, neither are the Balcones Escarpment and Edwards Plateau a priori guarantors of spatial sociocultural associations. This is not to say that Prewitt's chronology is useless. However, it is to say that although Prewitt has produced a largely successful sequential and chronological ordering of certain artifacts, he has failed to provide a reliable index which places either specific groups of people or specific adaptive strategies in a spatiotemporal framework.

A second, related reason for raising the issue of what sense it makes to talk in terms of Central Texas archeology has already been alluded to, namely, the limitations that the notion "Central Texas archeology" places on studying adaptive processes in non-Willey/Phillips-like contexts, regardless of whether or

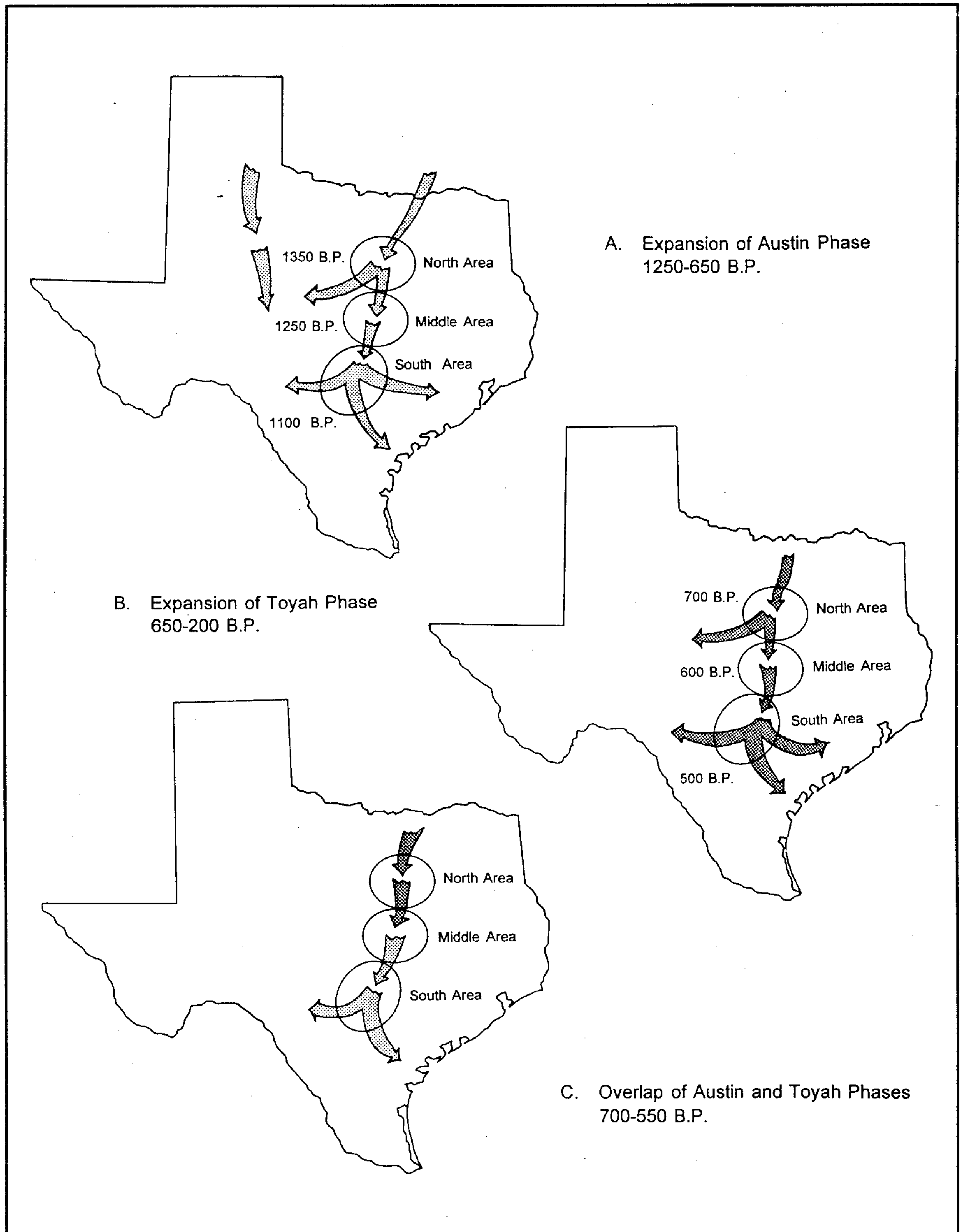


Figure 4.3 Prewitt's Model of Austin and Toyah Phase Expansion (Prewitt 1985:227) Cabeza de Vaca would have encountered South Texas Indians within several generations of initial Toyah developments in the South Area.

not any given adaptation is wholly contained within the Central Texas region. The environmental diversity of the Balcones Escarpment and Edwards Plateau has long been explicitly recognized by archeologists (e.g., Suhm 1960). However, with respect to this diversity, the term "Central Texas" can be systematically misleading when used to refer to adaptive processes at any given time, let alone from time to time (cf. Black and McGraw 1985:320-321; Peter et al. 1982:21.3). This follows from the fact that the term "Central Texas" is intrinsically typological and masks more information than it conveys. Hence, if one's goal is to study adaptive processes instead of sociocultural groups, to establish "Central Texas adaptation" as an object of inquiry is to establish an impressionistically-defined goal. The results of establishing this object can be readily appreciated by substituting "Central Texas adaptation" for "tool groups" and "adaptations" for "artifacts" in a passage from a provocative article by Johnson (1989:199): "[W]hen [Central Texas adaptation is] defined only impressionistically, the archaeologist's own folkish cultural background comes to the fore and causes him to imagine fairly discrete kinds of [adaptations] and to ignore much gradation between them simply because his folk semantics shields [sic] his eyes in blinders." Thus, to aspire toward a single model of Central Texas adaptation is to predispose oneself to look for large-scale uniformity that may or may not exist. Such a large-scale aspiration might impair an adaptation-oriented approach by obscuring the fact that the diversity or homogeneity of adaptive processes in Central Texas is an empirical issue to be resolved by research in and out of Central Texas (Black 1989:34).

A tendency toward large-scale interpretation historically has been an influential feature of Central Texas archeology. This trend may be at least partly a function of the culture-historical foundations of Central Texas archeology and may be reflected by Johnson (1987:20, emphasis added), who suggests, "It is at the point where we have (re)created phases that *truly interesting*, comparative studies of prehistoric societies begin." Indeed, it has been fairly rare for archeologists in Central Texas (and, in fact, almost everywhere else) to restrain themselves when it comes to drawing regional conclusions from limited data. For one example, regional cultural chronologies typically have been proposed without going through the basic step of identifying the spatial distribution of their constituent components (Black 1989:34-35; see, e.g., Sorrow et al. [1967:141], Peter and Hays [1982:19.5], and Black and McGraw [1985:321-323] for exceptions to the rule.) For another example, although it has only recently become routine to collect and analyze soil samples for floral subsistence data (Black 1989:33-34), the absence of such data has seldom prevented researchers (e.g., Prewitt 1981) from concluding that adaptation at any given time in Central Texas favored gathering over hunting or vice versa. Just as Johnson (1967, 1987) is undoubtedly correct in asserting that proper sociocultural phases can only be built from a series of tight, local associations at a number of locations, Peter and Hays (1982:21.3), Black and McGraw (1985:326), and Black (1989:34-36) are undoubtedly correct in asserting that knowledge of adaptation in Central Texas can only be built from a series of tight, local adaptive models that reveal the extent of adaptive variability across Central Texas in order to serve as a basis for identifying what, if any, characteristics, all Central Texas adaptations had in common at any given time (cf. Henry et al. 1980).

Perhaps ironically, Johnson provides an example of how to discover adaptive variability and integrate it into a larger-scale (if, perhaps, also unrestrained) framework. Following his own suggestions in Johnson (1989), Johnson (1990) attempted in his analysis of the Buckhollow site to avoid typological artifact descriptions in favor of technological descriptions that take account not only of morphology, but also of the specific procedures used to produce artifacts. For example, he examined arrow points that would normally be referred to simply as Perdiz points in terms of morphological metric variables (e.g., stem length), morphological nominal variables (e.g., stem shape), and procedural variables (e.g., whether the end with the original bulb of force was the stem or point end). Following his analyses of various artifact classes, Johnson compared the Buckhollow assemblage to other assemblages spread across a substantial area of Central Texas.

In his comparative analysis, Johnson appears at least partially to have abandoned the one-style/one-group approach to identifying social groups. In a comparison of the morphological and technological variability of Perdiz points from the Buckhollow, Hinojosa, and Las Haciendas sites, Johnson (1990:155-156) found strong statistical evidence that Perdiz points at these widely spread sites had different characteristics. Some of these differences were sufficient to lead Johnson (1990:501-502) to claim that they "betoken local ethnic styling," whereas other differences may follow from varying raw material availability. Regardless of whether Johnson has abandoned the one-style/one-group approach, it seems clear that he now regards sociocultural group composition as an empirical problem. Interestingly, he appears to believe that the empirical problem is to be resolved on the basis of adaptive and technological information rather than typological information, with typological constructs (including artifact types and phases) serving as linguistic conveniences that facilitate communication and initial analysis. Arguing largely from similarities and differences in subsistence remains, Johnson (1990:460) concluded that the Toyah diet had broad regional similarities, but was modified at the local level to suit local geographic and seasonal resource availability. This conclusion, whether correct or not, is an example of describing regional trends in terms of local variability. Arguing largely from local variation in ceramic and lithic tool evidence, Johnson (1990:471) concluded that individual Toyah communities did not range across wide geographic areas. This conclusion, whether correct or not, is an example of attempting to identify social groups on the basis of regional distributions of locally variable technologies. Thus, Johnson appears to be arguing *from* (1) the existence of relatively localized patterns of artifacts, ways of making artifacts, and subsistence resources *to* (2) the existence of local communities of people (3) whose coherence as communities can be inferred from the comparative distinctiveness of decision-making structures reflected by distinctive artifact patterns and (4) whose membership in a common adaptive tradition is reflected by commonalities of technological and adaptive structures at a regional level.

Consequently, it appears that Johnson's conclusions follow not from a one-style/one-group middle-range theory, but rather from a middle-range theory that attributes localized similarities of technologies and adaptive decisions to localized social structures within which technological and other information is transmitted from person to person and generation to generation. Such an approach would be consistent with the definition of culture Johnson (1990:409) invokes, a definition that includes knowledge and preferences that may have been either "universally or partly shared by Toyah societies." If this is his approach, then Johnson has reversed the traditional descriptive/explanatory relationship between s ociocultural groups and adaptive processes by making the description of technologies and adaptive structures the primary object of inquiry, and then identifying the composition of sociocultural groups as a factor that might account for regional variation in adaptive processes at any given. Note, however, that identifying local communities and broader adaptive traditions is not the same thing as identifying ethnic groups unless one employs a middle-range theory that implies it. Thus, regardless of whether or not one accepts Johnson's specific conclusions, he has demonstrated that fine-grained description of assemblages drawn from even modestly tight contexts provides a basis for constructing interesting and provocative models of adaptive variability, including the possibility of identifying localized communities whose members (irrespective of ethnicity) employed distinctive means for adapting to their environment. Furthermore, even if it is not his intent to focus on adaptive process as the primary object of interest, Johnson nonetheless has demonstrated that comparative studies of the local details of adaptive processes are what enable the archeologist to draw regional conclusions, and that relying on typological constructs of artifacts and phases as primary definitional criteria can easily hinder the observation of adaptively significant variability.

4.1.1.8 Summary

In summary, this survey of attempts to build Central Texas culture chronologies shows that research oriented toward defining cultural phases has been largely unproductive with respect to meeting more or less strictly construed Willey/Phillips-like goals. The Paleoindian phenomenon in Central Texas remains little more than an internally poorly differentiated stage, largely as a result of limited contextual data that would permit nonspeculative assessment of social and adaptive characteristics (Black 1989:25; Story 1990:177). Understanding of the Archaic stage is characterized by significant disagreement over which culture chronology and terminology to apply and by substantial gaps in understanding of the details and general characteristics of adaptive strategies (Black 1989:25-32). Although there is wide agreement about the timing and nature of Austin and Toyah phase phenomena, there is substantial research to be pursued vis à vis their origins and relationships to people in neighboring geographic areas and a possible role for agriculture in Toyah subsistence. Furthermore, links between Toyah and historic Native American groups remain mysterious (Black 1989:32-33).

Even if research has largely failed to reach its goal of defining a succession of well-defined phases, it has nonetheless been modestly successful at identifying chronological periods within which there are certain commonly occurring artifacts and site features. These chronological periods, however, have not been demonstrated to have any particular relevance to addressing problems of hunter-gatherer adaptive processes, which suggests that an alternative approach is necessary (Black et al 1989:34-38, 1992). This is not to suggest that the traditional culture-history focus in Central Texas archeology is illegitimate: its legitimacy is well attested to by the fact that several generations of archeologists have found it worth pursuing. However, it is to suggest that pursuing the history of adaptive processes is not being well-served by the traditional focus. The history of the nature of adaptive processes employed by people in Central Texas is as legitimate a goal as the history of sociocultural groups: the fact that studying adaptive process is a different pursuit than studying culture history means only that some researchers have different goals from others, and it can be no less legitimate to want to understand the nature of human adaptation than it can be to want to understand the history of who has been in Central Texas. This being the case, archeology in Central Texas currently is in a position where many researchers have taken an interest in problems that cannot be solved by traditional methods. Hence, "Central Texas" archeology is ripe for research designs that diverge from the historical norm regardless of whether or not one's primary interest is adaptive process or culture-history.

4.1.2 The Burned Rock Midden Problem in Central Texas

Burned rock middens are large masses of rock (usually limestone) that have been altered by heat. They vary greatly in size from several meters across to more than a hectare (Suhm 1960:68), and they occur in several distinctive forms (Weir 1976). Burned rock middens have been a major focus of interest in Central Texas archeology because they occur widely across the region as a feature that contrasts Central Texas with most of the rest of the state. Burned rock middens have been noted in Central Texas since 1847 (Hester 1991:*v*). Although more than 200 have been excavated by archeologists (Prewitt 1991:25; Howard 1991), fairly little of the specifics of their function is actually known (cf. Collins 1991:17; Black et al. 1992:26). Furthermore, although there is wide agreement that burned rock middens are adaptively significant, there is wide disagreement about the nature of that significance. The burned rock midden problem, therefore, is a major one in Central Texas archeology because 70 years of research have produced relatively few concrete results (Black 1989:35; Collins 1991:1; Black et al. 1992:26). Since many of the sites that figure into current understandings of Central Texas chronology and adaptation are in fact burned rock midden sites, the burned rock midden problem is a special case of more general problems that face Central Texas archeology. This section summarizes changing perceptions of the burned rock midden phenomenon and characterizes certain new directions that have emerged with respect to analyzing them.

4.1.2.1 Early Perceptions of the Burned Rock Midden Phenomenon

By 1941, at least 58 burned rock middens had been excavated, mostly by researchers affiliated with the University of Texas (Prewitt 1991:26-27). By that time, several hypotheses with varying levels of specificity had emerged to account for the large masses of burned rock. Pearce (1919) characterized them as "kitchen middens" composed of refuse that gradually accumulated as a result of cooking activities centered around a single fire, a general characterization that was maintained by Huskey (1935; cf. Collins 1991:3; Prewitt 1991:28; Black et al. 1992:19). Pearce and Huskey both recognized two kinds of middens (Black et al. 1992:19; Goode 1991:71-72), and both emphasized meat as the resource associated with burned rock middens (Prewitt 1991:28). Wilson (1930) suggested that because sotol occurred within the range of burned rock middens and Lipan Apaches used rock-and-earth ovens to prepare sotol, burned rock middens resulted from using earth ovens to cook sotol (cf. Collins 1991:4; Howard 1991:62). Kelley (1940) proposed that burned rock middens formed as repeated construction of hearths in the same place over long intervals led to the disturbance of previous hearths (Howard 1991:62). The Pearce, Huskey, and Kelley proposals imply that burned rock middens accumulated gradually, but it is not clear whether Wilson's proposal favors rapid or gradual formation.

4.1.2.2 Recent Perceptions of the Burned Rock Midden Phenomenon

Elements of early perceptions have remained part of subsequent developments in burned rock midden research, especially with respect to their function, form, and formation. Controversy over the primary resource associated with burned rock middens has involved renewed claims that they were earth ovens used to cook meat (Skinner 1974) or sotol (Prewitt n.d.; Goode 1991). An alternative claim that they were used to process acorns (Hester 1973; Weir 1976; Creel 1986) has been introduced. Creel (1986, 1991) examined the distribution of oak trees and burned rock middens in a large area of Central Texas, and found that the distributions were too similar to be a random outcome, despite the fact that a large number of middens in the Concho River Valley were outside the distribution of oak. Creel (1991) suggested that the soils and geology of the Concho Valley once may have supported oak forest that has since been eliminated by relatively recent drought. He further postulated that much of the rock in middens was burned in the course of stone-boiling to remove tannins from acorns. Using a similar inferential procedure, Prewitt (n.d.) and Goode (1991) have postulated that the distribution of middens coincides with the prehistoric range of sotol, and that wetter prehistoric conditions drove the range of sotol west. Howard (1991; cf. Peter 1982), however, noted that both the acorn and sotol hypotheses are weak because there is far too little ethnobotanical data to substantiate them. Peter (1982) noted that ethnobotanical data from the San Gabriel River area supported the notion that burned rock middens in that area were associated with acorn use, but that the middens represent relatively diverse resource consumption. He further suggested that roasting rather than stone-boiling accounted for most of the burned rock.

Considerations of form have continued to involve several kinds of midden. Greer (1965) proposed a classification that included six or seven kinds of annular middens (Prewitt 1991:25). Weir (1976) identified four types that include domed, annular, crescent, and sheet middens. Prewitt (1991:25), on the other hand, appears to recognize only the domed form and an annular form that includes Weir's crescent middens. Regardless of how many types are recognized, however, most researchers accept that annular middens generally are more frequent in the western part of Central Texas, whereas domed ones are more frequent in the eastern part (Creel 1986, 1991; Goode 1991; Prewitt 1991; Johnson 1990). Annular middens are also known to extend well into northern Mexico (Collins 1991:2). The distributions of the two basic forms overlap, although some believe (e.g., Creel

1991; Black et al. 1992) that the distributions are not distinctly different, whereas others (e.g., Prewitt 1991) believe they are. Furthermore, there is disagreement about the temporal distribution of burned rock middens. Although they were long considered to be a largely Middle Archaic phenomenon, there is growing evidence that they may have occurred both earlier and later (Treece 1992; Goode 1991; Black et al. 1992), although Prewitt (1991) discounts the frequency of earlier and later middens.

Consideration of formation has continued to include an emphasis on gradual accretion (Howard 1991; Peter 1982), although Kelley's intersecting-hearth hypothesis has largely displaced earlier accretional hypotheses (Black et al. 1992). However, two additional competing hypotheses have emerged. One, the dump hypothesis, proposes that middens accreted through a process of communal dumping of refuse (Sorrow 1969; Hester 1970). Another hypothesis, which may be loosely referred to as the aggregated-group hypothesis, suggests that at least some middens may have been formed over very short periods of time as seasonally aggregated groups processed a substantial amount of food (Collins 1973). This hypothesis involves a claim that middens easily could have been characterized by episodic rather than accretional formation.

In summary, then, very little agreement has emerged after 70 years of burned rock midden research. This has created a basic problem in burned rock midden research, a problem that deserves extended discussion before proposed solutions are presented.

4.1.2.3 Recognition of the Basic Problem in Burned Rock Midden Research

There is growing (if often implicit) recognition that part of the burned rock midden problem has grown from typological roots, although other factors also intervene. For example, annular and domed middens frequently occur at the same sites (Creel 1986:96). If they are roughly contemporary, then their co-occurrence is anomalous for hypotheses that involve functional specialization if form is a major part of the basis for inferring function. However, several researchers have noted that neither the form of middens (Collins 1991:5; Prewitt 1991:29) nor the form of hearths associated with middens (Howard 1991:62) have proven to be particularly productive variables from which to infer function: in other words, a focus on midden and hearth types apparently obscures the recognition of other data that would provide a resolution of the burned rock midden problem. Recognizing this feature of burned rock midden research, Hester (1991:*vi*) notes that the notion of a "burned rock midden problem" may itself be misplaced: "as there are many kinds of burned rock middens . . ., this variability in itself needs better definition." Thus, even the notion of a burned rock midden is questionable because there are many dimensions of variability among the masses of burned rock, and conceiving of them under a common rubric may be systematically misleading until much more is known about them beyond their formal, typological similarities.

Indeed, the problematic typological foundation of the burned rock midden problem is implicit in the more or less typological ways that researchers discuss which of the various hypotheses is (are) supported by their data. For example, Peter (1982:20.2-20.4) concludes that burned rock evidence in the North Fork and Granger Reservoir Districts supports the intersecting-hearth hypothesis (Kelley 1940; Kelley and Campbell 1942) rather than the dump hypothesis (Sorrow 1969; Hester 1971) or the aggregated-group hypothesis (Collins 1973). Interestingly, one of the sites on which the dump hypothesis is based (the John Ischy site [Sorrow 1969]) is in the study area. However, instead of regarding it as part of a range of variability, Peter (1982:20.4, emphasis added) regards it as "an *anomaly* among the burned rock midden sites of the North Fork drainage." For another example, Goode (1991:89-90) notes that an eastward decrease in frequency of annular burned rock middens corresponds with a plausible eastward limit for the prehistoric distribution of sotol. Although he is open to the possibility of an association with acorns, Goode (1991:91, emphasis added) nonetheless expects that patterning of Late Prehistoric middens will be resource-specific: "among the most plausible explanations for [patterning] would be one involving *a natural resource* such as sotol." Goode, therefore, appears to expect that within a given portion and/or period of the Central Texas sequence, a one-resource hypothesis will account for the distribution of morphological forms of middens. However, the fact that there is support of some kind for virtually any combination of accretional-/episodic-formation hypotheses and acorn-/sotol-/multiple-resource-exploitation hypotheses strongly implies that expectations of broad empirical generalizations may never be met because the burned rock phenomenon may result from a broad array of human activities (Collins 1991:3). Therefore, the notion of a burned rock "midden" (or a series of types thereof) as a typological construct historically may have been systematically misleading in the sense that not only has it obscured variability over wide temporal and spatial contexts, it also may have led to the postulation of insufficiently fine-grained explanations for a correspondingly grossly conceived phenomenon (cf. Collins 1991:5-6).

In other words, Central Texas archeologists have inherited a research problem that historically has been defined in the broadest of typological terms, and they have responded at an appropriate level of "either/or" simplicity that reflects the conceptual generality of the object to be explored. Confusions resulting from the typological roots of the burned rock midden problem appear in subtle ways. For example, the notion of a burned rock midden as a kind of phenomenon is typologically problematic for researchers who favor the intersecting-hearth hypothesis. Kelley (1940) originally proposed the model on the basis of observing stratigraphically discrete hearths that he thought would have made a midden in a more stable geomorphic context. Johnson (1991) and Collins et al. (1990) have recently reported rock hearths in discrete Early Archaic contexts. For proponents of the intersecting-hearth hypothesis (e.g., Howard 1991; Peter 1982), the only difference between these hearths and an intersecting-hearth midden may be that the midden typically is larger and more disturbed as a function of palimpsest activities (cf. Black et al. 1992:8). If so, the major differences between them would be a matter of geomorphic context, tempo of land use (cf. Binford 1981b), scheduling and patterning of land use, and other nonformal properties of site formation, and not a matter of differences in kind. In this case, accuracy would require referring either to the discrete hearths as "incipient middens," or to the middens as "palimpsest hearths."

A parallel confusion emerges for proponents of the dump hypothesis (e.g., Sorrow 1969; Hester 1971) when they attempt to discuss the function of burned rock middens. If middens are communal dumps, then in an accurate interpretation of "midden function," there is very little to describe or explain because the description itself captures virtually all there is to know about middens: they function as dumps that receive the debris from activities taking place elsewhere. To concentrate on midden function in such cases is to run the risk of missing the point that most of the interesting functions have very little to do with the midden itself. Thus, "burned rock midden" as a typological construct may be systematically misleading because it may direct archeologists' attention toward formal properties of a kind of large artifact when it should be directed toward contextual and behavioral processes that produced the artifact (cf. Collins 1991:15-16). Merely drawing an explicit conceptual difference between palimpsest hearths and dump middens, if both exist, goes a long way toward focusing attention on different analytical and explanatory problems that are otherwise difficult to perceive, let alone to solve (cf. Collins 1991:5-6). If the burned rock midden problem has been intractable, therefore, it may be because it is too much to expect that archeologists would find detailed answers to general questions framed on conceptually and semantically vague typological bases (cf. Johnson 1989).

Furthermore, it would be too much to expect that archeologists find detailed answers in an environment where other traditional emphases have not lent themselves to acquisition of appropriate data. One traditional emphasis--chronology building--frequently has led to selecting sites for excavation on the basis of their potential to yield large numbers of projectile points with temporally-diagnostic value (Black et al.

1992:29; cf. Peter 1982:20.4). Since sites yielding large diagnostic collections are likely to be on a surface that was stable or very slowly aggrading for extended periods of time, pursuit of chronology-building goals simultaneously and inadvertently may have produced a data base with the worst possible contextual characteristics vis à vis the possibility of identifying the processes that led to formation of burned rock middens (cf. Collins et al. 1990:90; Black et al. 1992:26; Peter 1982:20.4). Moreover, until recently, excavations traditionally have focused only on the middens, resulting in very limited data on which to base judgments about the place of burned rock middens among activities other than those leading directly to the formation of the middens themselves. Thus, for many of the burned rock middens that have been excavated, there is no complementary site data that would help place the middens in a behavioral or adaptive context (Collins 1991:15-17; Black et al. 1992:17-18).

It is also possible that traditional excavation procedures combine with the historical focus on large, highly visible burned rock middens to produce another, possibly very limiting conceptual constraint to the resolution of the burned rock midden problem. Traditionally, Central Texas archeologists excavate sites in arbitrary levels in small, vertical excavation units, primarily because natural levels are difficult to detect in burned rock middens and vertical units are conducive toward acquisition of data for chronology building (cf. Howard 1991; Black 1989:36). However, the preponderant use of vertically excavated arbitrary levels independent of natural stratigraphy guarantees that the maximum possible amount of mixing of cultural materials will occur in sites (Black et al. 1992:28; Johnson 1990:16-17, 1987:7), and the most frequent excavation strategies used on burned rock middens appear to minimize the number of hearths that can be found (Howard 1991:54-57). Typical excavation strategies traditionally implemented on large palimpsest middens, therefore, appear not only to follow from cumulative experience that natural levels are hard to detect in middens, but also to reinforce the use of techniques that will not find natural levels in the cases where they happen to exist, thereby reinforcing the cumulative expectation that excavating in natural levels is not worthwhile (Black et al. 1992:28). To the extent that this has occurred, it is unfortunate. Howard's (1991) recent survey of files at the Texas Archeological Research Laboratory (TARL) shows that there is reason to be somewhat optimistic about finding burned rock middens in fairly rapidly aggrading contexts, and that horizontal stripping is likely to be an effective technique for discovering features within palimpsest middens (cf. Black et al. 1992:7-8). Horizontal stripping procedures at Hop Hill (Gunn and Mahula 1977) yielded data from fairly highly discrete contexts in palimpsest deposits. Recent reports by Johnson (1990) and Collins et al. (1990) suggest that adaptation of horizontal stripping techniques to relatively ephemeral sites results in acquisition of highly interpretable data bases. It therefore appears that rethinking the way burned rock middens are excavated would be a major advance in burned rock midden research.

Rethinking burned rock midden research is crucial to Central Texas archeology. If such research to date is correctly regarded as very poorly advanced (Collins 1991; Prewitt 1991; Black et al. 1992; Black 1989), then by extension, much of Central Texas archeology is correspondingly poorly advanced because burned rock middens comprise much of the data base on which extant culture chronologies and adaptive models are based. However, to note that burned rock middens comprise much of the data base can both overestimate the quantity of hard data and underestimate the influence of a small number of reports on which much of Central Texas prehistory is based. To illustrate, Howard (1991:Table 1) notes that there are on file at TARL reports and other documentation on 225 burned rock middens excavated between 1918 and 1987. Of these, at least 73 (32%) have never been described in publication and, therefore, have not been widely available to play a public role in the resolution of the burned rock midden problem, although undoubtedly they have played a role in shaping their excavators' beliefs. Of those that have been described in print, only a small handful have figured into the historically important synthetic works (e.g., Weir 1976; Prewitt 1981, 1985) that in turn have served as the points of departure for recent discussions of Central Texas archeology at the local level (e.g., Black and McGraw 1985), the areal level (e.g., Hays 1982), and the regional level (e.g., Black 1989). In other words, the same limited data base that has failed to provide anything more than a vague understanding of the burned rock midden phenomenon is a major component of the effective data base for much of Central Texas prehistory as a whole. Thus, solution of the burned rock midden problem is central to understanding Central Texas prehistory in general because successfully understanding the behavioral and functional variability that makes burned rock middens interesting will by default shed a great deal of light on the nature of adaptation to the Central Texas environment.

4.1.3 Summary of Knowledge of Central Texas Prehistory

Given the foregoing discussion, it is perhaps self-contradictory to summarize the current state of knowledge of Central Texas prehistory. However, a brief survey can serve as a means for showing the gaps and conflicts that exist in our knowledge of adaptation. The following, therefore, offers a short description of what is known about each period of Central Texas prehistory.

4.1.3.1 The Paleoindian Period

The Paleoindian period (ca. 9200-6000 B.C.) in Central Texas is very poorly understood in terms of data acquired in Central Texas proper. Substantial numbers of Paleoindian projectile points have been found by surface survey (Hays and McCormick 1982:4.2). Unfortunately, few intact Paleoindian components have been recovered from relatively secure contexts in Central Texas (Black 1989:25) unless the Lower Pecos area (*per* Johnson 1991) is included in the definition of Central Texas (cf. Bement [1989:72-73] for a Lower Pecos overview). Consequently, subsistence data, settlement data, and reliable dates for the Paleoindian period can only be extrapolated for most of Central Texas from the Lower Pecos area and the Great Plains (cf. Hofman 1989), although recent excavations at the Wilson-Leonard site near Austin hold some promise for adding a major body of information (cf. Black 1989:25). Interestingly, Bement (1989:72-73) places a Paleoindian-to-Archaic transition in the Lower Pecos at approximately the date that Black (1989), extrapolating from the Plains, places the beginning of the Paleoindian period in Central Texas. Bement also places an Archaic adaptation in the Lower Pecos at the same time as Black's Paleoindian period in Central Texas, largely on the basis of claims that an Archaic adaptation had begun in the Lower Pecos area by approximately 9000 B. C. Given that the Paleoindian period is effectively unknown for Central Texas, the discrepancies between Bement's and Black's accounts are not surprising and serve to highlight our virtually complete ignorance of the Central Texas Paleoindian period and, hence, to highlight the importance of all Paleoindian research issues (cf. Black 1989:37). Furthermore, given that the definitional distinction between Paleoindian and Archaic adaptations revolves around the presumed large-game focus of Paleoindians, a specific focus Paleoindian research at Fort Hood should be to identify the role of small game and floral resources in subsistence in order to determine the extent to which a definitional distinction based on the role of big-game hunting is warranted (cf. Hofman 1989:45).

4.1.3.2 The Early Archaic Period

The Early Archaic period (ca. 6000-3000 B.C.) is not much better known than the Paleoindian period, although what data there is appears to show that the Early Archaic in Central Texas is similar in many respects to other areas (Black 1989:25-26). Although Weir (1976) and Prewitt (1985) have suggested that the period was characterized by low population density and very high mobility, the fact that the data base in Central Texas is fairly small and that many of the components on which analyses are based are drawn from below palimpsest middens suggests that there may not be a nonspeculative basis for these claims. Recent reports by Johnson (1991) and Collins et al. (1990) have produced interesting data (including residues on tools and burned rock in Collins et al. [1990]) that greatly improve our knowledge of what discrete Early Archaic sites look like. However, these reports do not add enough new information to the data base to flesh out regional patterns and variation because of the overall scarcity of comparably detailed information. Knowledge of Early Archaic adaptation, therefore, remains largely hypothetical and uncorroborated until much more data is forthcoming in all Early Archaic research issues (cf. Black 1989). Given that there are significant differences between the onset of the Archaic in Central Texas and the Lower Pecos, and given that the traditionally accepted definitional difference between the two is based on adaptive and, hence, subsistence patterns, accumulating more Early Archaic subsistence data is crucial. Dating Early Archaic assemblages remains a high priority given that Early Archaic chronology is based on a very small number of reliable dates (cf. Johnson 1991).

4.1.3.3 The Middle Archaic Period

The Middle Archaic (ca. 3000-1000 B.C.) is much better known than earlier periods, largely as a function of extensive excavations in burned rock middens. Consequently, our knowledge of Middle Archaic adaptation is only as sound as our knowledge of burned rock middens. Although rockshelter sites have produced a few comparatively excellent data bases for subsistence activities and other aspects of Middle Archaic adaptations (cf. Black 1989), they offer a relatively restricted view of adaptation in light of limitations on our knowledge of open air sites (cf. Story 1990:363-364).

The appearance of large numbers of burned rock middens in the Middle Archaic points strongly toward a shift in subsistence strategy (Weir 1976; Prewitt 1981; Creel 1986), but the nature of the shift and its relative uniformity across the region will remain largely speculative until much more subsistence data is forthcoming (Howard 1991). Furthermore, the nature of settlement patterns and social organization are largely unknown (Black 1989). Interestingly, data is emerging to show that there may be considerable variation in Middle Archaic adaptations (cf. Black and McGraw 1985; Peter et al. 1982), which in itself is valuable to know even if it does no more than point toward alternative Middle Archaic research programs. Given the likelihood of substantial regional variability, a primary data requirement is documentation of local Middle Archaic adaptations in geographically limited areas (as in Hays 1982). Dating Middle Archaic assemblages remains a high priority because extant chronologies are controvertible and based on relatively few dates, and because identifying adaptive patterns on local and areal levels requires fine-grained chronometric data whenever possible (Black 1989).

4.1.3.4 The Late Archaic Period

The Late Archaic period (ca. 1000 B.C.-A.D. 800) is perceived by Weir (1976) and Prewitt (1985) as representing peak population levels in Central Texas prehistory. Both models of population, however, require a number of assumptions about direct relationships between the number of site components at a given time and population levels, assumptions that cannot be validated on the basis of current data (cf. Black 1989). Evidence of at least one subsistence shift appears in the form of an episode of bison exploitation (Prewitt 1981), but how bison fits in with other elements of the subsistence base is largely conjectural owing to the small number of floral and faunal collections that have been analyzed (Black 1989). There is evidence of trade relations between Central Texas and groups on the Gulf Coast, and evidence of cemeteries occurs for the first known time (Hall 1981; Lukowski 1987). There is some evidence of settlement shifts in the San Gabriel River area, but it is not known whether these shifts are localized or regional (Peter et al. 1982). There is also some evidence that burned rock middens declined (Weir 1976; Prewitt 1991), but this evidence is slowly being contradicted as more data and dates accumulate to show that burned rock middens persisted as a major phenomenon well into the Late Prehistoric (Goode 1991; Treece 1992). Because much of the data on which knowledge of the Late Archaic is based comes from palimpsest middens and from relatively few well documented sites, knowledge of the Late Archaic is at best general. As with the Middle Archaic, it is necessary to obtain an array of geographically-limited data bases from which to document regional variability.

Furthermore, although the Late Archaic is much better dated than earlier periods, further dating remains a high priority because sorting out settlement patterns and subsistence strategies requires enough dates to establish the rough contemporaneity of sites (Peter et al. 1982).

4.1.3.5 The Late Prehistoric and the Historic Period Transition

The Late Prehistoric period (ca. A.D. 800-1800) is the best known of the prehistoric sequence largely because it is well dated and preservation problems are less severe. Furthermore, Late Prehistoric contexts are often less ambiguously identifiable because they frequently contain ceramics and because the introduction of the bow and arrow led to the creation of a distinctive projectile-point assemblage relative to the earlier dart-point assemblage. As a result, the Austin and Toyah phases of the Late Prehistoric represent the only part of Central Texas prehistory for which there is wide agreement (Johnson 1990).

As noted previously, Prewitt (1981) does not believe that the introduction of Austin phase people with bow and arrow technology marks a significant adaptive shift. Exploitation of bison in the Toyah phase marks an adaptive shift from an apparent previous dependence on deer (Story 1990). Ambiguous evidence of agriculture appears in the form of the very rare occurrence of corn (Jelks 1962; Prikryl 1987; Story 1990), although Johnson (1990:464) doubts that corn was traded into Central Texas. Given Johnson's (1990) claims that Toyah communities had subsistence bases that varied with geographic conditions, it is therefore necessary to acquire detailed subsistence evidence from many geographically-limited areas in order to test his claim. The possibility of Late Prehistoric agriculture merits detailed investigation. Given the diversity of the Central Texas area in general, it is also necessary to acquire similar data bases for the Austin phase. Continued evidence of wide trade (Prewitt 1982) suggests that data regarding the provenance of raw materials and origins of exotic artifacts will be essential for distinguishing between widely and narrowly mobile groups in both phases (cf. Black 1989). Prewitt (1974) has found the first known evidence of warfare in Austin phase cemeteries that contain the remains of persons who apparently died of arrow wounds. Interestingly, Prewitt (1985) posits a north-to-south introduction of Austin phase people, and lists warfare resulting from the expansion of Austin phase people as one of several possible sources of increased violence. (Note, however, that any claim of increased violence-related mortality for the Austin phase can only be substantiated by comparison to large Late Archaic burial populations [for which some data exists] and Middle Archaic burial populations [for which little data as yet exists]). Prewitt (1985; cf. Johnson 1990) also suggests that the subsequent Toyah phase represents a north-to-south movement of people, this time, following the southward expansion of bison. He notes (Prewitt 1974) that warfare may have occurred in the Toyah phase. If the postulated immigrations occurred, then interesting problems for Austin and Toyah phase research are to determine if and why there was no adaptive change in the case of the Austin phase, and to find evidence to identify immigration, diffusion, and/or acculturation as the processes involved in the transitions (cf. Ricklis 1992).

The Toyah case may be especially important with respect to resolving the relationships between Toyah people and ethnohistorically identified groups. If the Toyah phenomenon can be shown to involve dislocation of Austin populations, then interpretation of the ethnohistoric record of Native American groups may record recently introduced groups who were still readapting to a new environment when encountered by Cabeza de Vaca and other early Spaniards. If the Toyah phenomenon cannot be linked to population displacement, then the ethnohistoric record may describe groups that were in the midst of environmentally driven adaptive change. Given that Johnson (1990) has found strong evidence for localized communities in the Toyah phase, there may be a realistic possibility of locating communities in places corresponding to the locations of ethnohistorically documented groups if there was continuity. Primary data needs for Late Prehistoric and historic-transition research, therefore, are technological data which may show whether or not local continuities in production techniques for projectile points and nonprojectile point artifacts accompany discontinuities in atlatl-to-bow and dart-to-arrow-point systems. Further needs would be and detailed environmental data to show whether or not crucial environmental thresholds can be implicated in the Toyah-to-historic shift. Pursuing this line of research will require fine-grained chronometric data.

4.1.3.6 Climate in Central Texas Prehistory

Climate frequently has figured into Central Texas prehistory as a variable that explains change in the archeological record. The acorn hypothesis of burned rock midden function (Weir 1976; Creel 1986, 1991) depends on a prehistoric climatic shift that extended the oak savanna westward across Central Texas before the peak of midden formation. The sotol hypothesis (Prewitt n.d.; Goode 1991) depends on a prehistoric climatic shift that moved the boundary for sotol to the west after the peak of midden formation. Explanations for episodic exploitation of bison are based largely alternating wet/dry periods which created intermittently favorable grassland environments into Central Texas (Dillehay 1974). Gunn (n.d.) attributes sociocultural change to "preadapted" groups expanding into Central Texas from xeric areas to the west and southwest during drying periods, and to groups expanding into Central Texas from more humid areas to the east during periods of increasing moisture.

Unfortunately, there are considerable data gaps and disagreements about climate history in Central Texas. Bryant and Shafer (1977; cf. Bryant and Holloway 1985), on the basis of pollen data, postulate a gradual warming trend over the last 10,000 years. However, the data base comes from the peripheries of Central Texas (e.g., Lower Pecos, the eastern fringe of the Edwards Plateau), is supported by only a small number of dates (Story 1990), and, in any event, does not resolve short-term changes. Hall (1988) and Nordt (1992) have documented geomorphic evidence that is consistent with climate changes, but because major geomorphic adjustments mark events in which stability thresholds are exceeded (Butzer 1982), the geomorphic evidence is most appropriate to diagnose fairly long-term climatic change that may be too gross to be used in time frames relevant to culture change. Geomorphic and other evidence from the Lubbock Lake site (Holliday 1985; Holliday et al. 1983) add significant detail to the large-scale picture of climatic change, but may not be relevant to details of short-term climate in Central Texas. Gunn (n.d.) has constructed a provocative model of climate change in Central Texas that includes both long- and short-term components with considerable variation. However, as an unpublished document, it has not been subject to evaluation that could substantiate or improve its results or lead to its rejection. Henry et al. (1980), working in a small area just north of Fort Hood, provide a paleoenvironmental reconstruction for the Late Prehistoric that contradicts most other models. Given that the details of Central Texas climate history are poorly understood (cf. Johnson 1991) it follows that much more work is needed to identify relatively local climatic patterns and to improve the resolution of detail it provides.

4.1.4 Rethinking Burned Rock Middens and, Therefore, Central Texas Archeology

It frequently happens in the history of a science that a "crisis in confidence" (Kuhn 1970) or a "degenerating problem shift" (Lakatos 1978b) occurs in which ongoing research reaches a point of diminishing returns in terms of increasing the body of empirical knowledge and fostering the growth of model-building beyond the most basic level. When such a point is reached, practitioners may cast about, either in their own or other disciplines, for principles with which to rejuvenate the generation of scientifically interesting problems (Lakatos 1978b). By the middle 1980s, there were indications that trouble was brewing in Central Texas archeology as some researchers (e.g., Peter 1982; Peter et al. 1982; Black and McGraw 1985; Johnson 1987) found the culture-historical tradition to be unproductive with respect to reaching archeological goals. By the time the burned rock midden symposium (Hester 1991) convened in 1988, it was recognized that burned rock midden research had reached such a crisis, and that something had to be done about it.

The primary recognition was that as a matter of historical practice, important data bases were being systematically ignored, perhaps as a result of low expectations on the part of excavators (cf. Black et al. 1992) and/or a tendency to focus on middens as more or less whole artifacts (cf. Collins 1991). For example, as of 1987, attempts to analyze macro- and microbotanical samples had been made on only 19 middens, with 13 of those yielding at least some interpretable results (Howard 1991). This dearth of data not only obscures the analysis of burned rock middens, it also severely limits the data base on which to base judgments of the subsistence activities taking place at the majority of open sites excavated so far in Central Texas.

In recognition of problems such as this, Collins (1991; cf. Sorrow [1969] and Collins [1973] for earlier notice of the problem) suggested that it was time to start looking at middens in terms of several scales of observation: the macroscale, or the position of the midden in an areal environmental context; the mesoscale, or the position of the midden in its local environment; and the microscale, or the details of the site from the smallest components of the midden up to the level of the site as a whole. In Collins' (1991:6) terms, the midden itself occupies "the upper part of the microscale segment." To the extent that projects explore the whole site and its local setting, they address "part of the mesoscale segment" (Collins 1991:8). Thus, according to Collins, most excavations--which usually concentrate on the midden as such--have missed the macroscale component and most of the micro- and mesoscale components. Excavations have, therefore, largely ignored the data sets that would provide the details necessary to identify formation processes, feature function(s), subsistence function(s), site function(s), and, hence, the place of any given midden in the adaptive strategy of the people who created it.

In order to recover the needed data, Collins emphasizes two tactics. The first calls for a liberal dose of alternative middle-range theories on which to postulate the characteristics that might be expected in the archeological record, and explicit test hypotheses that would enable us to eliminate at least some middle-range theories as plausible and perhaps to establish others as viable (see "Middle-Range Theories," section 4.2.2 below). The second tactic, which is related to the first, is to apply a wide array of established and recently developed laboratory analyses to the examination of the midden content, including analyses of residues, soil chemistry, sediments, microfauna, and the burned rock itself, in addition to micro- and macrobotanical, macrofaunal, and artifactual analyses. Collins also suggests that the second tactic be applied to reconstruction of meso- and macroscale phenomena in order to place middens in their appropriate environmental and cultural contexts. Although he specifically addresses an approach to the burned rock midden problem, it is clear that Collins (1991:8) does not regard the midden problem to be detached from larger problems of adaptation in Central Texas: "The thrust of research with burned rock middens should be to build theory concerning temperate forest/savanna dwelling foragers or hunter-gatherers...." Given that his suggestions apply as well to nonmidden sites of all sorts as they do to midden sites, Collins' prescription for burned rock middens is therefore a prescription for Central Texas archeology as a whole.

4.1.5 Archeological Research in the Fort Hood Vicinity

If the foregoing review is defensible in terms of its assessment of the state of archeology in Central Texas, the implementation of a CRM plan and research design at Fort Hood is hindered by the absence of a well-developed understanding of regional phenomena. Although the prehistory of Central Texas is advanced enough to make certain broad comparisons between Central Texas and elsewhere at various times in the sequence (e.g., the basic differences between the Central Texas Toyah phase and the North Texas Henrietta Focus in the Late Prehistoric), very few detailed claims about Central Texas prehistory can be corroborated by evidence that justifies assertions about similarities and differences within Central Texas. Indeed, if the earlier review is correct, the absence of well-defined, well-corroborated Willey/Phillips-like phases entails that *we do not have* sufficiently detailed knowledge of most of the sociocultural groups who inhabited Central Texas, from which it follows that *we cannot have* sufficiently detailed knowledge of how they interacted, how they adapted, and why they changed.

The research design in Chapter 5 is predicated on Collin's call to pursue archeology with a view toward understanding human adaptation in Central Texas. It takes seriously the fact that archeological research to date has been largely unsuccessful at both its traditional goal of defining phases and the more recent alternative goal of establishing the nature of adaptations. Given the current state of archeology in Central Texas, there are sound scientific and regulatory reasons for taking a back-to-basics approach to archeology at Fort Hood (see Chapter 5). Given the likelihood of high area-to-area adaptive variability in Central Texas, the poor general levels of well-founded knowledge (*per* the foregoing review), and the nature of sound archeological practice, there are good reasons to concentrate on building Fort Hood prehistory before it is even plausible to compare Fort Hood on a nonspeculative basis to more distant areas of the state (see section 5.2.8). The following review surveys the results of archeology in the immediate area of Fort Hood.

The review focuses on the area within a 50-km radius of the approximate center of Fort Hood, an area of approximately 15,700 km^2 (Figure 4.4), in order to illustrate the nature of the Fort Hood data base relative to the needs of an archeological research program that deals with hunter-gatherer groups. The analysis of hunter-gatherers must center on the fact that they distribute their activities at a wide range of different places (Binford 1983b). As a result, the analyst must have data from a relatively large number of more or less contemporaneous sites in order to be able to sort out the nature of their artifact assemblages, subsistence strategies, settlement patterns, group interactions, and social boundaries (Binford 1982; Savage 1990; Torrance 1983). Consequently, it is necessary to have a large number of widely distributed sites from any given time period in order to pursue either traditional goals of identifying sociocultural groups or alternative goals of studying adaptation. Given that the annual range of the Nunamiut Eskimo observed by Binford (1981b) is 1,650 km^2 (11% of the review area) and the annual range of a Dobe !Kung group (Yellen 1976) is 320 km^2 (2% of the review area), a summary of the archeology within a radius of 50 km should highlight the nature of the archeological vacuum in which Fort Hood exists relative to the amount and kind of data needed to understand hunter-gatherer adaptation at the local level before one can draw regional conclusions. Several sites within the immediate Fort Hood vicinity have figured importantly in the development of Prewitt's (1981) chronology, providing a substantial portion of the data on which it was based. The review, therefore, will show that an insufficient Fort Hood area data base undermines the current capacity to use sites from this area to draw meaningful regional conclusions about hunter-gatherer adaptive behavior. This conclusion will follow from the fact that because extant data is too sketchy to serve as a basis for factoring site-to-site functional variation into local prehistory (either sociocultural or adaptive), it is too sketchy to serve as a basis for regional integration at all but the most impressionistic levels.

4.1.5.1 Preliminary Research in the Fort Hood Area

The earliest professional excavation in the review area was performed by A. T. Jackson in 1933 at the Willison Farm in eastern Bell County, but apparently never was reported (Young 1988). The Ranney Creek Cave site in eastern Coryell County was excavated by H. Ramseur in the early 1930s, but has not been reported (Prewitt 1974). The Belton area was preliminarily surveyed by Robert Stephenson in the late 1940s (Shafer et al. 1964). Early archeological research in the review area was dominated largely by Frank Watt, the driving force behind the Central Texas Archeological Society and the author and editor of most of the material published by the society (Lawrence and Redder 1985). A tireless avocational with professional sensibilities (Stephenson 1985), Watt surveyed and excavated over a wide area centered around Waco. Among several sites excavated

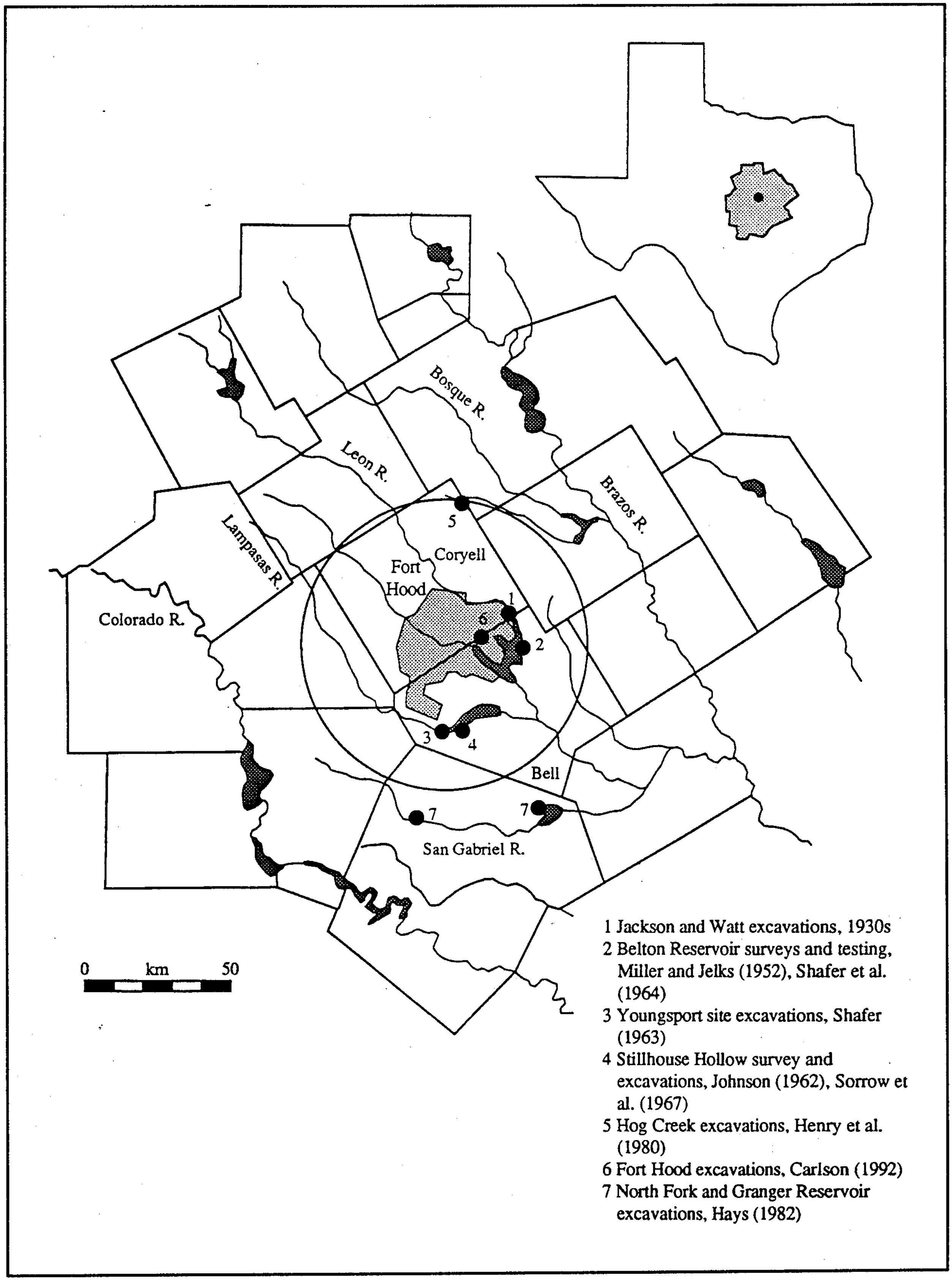


Figure 4.4 Review Area for Archaeology of the Fort Hood Area.

by Watt in the review area is the Aycock Rockshelter (also known as Kell Branch Shelter number 1, in eastern Bell County), from which Watt recovered more than 20 burials (Watt 1936) that were analyzed by a physician (Aynesworth 1936). Watt gained a thorough knowledge of artifact styles in Central Texas and other areas of the state (Stephenson 1985; Lawrence and Redder 1985; Redder 1985), including defining the Waco sinker as an artifact class with apparent geographic variation (Watt 1938). Although Watt's aims and techniques were consistent with the state of the art in Central Texas throughout his 40-year career (cf. Willey and Sabloff 1980), his emphasis on artifact typology has relatively limited utility for studies that rely on discrimination of the details of behavior or the systemic properties of hunter-gatherer adaptations (cf. Johnson 1989; Guderjan et al. 1980).

Beginning in the 1950s, the pace of professional archeology in the review area increased as reservoir development activities demanded attention to cultural resources. Miller and Jelks (1952) surveyed the area on the east side of Fort Hood in anticipation of the construction of Belton Reservoir. Testing in middens and rockshelters failed to provide substantial evidence that would sort out chronological information (cf. Henry et al. 1980). Johnson (1962) surveyed the Stillhouse Hollow Reservoir about 10 km south of Fort Hood in Bell County, performing the first organized archeology on the Lampasas River and laying the groundwork for later mitigation efforts (Sorrow et al. 1967).

Shafer (1963) performed substantial test excavations at the Youngsport site, about a mile upstream from Stillhouse Hollow on the Lampasas River. Although Shafer recognized that his excavation strategy prevented him from confirming stratigraphic relationships between excavation units, his results nonetheless implied that the projectile point sequence at Youngsport was largely consistent with the recently developed sequence in Southwest Texas (Johnson et al. 1962), and he provided a provisional definition for the Early Archaic Gower point. However, Shafer reported no subsistence or paleoenvironmental data, and no behavioral data beyond basic descriptions of some aspects of lithic artifact production techniques. Shafer et al. (1964) surveyed the Belton Reservoir in 1962. At least 12 sites were tested to some extent. The analysis in the report dealt largely with typological descriptions of the various artifact classes found in both surface and test collections, and the assignment of culture-chronological position to sites. Faunal material was collected, but not reported, and no paleoenvironmental or behavioral data was reported beyond some basic descriptions of lithic artifact production techniques.

In 1964, Sorrow et al. (1967) conducted test and mitigation excavations in Stillhouse Hollow Reservoir. On the basis of excavations at the Landslide and Evoe Terrace sites, they defined a series of local occupational phases which they compared to other areas of the region. These excavations provided further support for the Early Archaic status of the Gower point and further evidence that the projectile point sequence at least broadly conformed to that in other areas. Although they reported faunal remains associated with burned rock features, no paleoenvironmental data were provided, and behavioral information was again restricted to description of basic elements of tool production.

Thus, as of the middle 1960s, archeology in the Fort Hood area was largely absorbed in establishing chronological and typological baselines for identifying culture-area affiliations, a focus that was consistent with state-of-the-art problems then current in archeology throughout Central Texas (cf. Willey and Sabloff 1980).

4.1.5.2 Problem-Oriented Research in the Review Area

No substantial research was conducted in the review area between the middle 1960s and the middle 1970s. However, in the middle 1970s, archeology in the Fort Hood area began to augment its chronology goals with specific problem-oriented research. Archeologists from Southern Methodist University began a long-term project in the Hog Creek Reservoir in northeastern Coryell County and southwestern Bosque County (Larson and Kirby 1976; Henry et al. 1980). The project involved the testing and mitigation of rockshelter and open sites. In addition to reporting the traditional typological and chronological data, the SMU reports contained substantial information to support functional interpretations of tool assemblages and paleoenvironmental interpretations.

The reports are notable with respect to technological studies in that they incorporate statistical tests of assemblage similarity and difference (Larson and Kirby 1976; Henry et al. 1980). Reconstruction of paleoenvironmental conditions attempted to incorporate data from a variety of sources (pollen, snails, and sedimentation), although poor preservation inhibited the use of pollen (Henry et al. 1980). The absence of faunal and other reliable seasonality data led to creative use of the exposure direction of rockshelters as a proxy for more direct data (Henry et al. 1980). The SMU research also was remarkable for its attempts to integrate the Hog Creek data into models of hunter-gatherer land-use patterns (Larson and Kirby 1976; Henry et al. 1980). The settlement data led Henry et al. (1980:523) to conclude that the Hog Creek area represented "a detached portion of Central Texas" which may have had at least some contacts with areas to the north (Lake Whitney area) and south (Canyon Reservoir area). Thus, the Hog Creek project stands as a major contribution of behaviorally and systemically relevant research. Unfortunately, the bulk of the Hog Creek data pertains to the Late Prehistoric.

4.1.5.3 Excavations on Fort Hood

On Fort Hood itself, numerous surveys have been conducted since the late 1970s (see section 2.2). However, the only recent report of excavations is Carlson (editor, 1992), although some other reports currently are in preparation. Test excavations by a Texas A&M University field school in 1990 concentrated on two rockshelters and the area immediately outside one of them, and on documentation of what appears to be the largest known medicine wheel. The areas tested include Archaic and Late Prehistoric contexts, but the age and, hence, cultural significance of the medicine wheel are unknown.

Analyses of pollen, phytoliths, and macrobotanical materials from the excavations were attempted, but the results were limited (Olive 1992). Faunal analysis identified 15 edible genus- or species-level taxa at the rockshelters. Although the analysts did not claim that all taxa were culturally significant (Sanchez and Shaffer 1992), they did show that an array of diverse niches were represented, including niches somewhat distant from the sites. Thus, even allowing for representation of natural faunal elements, the analysis implied a substantial likelihood that people ranged across a wide variety of niches from the rockshelters (cf. Carlson 1992). Lithic analysis allowed for rough assignment of the sites to chronological periods via the presence of diagnostic types (Dickens 1992; Carlson 1992). A visual study of chert types showed that lithic materials had been transported to the site from a number of different sources on Fort Hood (Dickens 1992), further reinforcing the implication that the rockshelter residents covered a wide range of niches across the Fort (Carlson 1992). The combination of lithic and faunal evidence may provide a basis for suggesting that lithic procurement was incidental to other activities (Gould and Saggers 1985).

4.1.5.4 Relationship of Archeology in the Review Area to Central Texas Syntheses

The recent excavations at Hog Creek and on Fort Hood imply that it is realistic to anticipate that adaptively and behaviorally significant data can be obtained in the Fort Hood area, although it often will be necessary to contend with small samples and, in many cases, disturbed context. However, it is necessary to see how the data can be related to Fort Hood and regional prehistory.

The three sites excavated in some detail in Shafer (1963; Youngsport) and Sorrow et al. (1967; Landslide and Evoe Terrace) were incorporated into both Weir's (1976) and Prewitt's (1981) syntheses. Prewitt (1981) also incorporated data from the Penny Winkle site (Shafer et al. 1964). Thus, to the extent that any

Central Texas synthesis relies on these sites, it relies on sites for which very little faunal analysis and no ethnobotanical, paleoenvironmental, or significant behavioral analyses were ever performed. As a result, these sites provide no basis for determining whether the Fort Hood findings are functionally or socially representative of hunter-gatherers in Central Texas. Consequently, in the absence of a thorough re-analysis of the collections involved, these sites can make no significant contribution to understanding the social and adaptive relationships between Fort Hood and the rest of Texas except at the most basic of typological levels which cancels out the capacity to examine local variability (cf. Johnson 1989). This does not follow from problems with the way the archeology was performed, but rather from the fact that the archeology at the time had limited chronological objectives in a research stream that had not yet come to rely heavily on biological and environmental analyses.

As a result, the data base for comparative archeological research at Fort Hood is limited. The only major data base within the review area (Henry et al. 1980; Larson and Kirby 1976) that presents environmentally, adaptively, and socially applicable data that may pertain in its details to Fort Hood covers only the Late Prehistoric. The data base in Carlson (editor, 1992) is sufficient to identify some possible patterns of behavior, but they comprise too small a base from which to postulate events at Fort Hood, let alone for comparison against regional data bases or against the Hog Creek data. Fortunately, another major data base just outside the review area (Hays 1982) provides considerable comparative potential for the Archaic. Sites on the San Gabriel River in the North Fork and Granger Reservoirs were excavated in detail, and accumulated valuable (if sometimes meager) ethnobotanical and faunal data, as well as comparative cultural data from equivalently excavated areas in different environmental conditions. Although some tentative conclusions could be derived about change in subsistence and settlement behavior over time, the analysts were unwilling to extend their data to other areas of the state, largely because they believed that the current phase structure (Prewitt 1981, 1985) was not visible on the San Gabriel drainage (Peter et al. 1982).

However, from the perspective at Fort Hood, the two well-documented data bases that can serve for initial comparative purposes exist at the fringes of a 50 km radius. These data bases are approximately 160 km apart, with Fort Hood about halfway in between. The high quality data outside this area is too widely spaced to determine the nature of contemporaneous adaptations or social boundaries within the review area. In other words, the distribution of data is too sparse to permit substantive reconstruction of hunter-gatherer groups or adaptations at any given time. Because the Fort Hood data base is extremely small, it will take a substantial amount of effort to build a foundation sufficient for a comparison between the Fort Hood, Hog Creek, and San Gabriel areas so that a Fort Hood area synthesis can in turn serve as a basis for meaningful comparison to regional phenomena.

4.1.6 The Basic Sense of This Research Design

The history of prehistoric adaptation at Fort Hood can be considered to be virtually unknown. Little formal excavation has been done on Fort Hood proper (Carlson 1992), and the informal (Thomas 1978) and formal site surveys (e.g., Skinner et al. 1981, 1984; Carlson et al. 1987, 1988; Ensor 1991) which have been conducted cannot serve as an inferential base for constructing modeling prehistory at Fort Hood in the absence of a large body of data from controlled excavations. Given the largely unknown nature of adaptation in the Fort Hood area amidst only incipiently developed Central Texas models, it is essential to investigate adaptive processes in the Fort Hood area in detail. Given that climate is a major factor in the study of adaptation (Butzer 1982), it also is essential to investigate paleoclimate in the Fort Hood area in detail from the outset of research in order to avoid using paleoclimatic data that may not be relevant because it is derived from distant, perhaps irrelevant locales (Henry et al. 1980). Although an important geomorphological study of major drainages in Fort Hood has been completed (Nordt 1992), there still are significant areas of geomorphology to be studied so as to flesh out the model of landscape change in Fort Hood. Given that chronological issues are unresolved (Black 1989), work in this problem area is crucial as well.

This research design will take the spirit and content of Collins' (1991) suggestions very seriously by viewing Fort Hood as an archeological resource which, because it is virtually unknown and therefore not characterized by historically developed expectations of what specifically should be evident there, is an ideal laboratory within which to implement sophisticated research into the nature of hunter-gatherer adaptation in Central Texas. The attitude to be taken will be to acknowledge that although we know a fair amount at the typological level about the general nature of assemblages in Central Texas, it would be healthy to assume that very little is known about Central Texas adaptations in general, and that the emerging indications of variability elsewhere imply that what is known elsewhere may not apply at Fort Hood at a particularly informative level.

4.2 THEORETICAL PERSPECTIVES FOR THE RESEARCH DESIGN

The approach taken in this research design can be characterized as a back-to-basics approach which takes as little as possible for granted about what will be learned. Given our back-to-basics approach, before laying out the research plan itself, we will discuss the theoretical principles on which we will pursue research. This discussion, although perhaps tedious, is nonetheless essential for placing the research plan in a context in which its theoretical and methodological assumptions are as explicit as possible. Without such a discussion, the research plan would be purposeless and meaningless because the body of theoretical perspectives is the foundation on which the plan stands or falls.

In what follows, then, we lay out the overarching theoretical orientation advocated for managing the cultural resources of Fort Hood. This orientation is cultural ecology, and it consists of examining the interaction between prehistoric people and the surrounding natural and cultural environments. This section discusses the background and major research issues of using the cultural ecological approach and establishes a foundation for identifying the nature of adaptations and adaptive change as the principal objects of inquiry. Next comes a discussion of the nature and importance of middle-range theories as a basis for understanding site-formation processes and assigning meaning and significance to phenomena observed in the archeological record. The discussion of middle-range theories leads directly to a discussion of two particular such theories that will play major roles in the interpretation of archeological data at Fort Hood: a theory of adaptive communities and a theory of technology.

4.2.1 Cultural Ecology

The cultural ecology approach examines the adaptive relationships of a culture or group to its natural and cultural environmental setting (Helm 1962; Vayda and Rappaport 1968; Anderson 1973). Ecologically, the environmental setting includes both cultural-physical environmental interactions (exploitation) and multi-cultural interactions (intersocietal contacts). Archeology can offer a significant contribution to the cultural ecological approach to understanding human adaptation by providing the great time depth necessary to measure the natural or cultural environmental impacts on a culture. In addition, it can monitor the synchronicity of natural and cultural change in the environment as well as any positive or negative diachronic cultural responses.

Butzer (1982) has developed an especially interesting framework for pursuing archeology from the cultural ecology perspective by emphasizing the "interactive" nature of human beings and the environment, not only with respect to the impact of environmental change on human communities, but also with respect to human impacts on the environment. Thus, Butzer's approach requires not only studies of human systems and the environmental systems within which human systems operated, but also studies of the mutually affective relationships between the two. Furthermore, Butzer emphasizes the notion of scale in both description and explanation of human ecological relationships, especially with respect to short-term trends that may be embedded in longer-term trends. The notion of scale is important to ecological interpretation because the scale of analysis (e.g., local vs. regional) determines which phenomena are explanatory, and which not. For example, one might attribute the replacement of local Austin phase people by Toyah people to conquest of the former by the latter if there is evidence of extensive warfare at the Austin/Toyah transition in Fort Hood. If so, then a sociological process might correctly explain the details of adaptation at the local level. However, if this local phenomenon recurred at a regional level, invoking sociological processes to explain the Austin/Toyah transition would not be explanatory because it would not explain why there was regional warfare, and it would be necessary to identify the regional (or, perhaps, supraregional) processes which led to regional warfare.

The structure of the research design for Fort Hood is primarily derived from an emphasis on delineating economic change. Ecologically, the core of any cultural system involves the ways in which resources are acquired from natural and cultural sources and processed to extract the maximum productivity within the technological and social limits of the society (Steward 1973). The reconstruction of economies by archeologists mandates the consideration of multiple facets of a culture which are related to the economic structure. These facets include the social organization, social structure, inter-social, and inter-cultural relationships which are all closely linked to the economic factors. Changes in the economy are typically related to other aspects of cultural change and potentially should be reflected by alterations in the population structure, its relationship to natural habitats, or modifications in the resource procurement and processing strategies and technologies. Fundamental issues facing hunter-gatherers and horticulturalists alike involve strategies for selecting the kinds of resources to be used, determining the quantity of expected resources available or necessary for survival, identifying when and where resources are available, and, within the context of available technology, making decisions about optimal group size necessary to procure and process the resource during periods of both abundance and scarcity. These decisions, in turn, are reflected in a group's seasonal and yearly scheduling patterns, land use patterns, and demographic arrangements.

Obviously, as climatic changes may alter regional environmental conditions and the character of the biotic resource base, cultural responses may include changes in the degree of specialized reliance on select or dominant resources. Through time, cultural patterns may be reflected in assemblages indicative of general shifts in exploitation strategies between specialization on narrowly focused resource vs. generalized targeting on a diffuse range of biotic resources (Cleland 1976).

Even though some variation occurs through time in the relative abundance of dominant faunal resources (deer, antelope, and bison) throughout Central Texas and the Southern High Plains (cf. Dillehay 1974), ethnographic studies of hunters and gatherers have repeatedly demonstrated that where ecological diversity is present, major decisions regarding mobility scheduling, community size, and composition are based primarily on the availability of predictable floral resources (nuts, tubers, seeds, fruits) over the faunal resources (Lee and DeVore 1968; Winterhalder and Smith 1981; McCollough 1986; Thoms 1989). This revelation is archeologically disturbing, since preserved plant remains and plant processing assemblages and features tend to be more difficult to recognize and identify than bones, projectile points, or scrapers which reflect hunting procurement and processing activities. The relative visibility and temporal identification of different kinds of activities may yield radically different reconstructions of land use, population sizes, and intensity of occupation at various periods in the past.

In regions where biotic resources are abundant and available year round, such as in the Northwest United States, hunting and gathering groups could maintain a certain degree of sedentism as long as the population size did not exceed resource availability. As populations increased or resources were only seasonally available, other strategies, such as resource processing and storage, were required for the group to remain economically self-sufficient and stable (Testart 1982). In areas with lower resource productivity and/or resource availability on an irregular basis, a complex scheduling of group foraging would be necessary to successfully extract and obtain critical resources over the entire year (Rafferty 1985). Such scheduling may have engendered fluctuation periods of group fission and aggregation. Such strategies tend to focus on environmental locales displaying ecological diversity and productivity and involve foraging excursions into regions with less productivity and diversity.

The scheduling and nature of exploitation excursions depends upon two factors: (1) the regional extent and geometry of the resource (point, linear, or areally extensive distribution of resources); and (2) the seasonality and extent of resource availability. Tight resource procurement scheduling (as manifest by "seasonal rounds" of exploitations) is apt to occur when incongruently-distributed resources are predictably available from limited (point, line, or restricted area) zones within a broader region reflecting considerable environmental diversity. Binford (1980) has designated this logistical strategy as a collector's model characterized by planned exploitation of predictable, periodically-available resources. The exploitation pattern often involves reoccupation of a single locus and/or extension of the site or area usage through resource processing and storage behavior. The collector strategy includes a hierarchy of sites in which base camps are situated near the most stable and abundant resource in the area, but field camps, locations, stations, or observation points are located near various resources intended for exploitation. In general, resources are processed at the procurement site and reduced bulk goods are moved back to the residentially-stable base camp and stored for consumption. Base camps can be archeologically distinguished by their greater intensity and duration of occupation, a wider range of site functions, curation and maintenance activities, storage facilities, communal processing areas, and other kinds of site furniture. Thus, the base camps tend to have a greater density and diversity of implements and residues than the procurement loci and stations. Logistical procurement sites can be recognized by low diversity of tool and subsistence-resource assemblages and evidence of bulk processing.

In contrast to the collector strategy, the foraging strategy consists of a system of moving people to resources for consumption, which involves less restricted scheduling. The timing of movement is dictated by resource depletion and the direction of movement is dictated by the location of the next resource to be exploited (Binford 1980). The "free or restricted wandering" patterns as recognized by Beardsley et al. (1956) typically arise when resources are ubiquitously distributed over the landscape or resources are available over considerable periods of time. In cases where critical resources discretely occur within an otherwise homogeneous region, settlements may display redundancy in use over long periods of time (Taylor 1964). Under such "tethered" conditions, foragers may develop dual settlement patterns with residential camps placed near critical resources and "low-bulk" procurement locations covering a wide range of short-term activities scattered elsewhere. Group size among foragers tends to be very fluid, and considerable coalescence and fission mark the foraging strategy. Archeologically, foraging strategies differ from collecting strategies and tend to be marked by (1) less intensive occupations except at tethered sites; (2) less curation and maintenance activities; (3) the lack of stored or cached goods and other site furniture; (4) evidence of a very generalized and portable assemblage; and (5) perhaps less assemblage variability at any given location because of the generalized exploitation approach toward resource procurement.

These two very diverse exploitation patterns generally apply to biotic resources forming the subsistence base. The implements used to extract prehistoric economic resources are based on the technological level involving the modification of floral/faunal remains as well as such abiotic resources as cherts and clays. Clearly, implements made of geological materials are better preserved than those of biotic materials. The strategies of gathering cherts and clays by nonhierarchical societies often has been attributed to incidental or "embedded activities" conducted while individuals were engaged in other economic pursuits (Binford 1980). Embedded collection behavior is especially evident where resources occur in areas with easily accessible resources and where materials are of sufficient size for manual transport. In a few instances, such as in the Texas Panhandle and in North Dakota, prehistoric quarrying activities may have been undertaken to extract cherts with exceptional knapping qualities from bedrock or buried gravel deposits (cf. Bousman 1974; Ahler 1986). Extensive deposits of bedded and nodular chert of high knappable quality occur throughout Edwards Plateau of Central Texas (Banks 1990). The cherts on Fort Hood are within a few kilometers of the northeastern-most limits of their occurrence in primary contexts (Barnes 1970). Although comparable cherts occur as nonlocal materials in much of the Caddoan area to the east, little currently is known about the variability and distribution of Edwards Plateau cherts or the strategies and tactics of chert acquisition and exploitation by prehistoric groups at various times.

A wide range of variation can occur between the forager-collector dichotomous adaptive strategies and indeed, some options may involve seasonal shift from one strategy to another depending upon resource scheduling and availability. In addition, whole regions or portions of regions may be "simultaneously" exploited by multiple societies (Syms 1977:1-13). The relationships that develop between these archeologically contemporaneous groups depends upon the nature, abundance, and importance of the targeted resources. If the targeted resources ripen at different periods or occur in substantial abundance, then complementary exploitation can be conducted amicably--especially if the harvesting of different resources is scheduled at different seasons. Under such conditions, stylistic variation in artifacts may appear on complementary tools at contemporaneous sites or on different landforms, provided that functionally equivalent implements are present. On the other hand, the use of different kinds of tool kits by contemporaneous groups for separate resource exploitation may be impossible to detect, especially when no overlap in tool forms occur. In instances where competition occurs between separate societies for a single resource limited in abundance or season, evidence for hostile engagements may be preserved in the archeological record.

The marked technological changes postulated for the Central Texas culture area raise questions as to the adaptive effectiveness and contributing spectrum of factors underlying the cultural variability. Does the variability reflect adaptive responses to changes in the natural and social environment(s), or does it merely reflect economic innovations as a means of developing increasingly efficient methods of resource procurement and processing to ensure population security? These two questions encompass such issues as prehistoric site functions, settlement/land-use patterns, demography, economic activities, technological change, and environmental conditions.

The archeological examination of culture and economic change as it relates to environmental fluctuations is testable by gathering information on several different levels of investigation. Survey data, especially when used in conjunction with geomorphology, provides information on the distribution of cultural remains across various landforms and the recovery of functionally diagnostic artifacts provides indications of various activities associated with various landforms. More detailed patterns of land-use change through time can be discerned after a local chronological sequence has been established for diagnostic features, artifacts, and subsistence activities. Subsurface testing yields data to evaluate the potential importance of archeological remains in various settings from observations on material context, integrity, and preservation conditions for samples and artifacts necessary to examine regional research issues. Major mitigation projects often provide rapid advances in developing local sequences, and reconstructions of adaptive patterns are best derived by contrasting assemblages (especially with well-preserved remains) and features from temporally different single-component occupations. Well dated, single occupations in sealed stratigraphic contexts yield the best information concerning such issues as (1) environmental and seasonal context, (2) relative occupation intensity and site function, (3) productivity of subsistence activities relative to population density, and (4) relative exploitative technological efficiency. The cultural responses to environmental change can be monitored by documenting whether or not synchronous environmental changes occur with shifts in resource exploitation patterns and technology changes in the cultural record. In contrast, cultural changes occurring during periods of environmental stability may reflect conditions of immigrations, or cultural innovations possibly developed as responses to population growth. The main measures for determining economic stability involve monitoring population size indicators (site number/size, feature number/size etc.) relative to resource indicators such as the spectrum of resources used in the subsistence strategies and diversity of assemblages.

4.2.2 Middle Range Theories

The examination of hunter-gatherer adaptations encounters inherent limitations imposed by the various landforms within the project area. Unlike most archeological projects in the vicinity, which have typically focused only on alluvial terrace or rockshelter settings, Fort Hood as a project area represents an expansive geographical area with the potential to inform on sites in all topographic settings. The territory covered by most nomadic hunter-gatherer groups typically extends beyond an area as small as the limits of the Fort. However, it is necessary to note that the ethnographic and ethnoarcheological data base on which judgments of "typical" hunter-gatherer adaptive behavior are founded comes largely from observation of groups in marginal desert and circumpolar habitats. The topographic diversity of the Fort Hood area combined with its location in a region that has enjoyed at least some extended periods of temperate climate implies the possibility that resource diversity and productivity could at times have been sufficient to sustain a local population.

Thus, examination of the entire suite of landforms in the contiguous Fort provides a rare opportunity to explore the possibility of hunter-gatherer adaptive systems that were not tethered in Taylor's (1964) sense of being tied to dispersed crucial resources, but rather may have been "tethered" in the sense that historical exploitation of a diverse, productive environment obviated the need to range widely in search of subsistence goods. Hence, Fort Hood provides a laboratory setting within which to follow up on Collins' (1991) call to develop a theory of temperate-forest/savanna-dwelling hunter-gatherers. Within this setting, it will be important to determine as much as possible the transformations that have occurred on the landscape. Given that long-term impacts on the uplands have been severe, it will undoubtedly be very difficult to determine upland land-use patterns in any detail. However, it is reasonable to anticipate that by placing an emphasis on paleoenvironmental reconstruction whenever suitable data can be located, it will be possible to postulate reasonable models of paleoenvironmental conditions for the Fort as a whole, and to use these models to determine whether predominantly forager, collector, or other middle-range theories of hunter-gatherer adaptive strategies provide the best basis for interpreting the history of adaptation at any given time in Fort Hood.

Since most of the base involves relatively geologically stable surfaces, it is critical to the cultural reconstruction process that close attention be paid to the forces involved in site formation and transformation. Many of the interpretations proposed in archeological and paleoenvironmental studies of Central Texas will remain speculative until the structure of sites themselves and the processes that formed them are understood and documented. An obvious example of this is the functional uncertainty and social implications of large vs. small "open sites" and the definition of generalized "lithic procurement sites." Archeologists frequently become engrossed in attributing functional differences within the settlement/subsistence system (and, occasionally, even social differences) before acknowledging that the resolution of the higher theoretical and interpretive issues lies in relatively mundane analysis of depositional processes and chronological details. In other words, before archeologists can attend to the business of describing and explaining adaptive stability and change, it is necessary that they attend to the business of understanding how their data bases are affected by the human behavior and natural processes that produce sites. Without such an understanding, it is impossible to determine whether stratigraphic context bears any meaningful relationship to a human behavioral context (Schiffer 1987; Butzer 1982).

Binford (1981a) has defined middle-range research as the analysis of linkages between static archeological data and the dynamics of past human behavior. As such, middle-range theories are hypothetical constructs used by the archeologist to assign prehistoric significance to otherwise modern facts about artifacts and environments. He argues that assumptions of discrete or episodic occupations at particular sites are often erroneous since the stability and geometry of the paleolandform is often not considered. Most assemblages are probably palimpsest accumulations of materials involving a myriad of human and nonhuman activities that may be neither temporally nor functionally related (which is the basis for Johnson's [1987] critique of chronology-building).

This argument underscores the need for critical assessment of the contexts of artifact associations and for the use of geomorphic evaluation of site integrity and chronology prior to the reconstruction of occupational patterns. This caution is especially true on ancient surfaces that contain the entirety of human cultural remains in shallow deposits, such as the uplands and the surfaces of some stream terraces on the Fort (cf. Nordt 1992). In the absence of investigation of the geomorphic influences on site formation, establishing a relationship between large/small sites and large/small groups relies on a naive, implicit middle-range theory that the amount of debris at a site is directly proportional to the number of people who were there and that all sites represent comparable durations of occupation. A sensible approach to interpreting intensity and duration of occupation can only be based on a middle-range theory which acknowledges (however tritely) that the rate of artifact accumulation in a place is dominated by cultural processes, whereas the rate at which burial takes place is frequently dominated by natural processes (Binford 1982). Only by accounting for the impact (if any) of relatively long surficial exposure can we begin to establish a basis for distinguishing between real and spurious artifact associations from which to make inferences of prehistoric adaptation. Indeed, middle-range theories about the general relationship between rates of sedimentation and preservation of archeological materials (e.g., Ferring 1986) can be powerful interpretive tools.

Binford (1982, 1983b; Binford and Sabloff 1982) further argues that another kind of palimpsest phenomenon must be assessed, or, at least accounted for, in studies of hunter/gatherers. Because hunter/gatherers may use individual places on the landscape for different purposes, the record left in those places may be a short-term palimpsest resulting from different uses of the same place in a short sequence of times. For example, a place may be used in sequence as an observation stand, a hunting camp, and a residential site. To the extent that debris from each of the uses remains, an archeologically instantaneous assemblage may obscure organizational features of the activities taking place there by obscuring the fact that the place occupied different functional roles as the focus of activities shifted from place to place. In other words, "there is no necessary relationship between depositional episodes and occupational episodes" (Binford 1982:12). This implies that one must keep in mind alternative middle-range theories regarding positioning strategies when attempting to conduct analyses of hunter/gatherer adaptations.

It further implies that identification of site function must come from the perspective of an areal analysis in which function-specific assemblages are identified from a large number of rapidly buried components which minimize short-term palimpsest impacts resulting from overprinting during sequential short-term occupations: by focusing on sites with artifacts in rapidly buried contexts, recovered assemblages will contain the smallest possible range of function-specific subassemblages used during sequential occupations, which in turn will provide the highest probability of identifying contemporary sites with nonidentical subassemblages. From a data base of nonidentical subassemblages, one may be able to assign particular functions to particular subassemblages, thereby increasing the probability of distinguishing between subassemblages that co-occur as a result of sequential scheduling, and those that co-occur as a result of integration into a function-specific technology. Thus, assuming that contexts are at least short-term palimpsests produced by a scheduling process described by one of several middle-range theories about positioning strategies poses the analytical framework within which one must isolate function-specific assemblages in order to assign functions to sites. In turn, identifying function-specific assemblages provides the means by which one ultimately isolates the particular positioning strategy employed. Hence, identifying site function(s) can only be pursued against a backdrop of competing middle-range theories of hunter-gatherer scheduling, and identifying the particular strategy used can only be done by identifying function-specific assemblages.

This characterization of the way one identifies subassemblages and positioning strategies may smack of circularity in the sense that the discovery process may yield self-confirming results. This leads to several observations about middle-range theory that are frequently misunderstood and/or not typically discussed. Binford (1978b:358) captures the essence of middle-range theories very succinctly: "The ideas are my inventions." As such, then, middle-range theories and their use have two important characteristics: they are largely based on an investigator's intuitions about how things work, and they can never be corroborated by the phenomena inferred from them.

Given that they are based on intuitions, the way the assemblage/strategy problem above is solved relies on using a number of middle-range theories of positioning strategies as alternative interpretive devices with which to interpret assemblages. In this case, the forager and collector models are competing theories, one, both, or neither of which may produce interpretively plausible results. In attempting to apply these competing theories to a set of assemblages, it is necessary for the researcher to assess the assemblages in terms of other middle-range theories about subassemblages, some of which may be typological or drawn from ethnographic or experimental analogy. In the analysis, a researcher must implicitly or explicitly find the best fit between competing possible descriptions of subassemblages and competing possible descriptions of positioning strategies. This process is likely to involve further intuitions on the part of the researcher (cf. Binford 1983b:215), intuitions which, after examining the data, appear to hold promise for making the archaological record intelligible (cf. Binford 1981a:21-30). On identifying a best-fit scenario between subassemblage composition and positioning strategy, the researcher must then provide arguments of relevance not only for the best-fit scenario, but also for the superiority of that scenario over others (cf. Binford 1983b:390; Salmon 1982:129). Thus, circularity only emerges if the archeologist claims that in addition to providing a best-fit interpretation, he/she also has provided a true account of prehistoric reality because only in making this additional claim does the account become self-confirming: a data set interpreted according to a theoretical construct cannot possibly corroborate that construct, although it can falsify that construct's applicability to a specific case (cf. Binford 1983b:214; see below).

This feature of middle-range theories leads to another observation about them: culture histories and processual models cannot be built without them. The archeological record is mute with respect to the processes that produced it (Binford 1981a; Binford and Sabloff 1982), and to draw any conclusions about the past from the archeological record is therefore to employ some set of concepts (however explicit or implicit) that assigns meaning to the archeological record. The explicit or implicit concepts used to assign prehistoric meaning to archeologically-observed phenomena just *are* middle-range theories. Because a middle-range theory's status as such follows from the function it performs in research rather than from its broadness or narrowness of scope (Kosso 1991), it follows that not only are middle-range theories needed to sort out features of the archeological record, the ways in which lower-level archeological phenomena are interpreted are themselves driven by middle-range theories in the form of theoretical perspectives such as the cultural ecology perspective of this research design. "Post-processual" archeologists, therefore, are correct when they criticize processual archeology by asserting that processual frameworks such as cultural ecology impose the archeologist's worldview on the archeological record and, hence, on the past (cf. Hodder 1986). However, they are certainly incorrect if they believe either that this is a substantive criticism or that post-processual perspectives escape it: all archeological interpretation at every level relies on middle-range theory (cf. Kosso 1991).

This follows not from some peculiar weakness of archeology, but rather from the nature of science in particular and human cognition in general. It has long been recognized by many researchers in the philosophy of natural science that model-building proceeds on the basis of certain insights that are themselves not testable within the science that uses them and probably not testable in any other science (cf. Quine 1953; Lakatos 1978a; Putnam 1983; Kuhn 1970; Feyerabend 1975). These insights, being untestable, function as guides to model-building: statements which, if they were true, would explain certain basic features of the world and serve therefore as a basis for identifying other statements that also should be true, but should be subject to testing (Quine and Ullian 1970). These insights, consequently, comprise a kind of global middle-range theory that asserts some undemonstrable fundamental description of a portion of reality which serves as the basis for identifying testable models (cf. Lakatos 1978b). Because all cognition depends on the pre-existence of a conceptual structure to order phenomena (cf. Kant 1787; Salmon 1982), and because there is no theory-free perspective from which to test basic conceptual structures such as the basic theoretical premises of a research program (Feyerabend 1975), global middle-range theories can be neither confirmed nor falsified: they can only be shown to be more or less plausible and more or less productive with respect to fulfilling scientific goals (Feyerabend 1975; Kuhn 1970; Putnam 1983; Lakatos 1978c). Hence, the only criteria that count with regard to middle-range theories of all levels of generality are (cf. Putnam 1983; Lakatos 1978c): (1) Does it make phenomena intelligible?; and (2) Does it make phenomena more intelligible than other available theories?

Two things follow from the above. First, the value of cultural ecology as a theoretical perspective for this research design can only result from its ability to generate interesting research. We will not argue here that it does. Rather, we will rely on the historical fact that cultural ecology has managed to hold its own as a productive research orientation in cultural and applied anthropology and in archeology, and on the logical fact that rejecting cultural ecology as a plausible general cognitive framework for understanding human societies involves the implausible claim that human beings, although biological and dependent on interrelationships with the natural environment, are not subject to ecological processes. Note that our adoption of cultural ecology does not imply and cannot be construed as implying either that it is the only way to approach and interpret the archeological record or that it can produce an exhaustive account of human nature. It implies only that we believe cultural ecology to be a powerful descriptive and explanatory framework in general, and a more powerful framework than the traditional sociocultural approach that has characterized much of Central Texas archeology in particular.

The second implication that follows from the nature of middle-range theories is that it is necessary to be explicit about the phenomena we seek to describe and explanatory framework we will apply to them under this research design. The phenomena to be described and explained at Fort Hood include adaptations and technologies. For the purposes of this research design, explicit middle-range theories of these two phenomena are essential because the relevance of data and tests in this research design hang on specific views of each.

4.2.3 A Theory of Adaptations

We have characterized this research design as following a cultural ecological theoretical perspective. Since there are almost as many cultural ecologies as there are cultural ecologists, it is necessary to be specific about the cultural ecological content of our perspective, especially with respect to how we will define culture and adaptations, and how we conceive the relevant aspects of ecology. By making our theory of adaptations explicit, we can accomplish these goals.

It is a truism of most brands of cultural anthropology that "culture" refers by definition to the ideas, knowledge, standards, and other learned things shared by members of a group (cf. Harris 1979 for a notable exception). To the extent that the members of a group share a given set of ideas, knowledge, and standards about a given activity, it is likely that their behavior generally will conform to shared criteria and, therefore, will be similar from person to person. To the extent that the members of a group share ideas, knowledge, and standards about a wide range of activities, it is likely that behavior in a broad array of activities will be similar from person to person (Barrett 1987). In such cases, behavior is said to be cultural. Although it is generally conceded that culture is relevant to adaptation, there are disparities in the ways anthropologists view the relation (cf. Harris 1979 for an overview in a more polemical context of development of a cultural ecological theoretical perspective).

It is another truism of anthropology that cultural traits are transmitted from member to member of a group via socialization and other life-long learning processes so that over time, the behavior of one generation of persons will be similar to the behavior of persons in other generations unless something happens to alter either the structure within which knowledge is transmitted, the content of the knowledge that is transmitted, or both. Because culture traits are acquired via learning processes, they are acquired and transmitted via processes that are essentially Lamarckian in the sense that the members of a group can acquire and transmit knowledge that they do not get from their biological and sociocultural progenitors, and they tend to use that knowledge as long as their goals are met (cf. Harris 1979; Cohen 1978). On the other hand however, knowledge that becomes counterproductive as a result of change in the natural and/or cultural environment is selected against through more or less Darwinian processes, either as people act on alternative knowledge bases or as people who steadfastly cling to "obsolete" knowledge fail to meet their survival goals and, hence, fail to pass their knowledge on to others (cf. Bateson 1972; Cohen 1978). Thus, cultures are characterized by "reproductive modes" that perpetuate ways of doing things as long as those ways have survival value, and "adaptive modes" by which they adjust to changing conditions in the natural and/or cultural environment (Binford 1983b). Note that it would be more precise to say that adaptive modes *attempt* to adjust to changing conditions because the attempt may be unsuccessful in two senses: it may not work at all, leading to extinction of the group(s) making the attempt, or it may lead to readjustment at a level of survival that does not meet other goals.

The theory of adaptations may be summarized so far as follows. Knowledge is a central feature of human adaptations because knowledge is necessary if humans are to meet their survival goals. Knowledge is acquired via learning processes and is transmitted from generation to generation via socialization processes. To the extent that knowledge enables people to survive and (perhaps, but not necessarily) meet other goals, that knowledge will continue to be transmitted because it works. It is therefore always possible that the knowledge that works constitutes a suboptimal solution to meeting goals because it is always possible that either the knowledge of the optimal solution or the resources needed to implement an optimal solution are not available as a matter of historical, environmental, and/or political-economic contingency. When knowledge fails to work because of change in the natural or cultural environment, either new knowledge will be sought or unused knowledge will be applied to adjust to change and to meet goals. It is therefore always possible that adjusting to changing conditions will be unsuccessful or suboptimal because it is always possible that new or previously unused knowledge has long-term costs which negate any short-term adjustment value. Hence, it is always possible that attempts by individual producers to meet short-term interests can be incompatible with people's long-term interests or with long-term survival of the group. Two brief illustrations will show that human adjustments have long-term adaptive significance.

Minnis (1985), for example, argues that the Mimbres Mogollon attempted to adapt to population growth by first making a shift from semi-sedentary to fully sedentary extensive horticulture, and later (under continued population growth) by making a shift from extensive to intensive agriculture. According to Minnis, a period of drought in the A.D. 1100s led to the collapse of Mimbres society and the abandonment of the Mimbres heartland as a result of their inability to supplement poor harvests with gathered goods because they had by that time effectively degraded the nonagricultural environment. If Minnis's account is more or less correct (in addition to being plausible), then the choices they made to adapt to population growth are an example of the possible negative long-term consequences of short-term adaptive choices: "If the environment changes, the products of past selection may be stupid" (Campbell 1965:34).

The sacred-cow complex in India is a case in which adjusting to change may have led to readjustment that does not meet anyone's survival goals particularly well. Harris (1966) argues that the Hindu doctrine of nonviolence arose as a way of assuring that the cattle needed by Indian peasants for long-term agricultural and other purposes were not eaten as a solution to short-term periods of extreme food-scarcity. If Harris's account is more or less correct (in addition to being plausible), then although the sacred-cow complex sustains an extremely large population of Indian peasants, it does so under conditions of extreme poverty, disease, and short life expectancy that do not provide much for the peasantry beyond mere biological survival and population replacement. To the extent that Indian peasants want more material goods out of life than only those necessary to survive long enough to reproduce, then the sacred-cow complex, as a major element of their adjustment to natural and cultural environmental conditions, does little to meet those goals (Bennett 1967). Value issues aside, however, if Harris's account is correct, the sacred-cow complex has been rather successful at sustaining a population. Furthermore, if Harris's account is correct, it shows that the features of a successful adaptation may be suboptimal with respect to meeting people's nonsurvival goals even if it is efficient in the economic sense (*sensu* Schultz 1974) of using all available resources to the maximum extent possible.

Thus, a precise rendering of Binford's notion of "adaptive mode" as an attempt to adjust to changing conditions does not entail that the attempt will be successful, whether for agriculturalists or hunter-gatherers. Furthermore, it is necessary to note that this relatively precise rendering is simultaneously imprecise with respect to just exactly what is doing the attempting. On the "adaptationist" account, it is cultural systems that make the attempt in order to restore functional stability to the system (cf. Gould and Lewontin 1979). However, to claim that cultural systems are the objects that adapt is to attribute goals to those systems and, thereby, also to attribute a teleological character to adaptive processes: "To claim that an evolutionary change occurred *because* it was adaptive is to misunderstand evolution" (Rindos 1984:27, emphasis in original) and, perhaps, to ignore the fact that extinction is an evolutionary change that resulted from adaptive failure. Indeed, Rindos (1984:26, emphasis added) suggests that focusing on cultural systems as the things that adapt sidesteps the issue that "we must explain how *culture* recognizes perturbations [of equilibrium in the adaptation] and how *it* reacts to correct them." However, to claim rightly, as Rindos (1984) does, that attributing intentional or goal-oriented characteristics to cultural systems is unwarranted is not to provide a sufficient basis for claims that intentionality or purpose bear no relevant relationship whatever to adaptation, because adaptation depends on decisions made by people pursuing their subsistence and other goals. It is with regard to these goals that people act in their environments and from among these goals that people make choices. It would be an overly sharp application of Ockham's Razor, therefore, to eliminate human intentions from a theory of adaptation.

Consequently, the theoretical issue at stake is what role to attribute to human goals and intentional states such as knowledge of the environment and beliefs about the best ways to meet those goals. In our view, it is both false and methodologically inelegant to assume that hunter-gatherers wandered ignorantly and purposelessly about the Central Texas landscape. This entails that knowledge and goals are integral components of an adaptation, and that specific survival choices (whether made by individuals, consensus, or other means) are the basic units which determine the short- and long-term survival of hunter-gatherer groups. A human adaptation, therefore, can be regarded as a decision-making structure in which, given the information people have about the natural and cultural environment and the knowledge they have about technological means for exploiting resources in the environment, people decide what to do to meet their subsistence goals. Decision-making structures themselves are likely to be components of the knowledge transmitted from generation to generation because children are likely to be overtly and implicitly trained into those structures as they are socialized. Furthermore, in addition to the technical and social knowledge they obtain via socialization, children also tend to acquire aesthetic and stylistic preferences that affect their decisions.

Hence, an important feature of an adaptation is the socially transmitted decision-making structure people use to meet the subsistence and other goals contained in their preference structures. It follows, therefore, that it is people--not cultural systems--who recognize change in the environment and who react to it by proposing courses of action. This is not to say that they recognize climatic or environmental change as such, but rather that they recognize scarcity or abundance on a short-term basis and react to it by using whatever knowledge they have to meet their day-to-day and season-to-season goals relative to perceived or anticipated resource availability (Moore 1981; Binford 1981b; Blurton Jones and Konner 1976). If patterns of scarcity or abundance (including random patterns) are repeated often enough, their decision-making structure will be implemented repeatedly in response to recurring conditions. If the content of the knowledge base is appropriate, then short-term adaptive success will accompany repeated implementation of the decision-making structure and, given that the members of a group have a finite body of knowledge that is socially transmitted among them, the array of behavior that produced adaptive success will reflect the portion of the finite knowledge base that works. If the content of the knowledge base is inappropriate, then adaptive success can only come from changing the knowledge base and/or decision-making structure that guides choice.

As an object of inquiry, then, an adaptation is a knowledge base and a decision-making structure socially transmitted within, and historically implemented by, a community of people in order to meet their subsistence and other goals in an environment that contains a finite array of materials that can serve as the resources people use to meet their goals. Adaptations are *selected for* when ongoing historical implementation meets short-term goals and results in the continued social transmission of the decision-making structure by members of the community. Thus, for us, the reproductive mode of an adaptation is its continued social transmission. Adaptations are *selected against* when ongoing historical implementation fails to meet short-term goals, and the community either (1) adopts a new decision-making structure and/or knowledge base that meets short-term goals or (2) becomes extinct as a community. Thus, for us, the adaptive mode is the replacement of some or all elements of the decision-making structure and/or knowledge base by new elements that may or may not sustain the community. It follows from this discussion that a community with historical continuity can be in either the reproductive or adaptive mode for extended periods of time. In the former case, an adaptation may produce a consistently patterned archeological record that reflects more or less stable interactions between the members of the community and the environment. In the latter case, the community may pass through a series of adaptations in which change is incremental and detectable archeologically only on a cumulative basis.

In our version of cultural ecology, therefore, *adaptation* is the process of interaction between people and their environment. A history of adaptation in the Fort Hood area is the history of the succession of *adaptations* (i.e., decision-making structures) used by people to meet their subsistence and other goals. The history of adaptation (i.e., the succession of adaptations) is something to be explained in ecological terms, that is, in terms of the impact of environmental change on adaptations, the impact of adaptations on the environment, and the impact of contemporary adaptations on each other. This notion of adaptation, therefore, does not assume a priori that the history of adaptation will be characterized by relatively long periods of stability or homeostasis punctuated by relatively short (perhaps archeologically undetectable) periods of change. Rather, it assumes that identifying periods of stability and change is an empirical issue, and that the history of adaptation can in principle be characterized by long periods of change and short periods of stability.

The sense in which this ecological approach is cultural is that it assumes that knowledge is passed from person to person and generation to generation via socialization and other learning processes. Our notion of "culture," therefore, is somewhat old-fashioned in the sense that it refers to processes of transmission rather than to shared knowledge or to groups of people who share it. This is not to say that our approach regards groups of people as irrelevant: our concept of adaptations explicitly invokes communities as the frameworks within which adaptations are implemented. It is to say, however, that the identification of communities and the characterization of their structures is an important empirical problem because any given community is part of the biological and cultural environment for other such communities, and relations between communities are therefore important variables in the description of adaptations and the explanation of adaptive change. It is also to say that identifying ethnic groups whose members regarded each other as worthy of inclusion in a social group with a name is an interesting but peripheral and, probably, unanswerable question to which we will pay scant attention, but which other researchers can address on the basis of our results if they are so inclined.

4.2.4 Technology and Technological Change

The foregoing theory of adaptations does not address either the implementation of decision-making structures or the means by which we intend to identify or describe the structure of the communities that implement them. It seems clear enough that the implementation of decision-making structures has a great deal to do with technology, which in turn has a great deal to do with how communities are organized. This section, therefore, presents a theory of technology that deals directly with the nature of the systems through which people achieve their goals and indirectly with the means by which we will identify adaptive communities in the archeological record.

4.2.4.1 The Nature of Technology

In order to describe and explain the history of adaptation at Fort Hood, it is necessary to do so within a theory of technology that is sufficiently flexible to be applicable to a wide range of activities, environments, and so on, but also sufficiently robust to be useful as a guide for model building and hypothesis testing. The theory must:

- focus attention on the systemic relationship between tools and resources exploited by highlighting the fact that tools are produced in order to exploit certain resources (even if only generalized tools are produced);
- focus attention on the fact that the key systemic feedback link between tool production and tool use is knowledge of the requirements of tool use in production;
- focus attention on the fact that the support structures/processes which provide and maintain tools must be scheduled into the production activities in which tools are used;

- be applicable to analyses of technological stability and technological change;

- ideally be applicable to technologies ranging from the simplest to the most complex, but must at least be applicable to the technology of hunter/gatherers if it is to be used in the Central Texas area.

One such theory is Winner's (1977) concept of technology. Winner conceives of technology as involving three components or aspects that are analytically distinct, but functionally inseparable (Figure 4.5):

- technique, the procedural and other knowledge required to achieve a goal;

- apparatus, the tools and raw materials used to achieve a goal;

- organization, the social arrangement within which technique and apparatus are applied to achieve a goal.

Technology conceived in terms of these three components meets the requirements listed above. It focuses attention on the systemic relationship between tools and exploited resources by explicitly noting that all aspects of technology are goal oriented and that technologies are instrumental by nature. It further focuses our attention on the systemic nature of technology by forcing us to acknowledge that the goal of some technologies is to produce the tools needed for exploiting resources. Thus, some technologies occupy intermediate positions in the technological system by virtue of providing the support structures/implements needed to achieve a goal. Winner's concept therefore implies that a technological system includes subsystems for directly achieving goals (hereafter, "use-technologies"), and other subsystems that provide the basic services and equipment (hereafter, "support-technologies") without which use-technologies for producing commodities cannot function. This further implies that use-technologies must be integrated with support-technologies in order for either kind of technology to function: if there is no provision for support-technologies, use-technologies cannot be implemented, and if use-technologies cannot be implemented, neither can support-technologies.

In terms of archeological analyses, Winner's concept implies that a clear distinction must be made between support- and use-technologies. Because support-technologies are different from (albeit systemically related to) use-technologies, the attributes used to describe tool production (manufacture and maintenance) are likely to be inapplicable to the analysis of tool use, and the attributes used to describe tool use are likely to be inapplicable to the analysis of tool production even though both kinds of attributes often are present on the same artifacts. The explanation of technological change will involve describing the relationship between changing attributes of tool use and changing attributes of tool production amidst changing goal and decision-making structures (cf. Schiffer and Skibo 1987).

Winner's concept also meets the theoretical requirements above by focusing attention on the organizational aspects of the systemic relationships between support-technologies, use-technologies, and exploited resources. Regarding organization as a component of technology itself forces us to acknowledge consciously that tools do not make or use themselves, and making or using tools always takes place within some social context, even if that context is only an isolated individual acting on her/his own initiative for his/her own benefit. Persons making tools do so in a given social organization, persons using them do so in a given organization, and the relationship between persons making tools and persons using tools has some social organization, even if that organization is making tools for one's own use, which involves no exchange. Making and using tools, therefore, is necessarily embedded in an organizational framework that is undetachable from the making and using because the organization of a technology is as instrumental as the apparatus of technology.

In terms of archeological analyses, Winner's concept implies that spatial analyses are crucial to the analysis of tool production and tool use. The social organization of tool production cannot be inferred from tools alone, and must be inferred from lines of evidence such as the spatial distribution of given stages of the tool production process relative to the distribution of raw materials. The social organization of tool use can be inferred from evidence such as the spatial distribution of tools within sites, the distribution of tools from site to site, and the distribution of tools relative to exploited resources or paleolandscape features in the absence of direct evidence for exploited resources. An understanding of how tool production and tool use are socially organized into an integrated system of support- and use-technologies depends on a spatial analysis of the overlaps between tool production and tool use (see 4.2.4.2, "Rethinking the Nature of Technological Analyses" below).

Finally, the concept meets the requirements above by focusing attention on knowledge as an essential component of technology. Tools and commodities cannot be produced successfully without knowledge of some sort, and tools are the behavioral residue of the application of knowledge. Technologies cannot be propagated over time without a social organization for transmitting technological knowledge from generation to generation, and technological knowledge is a major component of the knowledge that is transmitted within an adaptive community. By focusing attention on knowledge as an inseparable component of technology, the concept further focuses attention on the vehicle through which technological change occurs. Within the cultural-ecological perspective of this research design, environmental variables are regarded as the primary causes of change (see 4.2.4.4 below). Although Winner's concept does not require this assumption, it is nonetheless consistent with such an assumption because environmental change alters the resource base, which in turn forces people to identify new resources (or identify new strategies for exploiting already recognized resources), which in turn forces them to change the ways they exploit resources, which in turn may force them to change the apparatus and organizations they use to exploit resources. Knowledge is the key variable in technological change because recognition of the effects of environmental change must occur before people can propose or recognize new means for exploiting resources and propose or recognize new structures to support the new means.

Thus, although knowledge never catches in the archeologist's screens, knowledge is a key conceptual component with respect to organizing archeological explanations of technology because knowledge is the instrument individuals use to link themselves to resources through tools used in an organization, and any explanation of the relationship between tools and resources makes at least implicit reference to this linkage (Schiffer and Skibo 1987). Furthermore, at a theoretical level, assuming that knowledge underlies adaptive behavior allows the researcher to infer on reasonable grounds that artifactual evidence of a distinctive adaptation refers to groups of people who shared a socially transmitted body of knowledge, although the inferred groups may not be equivalent to the emically identified cultures described by ethnographers because knowledge may be transmitted across community boundaries as well as within them.

4.2.4.2 Rethinking the Nature of Technological Analyses

Technological analyses of artifact assemblages typically are organized along the lines of chapters with titles like "Lithic Technology" or "Ceramic Artifacts" in Central Texas archeology. When they do technological analyses, researchers usually focus almost exclusively on the ways particular classes of artifacts are made (e.g., Dickens 1992; Ensor and Roemer 1989), in which case technological descriptions amount to descriptions of certain aspects of the support-technologies that are integrated into otherwise unanalyzed use-technologies for which the artifacts were produced in the first place. A focus on, say, "lithic technology" ignores the fact that lithic artifacts are produced for intended (even if sometimes general) purposes, in which case the researcher's analytical framework is virtually guaranteed not to coincide with the functional boundaries of any of a community's technological systems.

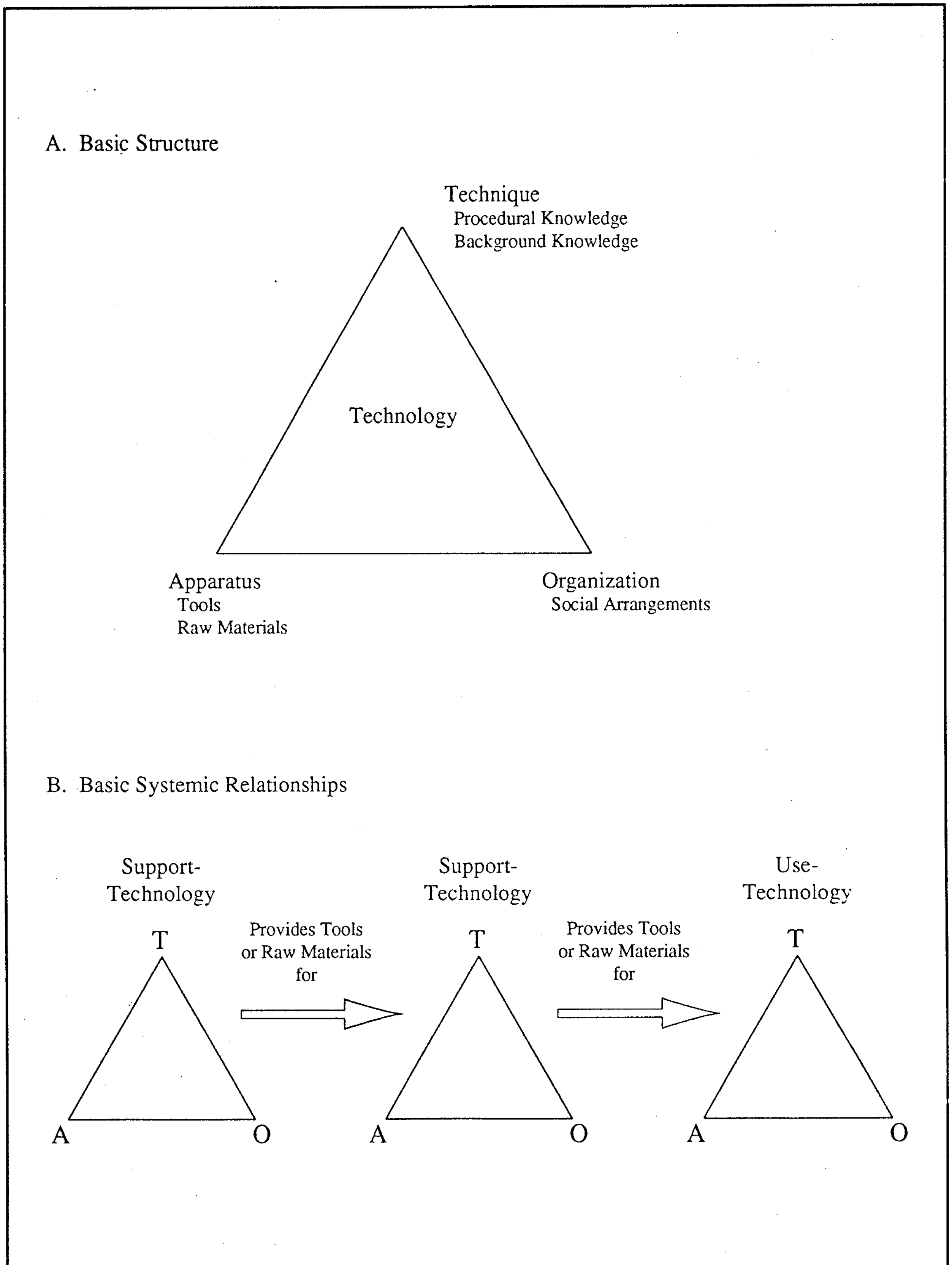


Figure 4.5 Winner's (1977) Concept of Technology (after Ellis 1992).

To illustrate, consider the steps that members of a hunter-gatherer community may go through in order to consume meat from large animals such as deer or bison. Figure 4.6 is a highly simplified model of a technological system for exploiting large game for meat consumption. (The hide-production system is not included, although it is certainly related.) At the most general level, they must employ a hunting technology that procures dead animals, a butchering technology that reduces dead animals to a portable, consumable, and/or storable size, and a processing/cooking technology that transforms dead-animal parts into consumable form. If they store meat for any period of time, they also must employ a storage technology. Each of these technologies is a use-technology linked together in a linear sequence that makes meat available for consumption, and each technology includes an apparatus, an organization, and a body of technique. However, the apparatus of each use-technology is itself a result of the employment of a support-technology (e.g., atlatl production) that in turn includes an apparatus, an organization, and a body of technique. Some of the support-technologies themselves may rely in turn on other support-technologies that, for example, provide the tools which serve as the apparatus for making points or digging sticks. Hence, the consumption of meat involves a series of distinct technological subsystems linked together by virtue of being directed toward a goal and organized amongst each other in a way that is intended to meet that goal. Note that some of the linkages between subsystems may be cyclical rather than linear if, for example, gut or sinew used to bind points to projectiles is procured from butchering animals killed with similarly made projectiles.

Furthermore, note that the technological system for meat consumption includes a number of elements that cannot be described in terms of more or less typical lithic technological analyses. For one thing, several of the technological subsystems (e.g., hunting, butchering, cooking) enter into the model after tool production (e.g., point, knife, scraper production--the usual objects of technological analysis) has taken place. Secondly, although analyses of procurement strategies and identification of raw-material sources have become a common feature of lithic analyses, a focus on lithic technology ignores the fact that there are other raw materials to be procured (e.g., fuel for fires, materials for making hearths) that figure intimately into, and may be indispensable to, the overall technological system for consuming meat. Still further, although attention to the spatial location of various stages of the lithic tool production process may shed some light on the organizational properties of lithic tool-production, a focus on lithic technology otherwise ignores the organizational properties of the larger technological systems for which production of any particular kind of lithic tool takes place. It is likely, of course, that the researcher never will be able to flesh out the details of a model such as that in Figure 4.6. However, note that Figure 4.6 is a graphic representation of a middle-range theory from which testable hypotheses about a particular meat-consumption technological system can be derived. As such, it points directly toward research questions that reasonably can be expected to yield answers: "Was meat procured in a meat-consumption technology organized along the lines of a logistical strategy?"

The items enclosed in dashed lines in Figure 4.7 are a hypothetical example of the array of activities represented by debris at a site. Suppose that the overall assemblage is meager in the sense of having low artifact density. Evidence of hunting includes the distal ends a couple of dart points. Evidence of butchering includes a broken blade with use-wear patterns typical of cutting bone and hide, and a scraper that has been identified as such because it has use-wear patterns typical of hide-scraping and lipid residues consistent with bison, the bones of at least two of which lie scattered around a hearth and concentrated a few meters away from the hearth. The bones themselves have cut marks, and very few portions of bison anatomy are unrepresented in the faunal assemblage, although the entire skeleton is not present. The hearth itself is made from a series of locally available flat stones laid on the surface, and the hearth stones have residues consistent with bison. Much of the debitage at the site has use-wear characteristics that indicate maintenance of tools used for cutting and chopping. A flat stone (also locally available) with

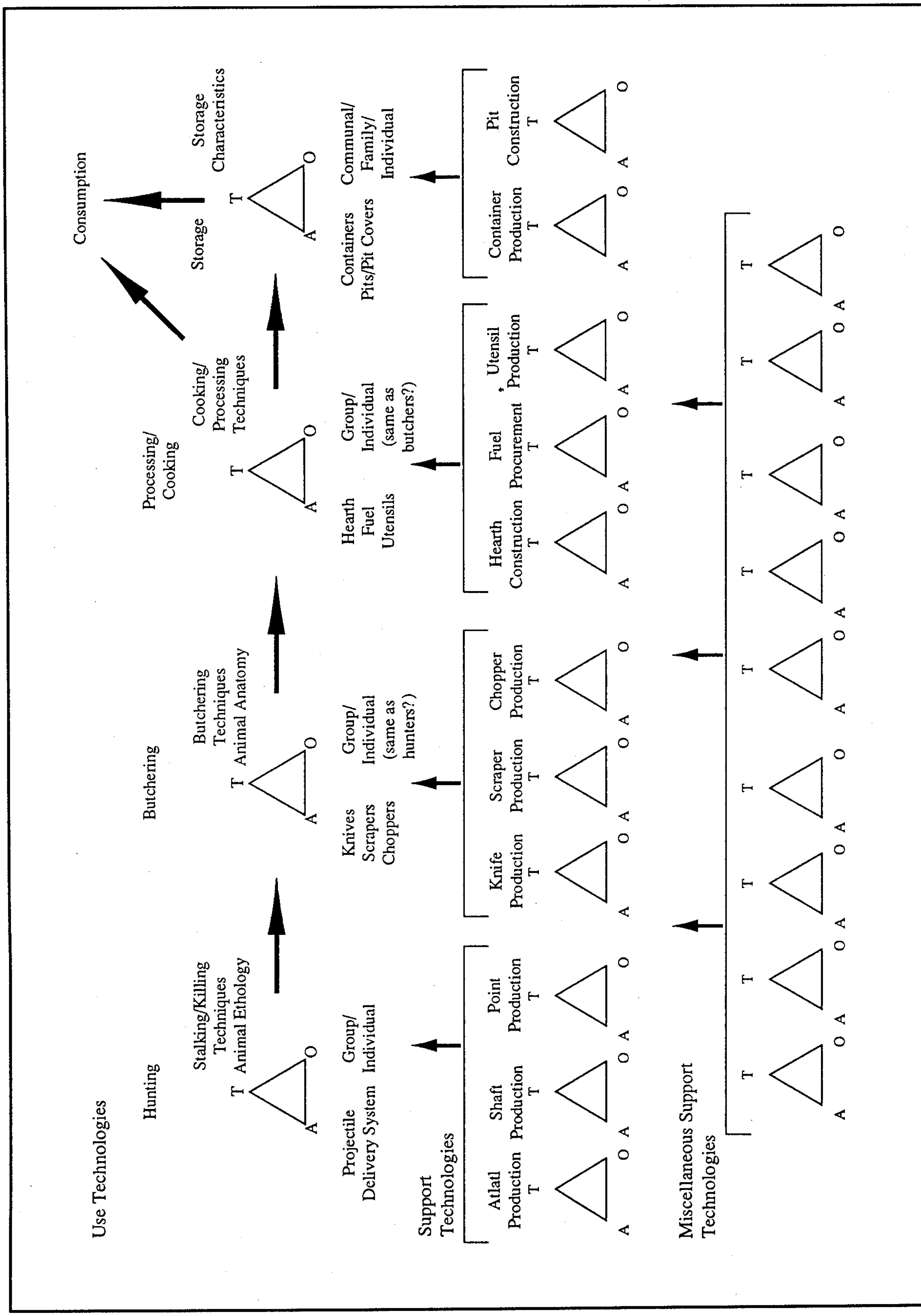


Figure 4.6 Hypothetical Technological System for Meat Consumption.

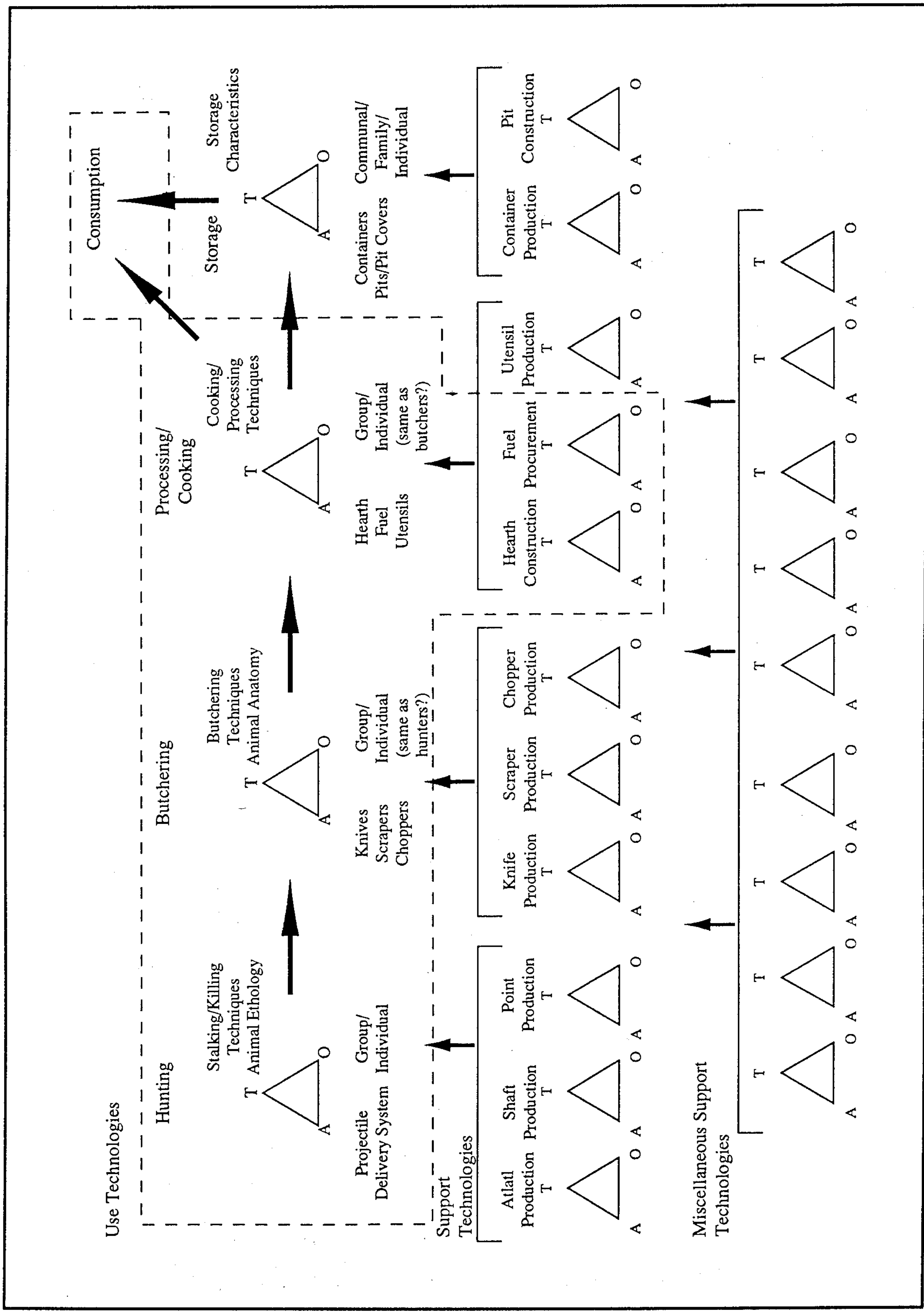


Figure 4.7 Elements of Meat-consumption Technology at a Hypothetical Site. Area in dashed lines represents a single site.

slight evidence of use-wear from grinding is near the hearth. Among the sparse ethnobotanical remains obtained between the hearth stones are charcoal flecks from wood and a few charred seeds from an edible species that matures in late summer, both of which are consistent with local availability in the reconstruction of the paleoenvironment. Several fragments of a turtle carapace belong to a species whose niche is consistent with paleoenvironmental conditions reconstructed for a small stream about a half-mile away. Radiocarbon dates from the seeds and charcoal are statistically indistinguishable, implying that if the site represents multiple occupations, they were too closely spaced to be chronometrically differentiated.

This hypothetical site has the earmarks of functioning in a meat-consumption technology organized in a more or less forager pattern. Not only does the evidence point toward procurement, processing, and consumption of bison in the same place (which implies that people were moved to the bison, and not vice versa); the variability of the subsistence remains implies that a range of subsistence tasks were performed there (which implies that the site was not occupied for mission-specific logistical purposes). The overall small size of the assemblage together with its low artifactual variability and functional integrity draw attention to what is missing at the site: evidence of relatively long occupation, evidence of a wide array of activities that would point toward a base camp in a collector-organized subsistence system, evidence of the support-technologies for the meat-consumption system, and evidence of most of the support- and use-technologies related to non-meat-consumption systems. This missing evidence is nearly as informative as the evidence actually found because it indicates that significant elements of the overall system were implemented elsewhere. Given the things that are present and missing, the site therefore appears to reflect a series of decisions made under a forager framework in which the decision to go hunting was followed by decisions to move people to the place where the bison was killed in order to butcher and consume at least part of it, and additional decisions to exploit other nearby resources. Hence, the hypothetical example shows that by framing a technological analysis in terms of the functional system instead of an artifactual category, an analyst has the capacity to move directly into the analysis of economic choices by focusing directly on the spatial distribution of various segments of the system, and noting the segments that occur together and those that do not.

Note, however, that characterizing the hypothetical example as a forager-organized meat-consumption technology does not successfully characterize it as *generally* being forager-organized. The site could represent, for example, an opportunistic event among people who usually were logistically organized with respect to meat-consumption, but killed a bison while en route from their late summer range to their fall range. The example would show only that the hypothetical site is consistent with a meat-consumption technological system that was forager-organized in one instance, and it would take a number of such sites to imply that the technology generally was so organized. However, even if enough sites are known to substantiate a forager-organized meat-consumption system, it still would be necessary to determine how that system was organized among other technological systems.

Figure 4.8 is a graphic representation of the possible relationship between the meat-consumption system and four unnamed subsistence systems. (For simplicity, miscellaneous support-technologies are omitted.) In Figure 4.8, several additional hypothetical site assemblages are enclosed in boxes in order to show that the primary problem of a technological analysis of hunter-gatherers involves identifying not only where the elements of any given system co-occur, but also where they occur relative to the places at which elements of other technological systems occur. For example, notice that elements of three systems are found at two different sites, and element of two systems are found at a third site. If the middle-range theories represented by each technological system are approximately correct, then the distribution of elements among different sites points to sets of subsistence- and support-related activities that occurred together at different places relative to other activities in the full array of subsistence technologies.

This further points to different sets of decisions made at different places. In a sufficiently large data base constructed with appropriate attention to archeological context, it should be possible to isolate use- and support-technologies that typically are and are not applied together. Furthermore, by identifying the seasonal characteristics of resource use, it is possible to identify patterns of *when* they occur relative to each other in addition to where. With this kind of technological data, the researcher is in a position to determine not only how individual technological systems are organized, but also how they are organized around each other at particular times of the year and how they are organized around each other from time to time in the year. Note that as data accumulate, the failure to locate portions of a particular system may be an important clue that the technological middle-range theory for that system needs revision. Hence, this form of technological analysis also provides a mechanism for refining one's ideas about how systems functioned.

Thus, although the elements of a typical technological analysis may yield substantial information relevant to the assemblage of support- and use-technologies for a given subsistence or other system, that information must be integrated into a totally separate analytical framework if one wants to know about the technological system as a whole. Conceiving of technologies in Winner's terms provides a powerful conceptual basis for reordering the study of technology in a way that models interrelated functional technological systems and subsystems within an overall technological system. By focusing on identifying the properties of functional systems rather than artifact classes, the theory of technology conceives of the overall technological system in a way that concentrates directly on the sequences of decisions made by hunter-gatherers to achieve their goals. This entails that the analysis is explicitly economic in the sense that it focuses on the trade-offs they made in their attempts to achieve their goals. In other words, it focusses on adaptations and people rather than on tools. This is not to say that typical technological analyses are irrelevant: the interpretive framework in the example above is totally dependent on elements of such analyses. However, it is to say that technological analyses should be done in reference to functional technological systems in order to obtain a maximum amount of information about the decision-making patterns that characterize individual technological systems as well as patterns among individual systems.

4.2.4.3 Identifying Communities

The foregoing theory of technology and theory of adaptations together provide a framework within which it may be possible to identify individual communities of persons. A "community" will be regarded in this research design as a group of people who interact with each other more than they interact with other people. The common root shared by the terms "community" and "communicate" is semantically and substantively important because in principle, a community defined in terms of intensity of interaction can cross ethnically, genetically, or emically defined boundaries in the event that people in, say, one emically defined group have more frequent contact with members of another such group than with members of their own group (cf. Harris 1979). This notion of community, therefore, is scale dependent. For example, two groups of people (say, groups A and B) can have high levels of day-to-day within-group contact and low day-to-day between-group contact. On the other hand, the members of groups A and B can have higher levels of season-to-season contacts with each other than they do with members of a third group C. Over the course of a generation, the members of groups A, B, and C can have higher levels of year-to-year contact with each other than they do with members of a fourth group D. Thus, the members of a community at any given scale can be members of any number of other communities at other scales.

Because people take their knowledge with them wherever they go, information exchange is likely to occur in both within- and between-group contacts. For example, when hunters gather to tell stories about a just-completed hunt, the story-telling activity directly exchanges information about the abundance and distribution of game and indirectly exchanges

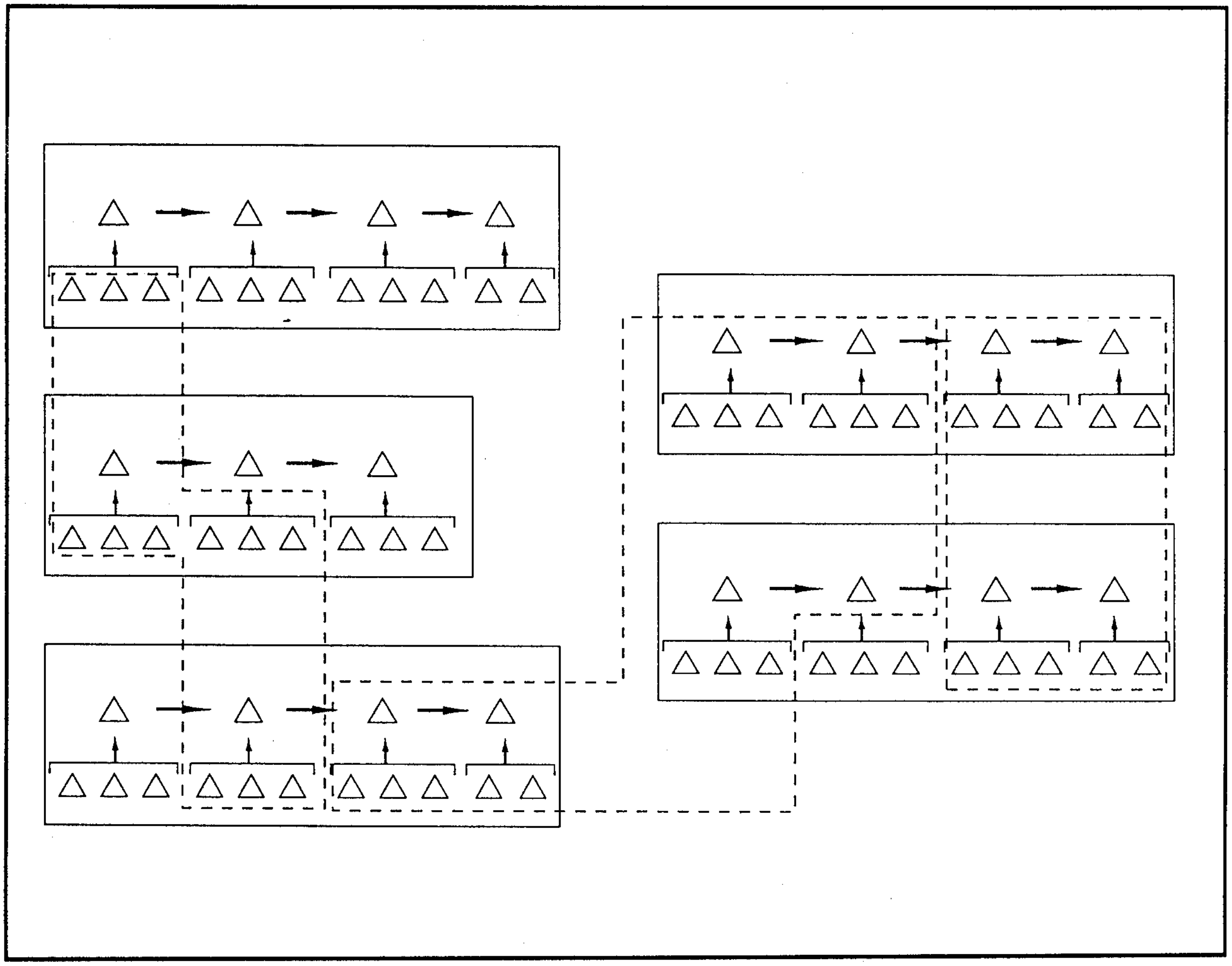


Figure 4.8 Hypothetical Intersite Relationships between Different Technological Systems. Each area in dashed line represents a different site.

information about animal behavior and ways to hunt (Blurton Jones and Konner 1976). If a mate moves from one group of people to another, his or her knowledge base goes along and becomes part of the day-to-day information-exchange base of the new group. Note, therefore, that to the extent mates are exchanged on a more or less reciprocal basis, marriage alliances between groups also are information sharing alliances, even if knowledge of certain tasks is gender- or role-specific (cf. Nanda 1991). Trade also exchanges information along with goods (van der Leeuw 1981).

Among the kinds of knowledge exchanged is knowledge of tools. Knowledge is an essential part of the tool-making process, and such technological knowl edge is a major component of the knowledge base handed down from generation to generation via conscious and unconscious socialization processes. The body of tool-making knowledge contains both procedural and stylistic elements. Stylistic features of artifacts are frequently a substantial portion of the basis on which artifact typologies are based because it is generally assumed that formal style is a culturally sensitive aspect of artifact production (Phillips 1970; Wilmsen and Roberts 1984). On the other hand, however, it is less widely appreciated that procedural aspects of artifact production are stylistic in the sense that although there are many possible sequences of steps a producer can go through to make an object, producers often may use only a limited array of possible steps (Lechtman 1977; Ellis 1992). Patterning in the procedures used to produce artifacts has been referred to as "technological style" because it reflects choices from a set of technical standards that are no less stylistic than the stylistic choices made from a set of formal or aesthetic standards (Lechtman 1977). Furthermore, although attempting to produce an artifact with certain formal or aesthetic properties may somewhat limit the array of procedural choices that will be successful in the production process, the procedural details of production of virtually any artifact can vary significantly (Rice 1987).

Within the array of procedural, formal, and/or aesthetic properties, it is possible for consistent variations to develop as a function of a kind of "founder effect" in which the historical transmission of knowledge among members of different communities begins with a few persons who have slightly divergent ways of making "the same thing." As this knowledge passes from generation to generation, the specific procedures transmitted from person to person may be modified slightly. In any given community, artisans with varying teaching skills, production skills, and/or specific applications for finished artifacts (e.g., using points on different kinds of shafts) may introduce and transmit procedural variability relative to the variability introduced by similar artisans in other communities, especially if the artisans in any given community regularly critique each other's products and/or adjust their production to reflect variability in the quality or availability of the natural resources (van der Leeuw 1981). Interactions among producers of a particular kind of artifact in a particular community can therefore generate relatively localized ranges of variability for technological style (as well as formal and aesthetic style) that may differ from the ranges of variability of producers in contemporary communities (cf. Rice 1987). The key variable is how widely information is exchanged, which in turn reflects the extent to which the social and, hence, information-exchange boundaries between producers are open or closed.

The identification of communities, therefore, depends on identifying relatively localized patterns of choices made with respect to the procedural, formal, and aesthetic details of artifact production. As noted previously, Johnson (1990) has found evidence in widely separated collections of Perdiz points that this approach may be realistic. He (Johnson 1990) has applied a similar approach to analyzing Toyah ceramics and found provocative (if also preliminary) evidence for localized variation. Ellis (1992) used variation in technological style to characterize a community of ceramic producers at a site in northern Harris County, and found substantive (if also preliminary) evidence that the producers who supplied the site's ceramic assemblage had distinctly different approaches to making pottery compared to the producers who supplied two other sites about 25 and 50 miles away. Interestingly, the evidence in both Johnson (1990) and Ellis (1992) allows for possible differentiation of communities of artisans in areas where little or no differentiation is visible in terms of projectile point and ceramic typological criteria. Moreover, within a technologically homogenous area that comprises a relatively large-scale community, it may be possible to distinguish smaller communities on settlement data (Savage 1990).

Thus, a middle-range theory that characterizes culture as the processes for person-to-person and generation-to-generation transmission of knowledge and characterizes adaptations as the knowledge bases and decision-making structures people use to meet their needs provides a solid basis for assuming that if one finds a number of distinct localized ways of producing artifacts, one has found evidence of the geographic range within which members of specific communities historically transmitted distinctive knowledge bases. Note that this is not necessarily the same thing as identifying genetically or ethnically related groups of people: information can easily cross boundaries between genetic or emically defined groups; genes can easily cross boundaries between emic groups or communities that share a common knowledge base; and emic groups need not coincide with the boundaries of genetic subpopulations or social structures whose members exchange information. The most that is identified is a historical continuum in which people, many of whom probably were biologically and ethnically related, exchanged information and attempted to meet their goals. It would take an additional middle-range theory, which we are not prepared to offer, to make any further distinctions.

4.2.4.4 Explanation in the History of Adaptation

The foregoing theories of adaptations and technology give a central role to knowledge, and to a large extent, our version of cultural ecology can be characterized as an ecology of ideas (cf. Bateson 1972). Such a characterization may seem odd because the various forms of cultural ecology generally are considered to be materialist perspectives (cf. Harris 1968, 1979). However, to acknowledge that intentional phenomena such as human knowledge, beliefs, and goals play a significant methodological role is not to abandon materialism; instead, it is to identify humans as cognitive animals who respond to changes in a physical environment that contains other such animals, and to acknowledge (contra Skinner [1953] and Harris [1979]) that thoroughly behaviorist materialisms have not been especially productive approaches to social science except when they violate their basic behaviorist premisses (cf. Rosenberg 1988; Putnam 1975). Indeed, even Schiffer, who has been as behaviorist as any other archeologist in rejecting a theoretical or explanatory role for intentionality (cf., e.g., Schiffer 1976) has found it necessary refer to intentional states to explain technological and, by extension, adaptive change (cf. Schiffer and Skibo 1987). In so doing, he violates or implicitly rejects the essential behaviorist methodological move which denies explanatory value to intentional states (cf. Rosenberg 1988). It is therefore necessary to for us to discuss how we will implement cultural ecological explanation of observed archeological phenomena in a theoretical framework that accords a major role to knowledge.

When archeologists implicate the environment in explanations of adaptive stability or change, they refer either implicitly or explicitly to a causal relationship between observed environmental conditions and observed archeological conditions. To say, for example, that expansion of the oak savanna in Central Texas led to the widespread adoption of a burned-rock technology for processing acorns for consumption is to propose a materialist causal statement, although it neither identifies a specific cause nor explains in detail the causal relation between the appearance of large numbers of oak trees and large numbers of burned rock middens. In addition to being a materialist causal statement, it also is a functional account of the emergence of burned rock middens which implies that the burned-rock technology was adopted amidst expansion of the oak savanna because doing so helped assure the survival of groups living there. Functional accounts such as this have been criticized (cf. Rindos 1984; Salmon 1982; Rosenberg 1988) because they appear to place the explanatory cause (adaptive success) sequentially later than the effect (adoption of acorn-based subsistence and burned-rock technology), thereby relying on teleology to explain adaptive success. However, the substance of such criticisms may be misplaced if functional claims are merely overly general as a result of inattention to detail on the part of researchers making them instead of being based on adaptationist optimism (cf. Rosenberg 1988; Salmon 1982; Cohen 1978).

If, as we have claimed, adaptive success or failure results from making choices that affect survival on a number of specific occasions, then the causal relationship is structured as follows. The environmental change that introduces large amounts of acorns must, given what we know in general about ecosystemic principles, be accompanied by reductions in other biota. To the extent that members of a community in this changing environment depend historically on the other biota for survival, their adaptation will fail increasingly as a means for meeting their short-term subsistence goals. The increasing frequency of failure to meet these goals poses a series of novel decision-making circumstances for members of the community in the sense that their survival goals remain, but the knowledge and/or decision-making structure that previously met those goals can no longer meet them (or meet them very well).

If the knowledge base/decision-making structure contains appropriate content that has hitherto been unused or if invention, diffusion, and/or acculturation provide new appropriate content, then the members of the group (given their survival goals) may be able to survive if they change the knowledge they act on or change the way in which they make decisions to act. In this event, the cause of adaptive change is cognition that circumstances have diminished the current value of the usual ways of doing things. If the solutions proposed on the basis of cognition are compatible with the nature of environmental change, then the effect is ongoing short-term adoption of new ways to meet old goals, and the replacement of old content by new content in cultural processes that transmit knowledge among members of the community. If the solutions proposed are incompatible with the nature of environmental change, then the effect is either extinction of the community as such or ongoing cycles of cognition and proposal of new means which eventually either sustain or fail to sustain the community.

If the acorn hypothesis is true and the adoption of burned-rock technology to exploit acorns is explanatory, then explanation of adaptive success would, therefore, be functional, but would refer to causes (environmental change and cognitive events) that are sequentially prior to their effects (new courses of action that worked on repeated implementation). In other words, the success of new adaptations is explained not only by the tautological fact that new adaptations sustained the members of communities adopting them; but also by the fact that at the time challenges arose to the survival value of previous adaptations, people had at their disposal means of meeting those challenges and transmitted those means among members of the community (cf. Cohen 1978; Salmon 1982). Similarly, adaptive failure and adaptive stability are explained by the respective tautological facts that means failed or succeeded in sustaining communities. However, in the former case, people did not have at the time appropriate responses, whereas in the latter, they not only had appropriate responses at the time, but ongoing transmission of the responses turned out to have survival value when implemented repeatedly over long periods of time. Thus, the explanation of adaptive stability and change within this research design is functional without being teleological because it refers to adaptive success, stability, and failure not as an intentional property of systems, but rather as the unintended net outcome of many instances in which the members of communities attempt to meet their short-term goals. In other words, the nature of explanation in this research design regards adaptive success or failure as accidental properties of systems composed of interdependent decision-makers, and assumes that people ask themselves and each other "What are we going to do today?" much more often than they ask "How are we going to set up a system that maintains us at equilibrium in the environment?"

The foregoing discussion suggests that we will use functional explanation, but it does not express the sense in which our approach is materialist. Our approach is materialist in the sense that it assumes (following Marx and Engels [1846] or Mill [1859, 1863], depending on whether one favors a radical or conservative inspiration) that adaptive significant choice is more likely to be influenced by the material contexts in which humans live than by ideological contexts. In our view, physical environmental conditions are especially crucial elements of the material context, not only for hunter-gatherers whose survival is very directly affected by environmental conditions, but also for people with other general approaches to survival. Even in sociopolitically complex groups, environmental change can lead to important long-term change. For example, in the early decades of the 1300s, recurrent wet summers ruined crops and led to massive depopulation and abandonment of agricultural lands in many areas of Europe (Lamb 1977). This in turn led to importation of grains from other areas, which may have introduced the Black Death (an environmental agent) into Medieval Europe (Gore 1992). The attendant massive mortality led to a severe reduction in the agricultural labor base, which provided a temporary improvement in the economic conditions of farm laborers that in turn may have been an important precursor to the rise of capitalist economies in Europe (cf. Toynbee 1976). Consecutive cold summers in New England in the early 1800s led to a massive wave of westward emigration and another round of dire adaptive consequences for Native Americans (Gunn n.d.).

Thus, it seems clear enough that environmental agents (such as climate and pathogens) can have a dramatic impact on human beings irrespective of the complexity of their economies or technological bases.

However, this is not to say that social and/or political-economic structures are unimportant. For example, Franke and Chasin (1980) note that the establishment by European powers of colonial borders in Africa helped disrupt symbiotic economic relations between Sahelian herders and horticulturalists. Franke and Chasin further suggest that the imposition by colonial governments of a head tax in a mostly cashless economy helped create an agricultural labor shortage by siphoning labor out of the subsistence-production system and leading to population growth as families attempted to replace their lost laborers. Spanish reliance on cattle and horses introduced elements into the Southwestern environment to which the Mimbres and Gila Apache apparently adapted in part by establishing a form of "ranching" wherein Spanish and Mexican colonists raised cattle and horses which the Apache subsequently harvested during raids (Smith 1962). Thus, political-economic features count as part of the environment to which people adapt.

This research design is therefore materialist in the sense that it looks first to the physical environment for the source of adaptive change. Specifically in the case of hunter-gatherers, it assumes that change in the physical environment is the most likely and immediate source of change because hunter-gatherers rely overwhelmingly on what the physical environment makes available to them. However, even hunter-gatherers can have a profound influence on the environment if, relative to the availability of resources, their level of resource extraction exceeds the level of resource reproduction. Thus, hunter-gatherer reproduction rates may be a feature of the biological environment to which a community must adapt and to which other communities must adapt.

On the other hand, political-economic factors also may be important if, for example, in an otherwise climatically, biotically, and demographically stable environment, one group's control over a crucial resource or one group's displacement by another group places it in conflict with other groups. In the absence of a plausible, identifiable environmental cause for adaptive change, this research design looks to political-economic factors as causes. Still further, there may be cases where both physical and political-economic factors are mutually affective such that change in each leads to change in the other in the form of positive feedback relations. Thus, like Harris (1979), we anticipate that environmental variables and causes can explain hunter-gatherer adaptation in Central Texas. Unlike Harris, however, we will not be surprised or disappointed to discover that political-economic variables and causes explain a great deal of adaptive change.

Having said this, it remains to examine the role of hypothesis testing in this research design, especially given our earlier claim that high-level middle-range theories such as our cultural ecological perspective can be neither corroborated nor falsified. Our theoretical perspective comprises a plausible worldview which we believe will lead to productive research. As such, any models developed under it cannot be regarded as confirming the correctness of the perspective whenever it happens that we produce plausible models. The role of the theoretical perspective, consequently, is to serve as a basis for deductively identifying testable hypotheses that cannot be false if the perspective is a good device for making archeological phenomena intelligible. Therefore, hypothesis testing must have some other role or roles.

One role for hypothesis testing is to discriminate distinct sets of data that are relevant to the theoretical perspective. As such, this role amounts to using statistical and other analyses to identify plausible candidates for phenomena such as function-specific tool assemblages and individual communities so that these can serve as an inductive basis for interpretation. In other words, hypothesis testing links our lower-level middle-range theories about tools and so on to empirical data in order to substantiate claims that there is a basis for believing that an assemblage has the meaning we assign to it. The results of hypothesis testing in this context provide the justification for using claims about assemblages as a basis for further interpretation.

The second role of hypothesis testing is to determine whether intuitions we have about relationships between claims emerging from the first level of testing are consistent with our theoretical perspective. In other words, having previously derived a series of claims about assemblages, the second level of hypothesis testing attempts to construct models of adaptations by determining whether or not, for example, the spatial relations between assemblages are consistent with a forager-organized strategy. Thus, the second level of hypothesis testing differs from the first only in the sense that it demonstrates whether higher-level phenomena are substantiated by the data.

It therefore follows that if this design is wildly successful in producing results, those results will be that the past had certain characteristics that appear to be highly plausible, *at least from our theoretical perspectives.* It also follows that if researchers operating from other perspectives reach different conclusions, theirs cannot falsify ours nor ours theirs because each perspective's successful models follow from competing untestable worldviews (Kuhn 1970; Feyerabend 1975; Lakatos 1978c). It further follows, therefore, that rejection of our conclusions can come only from two sources. The first is that within our perspective we have accepted hypotheses that are false in terms of our own perspective. In such cases, our conclusions are false because we have generated internal inconsistencies in our use of data, and they deserve to be rejected as such (Quine and Ullian 1970). The second source for rejection, however, is that regardless of how internally consistent our models and conclusions may be vis à vis our perspective, another perspective may produce conclusions that in addition to being internally consistent make better sense within the other perspective than ours do within ours. Thus, under the second criterion, if an alternative approach makes the world more intelligible than our approach, we should reject the latter because it is more feeble, not because it is false (Lakatos 1978c).

Such, then, is the project upon which this research embarks. It will examine the archeological record at Fort Hood from a cultural ecological perspective that includes other specific theoretical items. It does so in contrast to more traditional approaches not because the traditional approaches are based on false premisses, but rather because they have not succeeded in making the past particularly intelligible. Given that much of the previous work that has been done in Central Texas is predicated on traditional emphases that have not proved to be especially helpful to the study of adaptation in Central Texas and given that very little archeological work has been done at Fort Hood, it will be necessary to take a back-to-basics approach. What follows in Chapter 5, therefore, is a detailed plan for integrating data into the description and explanation of adaptations and adaptive change in the Fort Hood area, and for integrating Fort Hood prehistory into larger regional contexts.

4.3 CASE STUDY CONCLUSIONS

This chapter has presented a detailed account of the development of archeology in Central Texas in order to show that a research design for Fort Hood has little substantial empirical knowledge upon which to draw. The primary value of this example for cultural resource managers and interested parties at other installations is to show that a long history of archeological research in the region surrounding a military base does not necessarily produce a firm foundation for the definition of historic contexts that can govern CRM activities. This example also can be applied in regions where archeological research has been more successful than in Central Texas. However, in cases where previous research has been highly fruitful, research in some topic areas or for some time periods may be very highly developed, whereas research in other topics and periods may not have advanced beyond the most rudimentary levels. For example, in much of the Southwest, research in most topics in the archeology of agricultural groups has developed to the point where extremely specific historic contexts can be defined, whereas research in most topics related to preagricultural adaptations and groups has not advanced much beyond the state of Central Texas archeology (cf. Cordell 1984). In such cases, the level of scrutiny devoted here to Central

Texas archeology as a whole can and should be applied to existing individual historic contexts and to the background research upon which new historic contexts will be defined. Periodic critiques such as these will help assure that the state of the archeological art is well understood at any given time. This in turn will help assure that the current value of a cultural property is well understood so that management decisions can be made in accord with that value.

This chapter also presented an account of the theoretical perspectives that will guide research at Fort Hood. Although we believe that our theoretical perspectives can be applied productively at Fort Hood and elsewhere, our discussion should not be construed as a theoretical prescription for installations everywhere. The primary value of this account for persons interested in cultural properties at other installations is to illustrate the kind of detail one must go into in order to develop theoretical premisses into positions that can be critically assessed for their content. The content of the theory of technology and technological analysis, for instance, diverges fairly radically from standard usage in archeology. Had we not discussed this theory, even archeologically informed readers would not be in a position to determine what we mean by technological analysis. As a result, technological elements of the research design in Chapter 5 would make no sense. Had we not discussed the theory of technology *in detail,* we would have left ourselves open to dismissal for having sent a vague metaphor to do a theory's work. This points to a common problem with many of the terms (e.g., culture, adaptation, technology, context, science) used in archeological and anthropological theory: they have acquired so many divergent, but also widely accepted, meanings and nuances that one cannot assume that the use of such terms will result in communication. Thus, although the level of detail in this chapter is admittedly cumbersome, it gives readers (including those responsible for CRM at Fort Hood) a good chance of being able to tell exactly where we stand, including giving them an opportunity to identify potential weaknesses in our position and, therefore, to determine whether our research design is predicated on reasonable theoretical grounds. Hence, the value of the theoretical discussions is to serve as an indication of the level of performance that cultural resource managers at other installations should expect from the contractors or other persons who will establish the theoretical foundations for CRM activities.

5 RESEARCH DOMAINS

G. Lain Ellis

This chapter delineates a "back to basics" research design for archeological research at Fort Hood. As Chapter 4 demonstrates, there is considerable work to be done in the description and explanation of adaptive change in Central Texas as a whole. The prehistory of Fort Hood is as yet too poorly known to be able to tell how well general Central Texas frameworks apply at Fort Hood. Furthermore, given that there are indications that the notion of a "Central Texas" framework may obscure variability of adaptations both over time and at any given time, Fort Hood should be regarded as a laboratory within which to build a local history of adaptations to compare with other such histories in order to determine the extent to which there are grounds for asserting that Central Texas conforms to a regional model of adaptation. Consequently, there are good scientific reasons to take a very basic approach to the definition of research domains for Fort Hood archeology. Furthermore, given that a regional historic context for Central Texas has not been well developed with respect to the history of adaptation (or, for that matter, sociocultural groups), the possibility of implementing CRM activities at Fort Hood within historic contexts is limited to historic contexts of the most general of scopes. Still further, given that Fort Hood is an especially poorly known archeological area amidst only slightly better known areas, Fort Hood is a case where CRM activities should be directed toward developing a basis for the eventual definition of specific historic contexts. The back to basics approach of this research design, therefore, is consistent with Section 106 requirements to develop a basis for defining historic contexts where none exist.

Consequently, this research design approaches Fort Hood archeology as if it were new territory to be explored on the basis of limited prior information. Doing so from the outset will assure that as little as possible is taken for granted with respect to research in other parts of Central Texas, thereby assuring as much as possible (within the assumptions of our theoretical perspectives) that when one assigns significance to archeological phenomena at Fort Hood, one has not merely confirmed expectations of what should occur because it occurs elsewhere in the state. Furthermore, "starting from scratch" will assure that basic data from Fort Hood serves as the foundation for conclusions about prehistory at Fort Hood under the assumption that understanding local adaptation is logically and empirically prior to determining how Fort Hood fits into regional prehistory and regional models of adaptation.

In order to start this approach to Fort Hood archeology, two kinds of research domains will be defined: fundamental-research domains and substantive-research domains. Fundamental-research domains (or "fundamental domains") address the basic issues which underlie archeological analyses, but which ordinarily may be glossed over or collapsed into other less basic domains. Research topics within fundamental domains are expressed in the form of basic questions which often have obvious, even trivial answers. Fundamental domains pose these basic questions in order to focus the research program explicitly on basic data needs and basic research issues. They further focus researchers' attention on the fact that (1) answering mundane, foundational questions is a prerequisite to answering interesting ones and (2) a detour around the basic questions is the most direct path to idle speculation. The topics of the fundamental domains include identifying sets of chronological markers with which to date archeological and natural processes, reconstruction of paleoenvironmental conditions, identification of the subsistence resource base, and identification of technological attributes from which to infer the structure of technological systems.

Substantive-research domains (or "substantive domains") comprise the topic areas within which one is entitled to begin exploring adaptation and adaptive change after research in fundamental domains has established appropriate evidentiary foundations. It is in substantive-research domains that one can proceed from data to interpretations of the significance of data through a process of hypothesis testing. Thus, where fundamental domains establish data bases, substantive domains determine which hypotheses are sustained by the data, and which are falsified by it. Furthermore, the results of testing in any given substantive domain may serve as the foundations for testing hypotheses of increasing specificity and interest in subsequent substantive domains. Substantive domains, therefore, are the domains within which one moves from the most basic to the most complex conclusions about adaptive process and adaptive change that can be supported by the data, the inferential procedures, and the theoretical perspective.

The substantive domains are set up in an inferential structure that begins (in section 5.2.1) with the identification of technological apparatus, from which organizational properties of individual technologies are inferred (in section 5.2.2). Section 5.2.3 identifies the patterns of timing of changes in technologies and subsistence resources in order to identify temporal boundaries between possible adaptations and to determine whether an approach that uses temporally-diagnostic artifacts to define phase boundaries is relevant to the history of adaptations at Fort Hood. Candidates for distinct adaptations identified in section 5.2.3 are examined in section 5.2.4 in order to determine whether the evidence substantiates temporal divisions between adaptations. Section 5.2.5 carries the process further by attempting to identify distinct adaptive strategies whose characteristic stability/change is to be explained in section 5.2.6. The inferential chain ends in section 5.2.7 by placing the history of adaptation at Fort Hood into a regional context that may or may not coincide with the boundaries of Central Texas as it usually is defined.

Note that division of the research design into fundamental and substantive domains does not imply that research in any given area must await the completion of research in all prior domains. It is to be expected that data acquisition for each domain will occur on an ongoing basis, and that in the early progress of research it may be necessary to use plausible theoretical constructs in cases where empirical data is insufficient to draw substantive conclusions. It also is to be expected in the long run that detailed attention to some fundamental domains (e.g., "Chronological Markers") may become increasingly unnecessary while the addition of new fundamental domains may become necessary by the development of new analytical devices (e.g., use of chert-patination for absolute and cross dating). Thus, this research design is intended to serve as a guide to collection and analysis of data in projects of a wide variety of scales, with results from its implementation being largely cumulative and contingent on the amount of data collected at any given point following its implementation. Clearly, devotion of very large amounts of money and labor in a short period of time could lead to earlier substantive results than smaller amounts of money and labor spread over a longer period of time. Consequently, at any given time during the implementation of this research design, the researcher should not despair if budget or other constraints do not permit definitive resolution in one or more domains. Rather, the researcher should recognize that the research design is a framework within which results will emerge from both large and small contributions, and that incremental growth can be an important part of the research development process by showing where more attention is needed. Thus, this research design is predicated in part on the assumption that determining there is insufficient data on which to make certain inferences is a substantive conclusion that points not only to a need for interpretive restraint, but also to specific data needs.

Caveat Lector

Although nonarcheologists involved in CRM activities at military installations can gain some benefits from reading this chapter, it is intended almost exclusively for an archeological audience because it serves as a technical reference document that outlines a proposed course of research for Fort Hood. However, even for archeologists, the chapter is not entertaining reading because its structure is complex and its content is extremely (perhaps, as a previous reviewer put it, "mind-numbingly") detailed. Indeed, the structure and content of this chapter ask for a great deal of effort on the reader's part. The structure and content are complex and detailed for several reasons.

First, our basic theoretical perspective examines the history of adaptation in terms of human ecology, which implies necessarily that we will examine systems. By definition, systems are interconnected wholes within which no single component is isolated from other components (Bateson 1972), and our theory of technology and technological analysis characterizes tools, raw materials, social organizations, and purposes as having inextricably close systemic links. Thus, like Hodder (1986), although for different reasons, we do not view technology, social organization, subsistence, settlement, and other topics as separate areas of inquiry that can be addressed productively in disarticulated research domains. As a result, the substantive domains are set up in an "architectural" structure that serves as an integrated mechanism for translating data acquired in the fundamental domains into models of adaptations and adaptive change. Furthermore, the terms in which we have expressed our theoretical perspectives in Chapter 4 (especially the theory of technology and technological analysis) do not contain obvious methods for actually applying them in research. Hence, having adopted our particular theoretical perspectives, we have acquired the additional burden of showing the reader exactly how we intend to make them work.

The research design is organized as an inferential structure that therefore explicitly describes a logic of discovery within which we will implement research according to our theoretical perspectives. Thus, a second reason for complexity and detail is that the inferential structure would be highly flawed if we omitted or glossed over significant steps in the inferential sequence. Moreover, because the structure is a logic of discovery, it is necessary to attempt to be as precise as possible when fleshing out the content of each hypothesis and inferential step in order to be as unambiguous as possible about how we will move from step to step. Hence, much of the complexity and detail emerges from an attempt to assure that we have covered as many bases as possible because ambiguity or incompleteness in earlier steps could undermine the validity of later steps. Even in research conducted from other theoretical perspectives, it is necessary sooner or later to get down to this level of detail if one is to argue successfully for the validity of one's results. We believe that saving the hard work for later helps to assure that details will be overlooked during the course of research.

A third reason for the detail of the research design is to provide a basis for specifying the kinds of data that are necessary for research under our theoretical perspectives. The nature of each of the hypotheses (and their respective test implications) demands certain kinds of evidence. By presenting a detailed account of the elements of each research domain, we have also presented a case for the relevance of certain kinds of data. By default, we have also presented a case for many of the criteria that are relevant to determining a site's significance according to the research design. Much of the detail therefore provides explicit links between the research design itself and the criteria that determine eligibility according to the research design. For this reason, it may be worthwhile for the nonarcheological reader to work his or her way through at least some the fundamental domains in order get a feel for the ways in which the relevance of data is established and to get an idea of the kinds of data required by many modern approaches to archeology.

5.1 FUNDAMENTAL-RESEARCH DOMAINS

As noted, fundamental-research domains are problem areas within which research builds the foundational data on which archaeological inferences are based. The fundamental domains to be defined in this research design ask basic questions about chronological markers, environment, tools, artifact assemblages, and subsistence resources. These subjects comprise the basic data from which to derive models of adaptation. Consequently, this research design necessarily involves research issues normally pursued by disciplinary specialists because its theoretical perspective requires researchers to look to an array of natural as well as human data for the description of adaptive processes and the explanation of adaptive change. However, the requirements of description and explanation themselves require an interdisciplinary rather than multidisciplinary approach because the data from any one discipline must be thoroughly integrated with the data from other disciplines in order to be meaningful from the perspective of cultural ecology. The fundamental-research domains establish the basis for interdisciplinary integration by assembling the base of technological and environmental data that will serve jointly as the foundation for inferences of adaptive processes.

Each fundamental-research domain contains:

- a discussion of the nature of the domain and its relevance to Fort Hood archaeology;
- one or more basic questions to be answered in the domain;
- a discussion of the relevance of each basic question;
- subsidiary questions related to each basic question;
- a discussion of the relevance of subsidiary questions;
- data requirements necessary to answer the basic and subsidiary questions.

These domains are exceedingly basic in what they attempt to achieve. Consequently, some of them involve questions and levels of detail that the reader is likely to know so well as to regard them as trivial. They have been included, however, to establish in detail what needs to be done in archaeology at Fort Hood. If the reader has no desire to read through them, they can be skipped over and used as points of reference if questions arise later in our treatment of less basic issues. On the other hand, the reader should not skip section 5.1.4 ("Technological Apparatus in the Fort Hood Area") because this domain contains methodological information crucial to operationalizing the theory of technology and the form of technological analysis described in our theoretical perspective (see sections 4.2.3.2 and 4.2.3.3).

5.1.1 Fundamental-Research Domain: Chronological Markers in the Fort Hood Area

Problems of chronology are central to archaeology. In most research designs, the "Chronology" section refers to chronologies of the succession of cultural phases. Given that current models of the succession of cultural phases are controversial at best (Johnson 1987; Black 1989; Peter et al. 1982), culture chronology is something that should emerge from testing and should not be the subject of a fundamental domain. However, a basic problem to be worked out (at least in part) before culture chronologies can be confidently asserted is the identification of reliable chronological markers that can be applied in order to determine the timing of shifts in the nature of other data sets which serve as the basis for identifying specific adaptive strategies and, hence, culture-historical units that refer to adaptations. This section, therefore, concerns itself with the identification of chronological markers under the assumption that identifying chronological markers is a point of departure which is logically prior to identifying a succession of distinctive adaptations. This section is extremely basic and needs to be read only if the reader wants to know our rationales and methods for identifying chronological markers to be used as raw data for other purposes.

5.1.1.1 Temporally-Diagnostic Artifacts in the Fort Hood Area

Discussion

In a "target-rich" environment with relatively large amounts of chronometrically-datable material, problems of chronology can be significantly reduced simply by obtaining chronometric data that can be closely tied to the artifacts in an archaeological context of interest. Reducing problems of chronology, however, is not the same thing as eliminating them because even in regions where chronometrically datable items are well preserved and abundant (e.g., the Southwest), it is routine to encounter interesting contexts for which chronometric data is unavailable or in which the linkage between artifacts and chronometric data is not close enough to be useful (Cordell 1984). Thus, even in regions where there are many target-rich sites, nonchronometric dating often is necessary.

The principal means of establishing nonchronometric dating standards is to identify temporally-diagnostic artifacts. Identifying temporally-diagnostic artifacts requires identifying in the regional stratigraphic sequence a series of artifact types which either appear for short periods of time or appear in predictable frequencies relative to other artifacts (cf. Willey and Sabloff 1980). The assumption is that the sequential occurrence of distinct artifact types reflects the sequential adoption of distinct ways of making objects by the people in a region. Consequently, once the sequence of occurrence of distinct artifact types has been established for a region, whenever one finds temporal diagnostics in a new context, one can infer (within limits) that the new context is contemporary to other contexts with similar temporal diagnostics. When a sufficient number of temporally-diagnostic artifacts have been closely linked to reliable chronometric measures of age or date, then it is possible not only to identify a context's place in a regional sequence, but also to identify (within limits) the date of the context. Thus, chronology in archaeology requires both an understanding of the sequential order of temporally-diagnostic artifacts and a measurement of the dates at which different parts of the sequence occur.

However, the "within limits" proviso pertaining to the identification of temporal diagnostics masks considerable difficulty which reflects the fact that chronology-building procedures are affected by site-structure characteristics, which in turn are affected by site formation and transformation processes (Schiffer 1987). Re-use or long-term curation can blur the temporal boundaries during which an artifact was actively produced. Natural and cultural disturbance processes can introduce earlier artifacts into later contexts and later artifacts into earlier contexts. Uneven deposition rates across a given site over an extended period of time can place noncontemporary artifacts in the same excavation levels when a site is excavated in arbitrary levels (cf. Johnson 1967, 1987). All of these problems (and more) can weaken the linkage between artifacts and dated contexts in the absence of a critical evaluation of the processes that produced a given site structure modified by various formation and transformation processes. These problems further can weaken the linkage between target events (dated artifacts) and dated events (dated materials; cf. Dean 1978), especially when judgments of age for a given artifact type are determined from very small numbers of dates (cf. Turpin 1991; Johnson 1990, 1991).

Another set of problems emerges from the use of typologies for cross dating sites on the basis of diagnostic artifacts. During the early stages of modern scientific archaeology, theoretical procedures for identifying temporal diagnostics were fairly highly developed given the discipline's chronological focus (Willey and Sabloff 1980). However, an artifact typology can be subject to ambiguities that follow from problems of definition or replicability (cf. Johnson 1989; Dunnell 1971). For example, some Texas projectile point types have such wide ranges of variability that in some cases artifacts can only be referred to as, say, Bulverde-like points, while in other cases different researchers often cannot agree on type designations for individual artifacts (Johnson 1991). These problems negate (or at least weaken) judgments of chronological placement whenever ambiguously classifiable artifacts serve as the basis for cross dating.

Archaeological sites in Central Texas (and other regions of the state) typically do not provide target-rich environments for chronometric data, although the development of accelerator mass spectrometry (AMS) as a means of radiocarbon dating could ameliorate this problem to a great extent if AMS dating were applied more often (Black et al. 1992). Thus, establishing the age of a given site or provenience within a site typically depends on the use of temporally-diagnostic artifacts. Few (if any) typologically distinct artifacts have been directly dated at Fort Hood. Consequently, using temporally-diagnostic artifacts for chronological purposes at Fort Hood requires that temporally-diagnostic types be: (1) well-defined elsewhere with respect to diagnostic capacity; (2) well-dated elsewhere; and (3) relevant to Fort Hood chronology because they have the same dates at Fort Hood and elsewhere. Given that (1) many of the currently accepted diagnostic types for Central Texas were originally defined at sites relatively distant from Fort Hood; (2) many diagnostic types are dated on the basis of very small numbers of radiocarbon dates; (3) many were dated in the early stages of radiocarbon dating before there was a wide knowledge or application of procedures such as DELTA C-13 corrections; and (4) many were associated with radiocarbon dates before there was wide appreciation for the role of site formation processes as factors that can weaken the relationship between chronometric data and dated artifacts, then it is not at all evident that currently identified diagnostics can be applied at Fort Hood without a critical examination of their chronological place in the Fort Hood stratigraphy. This conclusion is reinforced by the observation that if diagnostic artifacts for the Toyah phase show a wave-like pattern of appearance (*per* Prewitt 1985), it surely is necessary to see if other diagnostics also appear more or less simultaneously and uniformly across Central Texas.

Thus, using temporally-diagnostic artifacts for cross dating at Fort Hood requires the analyst either to assume from the outset that what occurs at Fort Hood is identical to what occurs elsewhere and that what occurs elsewhere is uniform, or to begin chronology-building at Fort Hood with a critical examination of the relevance of already defined diagnostic types to Fort Hood. The former assumption will tend to lead automatically to conclusions that typological changes at Fort Hood and elsewhere occurred simultaneously and, therefore, is inconsistent with a research design in which one of the ultimate goals is to determine how Fort Hood fits into regional chronological framework. The latter approach, on the other hand, regards temporal diagnostics with a critical eye which, therefore, automatically regards the issue of the timing of typological change as an empirical issue to be resolved. At the least, a critical approach to identifying temporal diagnostics that verifies the existing basic chronological typology at Fort Hood will increase the regional utility of the typology by increasing the level of detail of temporal resolution within it. At most, a critical approach will demonstrate that the regional distribution of diagnostic types is chronologically complex, leading to appropriate revision of chronological aspects of Central Texas prehistory.

<u>Key Assumption</u>: Distinct types can be defined within a given artifact class (e.g., projectile points), and these types can be shown to belong to limited time spans on the basis of reliable stratigraphic and chronometric evidence. Note that the basic and subsidiary questions do not refer to named artifacts. This does not imply that nothing at all is known about diagnostic artifacts, but rather leaves researchers the options of testing both widely known, relatively established or innovative typological constructs in the evaluation of temporal diagnostics. It also implies that the search for temporal diagnostics can be directed toward artifact classes that have not yet been examined for temporal diagnostic potential.

Basic Question 1: Is there a succession of temporally-diagnostic artifacts at Fort Hood?

Relevance: The answer to this question is certainly and trivially yes. However, it is necessary to determine the temporally-diagnostic limits of artifact types at Fort Hood in order to use artifact types for cross dating.

<u>Subsidiary questions (SQ)</u>

SQ-1.1: For a given artifact class, which distinct types initially appear demonstrably earlier than other distinct types in the Fort Hood area, and which types do not?

Relevance: One feature of a temporally-diagnostic type is that it occurs earlier or later than other types in the sequence. Identification of the earliest type appearance date in dated contexts places a plausible lower limit on its occurrence in otherwise undated contexts. Clearly, the reliability of estimates of initial appearance depends on the number of dates available for a given type.

SQ-1.2: For any given artifact class, are there distinct types with temporal distributions that do not overlap significantly?

Relevance: One feature of a temporally-diagnostic type is that it has a limited temporal distribution relative to other types. Identification of the time spans of a type in dated contexts places a plausible limit on the time range of its occurrence in otherwise undated contexts. Clearly, the longer examples of a given type were made, the less precisely it is possible to use that type for cross dating.

SQ-1.3: For a given artifact class, are the relative frequencies of all distinct types in any given temporal interval of a frequency seriation for the Fort Hood area statistically different from all or most nonadjacent units of the seriation?

Relevance: In cases where the temporal distributions of types overlap significantly, the distribution of types in any given unit of a frequency seriation may be statistically different from the distributions in other units of the seriation. If so, then frequency seriations may be more valuable than occurrence seriations for cross dating, especially since cross dating from a frequency seriation accounts at least partly for curation and re-use, whereas cross dating from an occurrence seriation cannot.

Basic Question 2: Do diagnostic artifacts at Fort Hood have temporal properties identical to those in other parts of the Central Texas region?

Relevance: The answer to this question probably is trivially yes, at least for some parts of the sequence. Prewitt's (1981, 1985) chronology holds up fairly well as a projectile point seriation and a rough chronology of point-type appearance. However, Central Texas, as a defined archaeological region, is very large and somewhat variable (Jelks 1978; Prewitt 1981; Johnson 1991) and may be characterized by minor or major chronological differences from area to area. Identifying the similarities and differences between temporal diagnostics for Fort Hood and other areas is the only way to make sure that intraregional chronologies are comparable.

Subsidiary Questions:

SQ-2.1: For a given artifact class, is the date of initial appearance of temporally-diagnostic types the same in the Fort Hood area and elsewhere in the Central Texas area?

Relevance: Answering this question establishes one of the necessary bases for determining whether a given type places identical plausible lower limits on its occurrence in otherwise undated contexts throughout the region. If so, then there is a means for correlating events at Fort Hood with events elsewhere. If not, then other means may be necessary to cross date Fort Hood sites with sites elsewhere.

SQ-2.2: Are the temporal distributions of diagnostic types identical in the Fort Hood area and elsewhere?

Relevance: Answering this question establishes one of the necessary bases for determining whether a given type occurs at the same times in otherwise undated contexts throughout the region. If so, then there is a means for correlating events at Fort Hood with events elsewhere. If not, then other means may be necessary to cross date Fort Hood sites with sites elsewhere.

SQ-2.3: For a given artifact class, do all or most intervals of the frequency seriation for the Fort Hood area accurately predict the relative frequencies observed in contemporary contexts in other areas of Central Texas and vice versa?

Relevance: In cases where the temporal distributions of types are identical and overlap significantly in Fort Hood and elsewhere, the distribution of types in any given unit of a frequency seriation may be statistically identical to the distributions in contemporary units of seriations elsewhere. If so, then frequency seriations may be more valuable than occurrence seriations for cross dating, especially since cross dating from a frequency seriation accounts at least partly for curation and re-use, whereas cross dating from an occurrence seriation cannot. If not, then other means may be necessary to cross date sites in Fort Hood with sites elsewhere.

Data Requirements

Temporally-diagnostic Artifacts: The primary requirement is for a large, stratigraphically sequenced set of potential diagnostics for which a substantial chronometric data base is available at crucial points. Identification of temporal diagnostics for the Fort Hood area should and can only realistically begin with currently accepted typological criteria. Because current typological criteria are now and long have been widely used in the professional community, abandonment of current chronological type definitions should have a last-resort priority in order to minimize the introduction of unnecessary disarray into archaeological communications (cf. Johnson 1989 for both pro and con assessments). Furthermore, use of current typological criteria for their intended culture-historical purposes does not obviate using alternative classifications for nonchronological problems (Dunnell 1971; cf. Johnson 1990 for such a "cross-over" approach). Modifications to chronological typologies should occur only after diagnostic superiority of new or modified type definitions has been clearly and substantially demonstrated. Nor should the emphasis on identifying the date of initial appearance of various types be construed as a challenge to see who can find the earliest object, a contest that would transform identification of chronological markers into an end in and of itself. Preferred contexts for potentially diagnostic artifacts are discrete occupations and stratified sites in order to minimize cultural mixing (cf. Johnson 1967, 1987). In both cases, preferred sites for analyzing temporal diagnostics will occur under conditions of relatively rapid burial, which will minimize the impact of palimpsest overprinting (cf. Ferring 1986).

Chronometric Data: The chronology fundamental domain requires a rigorous approach to collecting and using chronometric data. Because chronometric data is only as useful as the closeness of the linkage between target events and dated materials (Dean 1978), the use of chronometrics to identify diagnostic artifacts must be self-consciously critical in two senses. First, materials for dating should, whenever practical, come from materials with precisely known stratigraphic relationships to the artifacts for which dates are needed. This entails a watchful eye on the part of excavators and careful documentation of the provenience of artifacts and samples collected for dating. It is essential that evidence of disturbance and other processes that negate the law of superposition be as well documented as possible. Second, interpretation of chronometric assays should be conservative in the sense that dates loosely associated with their respective artifacts or contexts are not taken more seriously than the association allows. Analysis of possible problems such as "old wood" (Schiffer 1986) is part of a conservative interpretation of chronometrics. To increase the reliability of chronometric dating, it is desirable whenever possible to obtain replicate dates and to use dates from over- and underlying contexts in order to place temporal brackets around diagnostics. Bracketing dates will be especially useful for building seriations. Collecting artifacts and dating materials from natural rather than arbitrary excavation levels whenever possible will help tighten the linkage between artifacts and chronometric data.

5.1.1.2 Geomorphic Dating in the Fort Hood Area

Discussion

Temporally-diagnostic artifacts do not occur at every site, especially in sites used only briefly by hunter-gatherers such as those who presumably occupied Fort Hood prehistorically. Landscapes, however, are only more or less stable, and geomorphic modification of landscapes often results in the burial of sites via processes for which approximate time frames can be established (Butzer 1982). Dating of geomorphic events, therefore, often can provide an alternative basis for dating archaeological sites (at least within gross limits) by establishing the age of various landforms, surfaces, and paleosurfaces, and for using that information to place temporal limits on the age of archaeological sites according to their stratigraphic relationship to dated geomorphic events. One especially informative limit to be derived from geomorphic evidence is the identification of surfaces which have been (or once were) exposed for extended periods of time. Such palimpsest surfaces can accumulate archaeological materials throughout the time they are exposed so that noncontemporaneous artifacts (temporally-diagnostic or otherwise) appear to be associated together, in which case the geomorphic evidence leads the analyst to reject the apparent associations (Binford 1977).

A basic geomorphic history has been established for the deposition of alluvial sediments in the major drainages at Fort Hood (Nordt 1992). This history correlates well with major geomorphic trends in other areas of Central Texas, and can be used to assign gross time limits to sites on their surfaces or buried during deposition. Knowledge of the geomorphic time limits on sites is valuable during site surveys for providing gross limits within which sites can be dated, for dating sites for which no other chronological data is available, and for identifying areas within which to look for sites when data from a specific time period is needed to flesh out a particular portion of the prehistoric record. However, little is known about the cut-and-fill histories of smaller drainages or about the timing of colluvial deposition processes at the interfaces between the uplands and the valleys at Fort Hood. The absence of such information inhibits the CRM process with respect to site survey, site prospecting, and dating of sites without temporal diagnostics or chronometric data. Furthermore, a thorough understanding of overall geomorphic change is necessary to determine whether it is possible that time periods or portions of the record in a given time period are missing as a result of wholesale erosion (Blum et al. 1992).

Basic Question 3: Is there evidence of chronologically diagnostic geomorphic change at Fort Hood?

Relevance: The answer to this question is trivially yes. Nordt's (1992) study has established a basic chronology of cut-and-fill episodes in the major drainages. However, even Nordt (1992:63) allows that more chronometric data is needed for portions of the chronology. Furthermore, Nordt's study did not extend into smaller drainages and did not deal with colluvial processes or landforms. Consequently, substantial data on geomorphic chronology is needed in order to use geomorphology as a chronological tool and to capitalize as fully as possible on Nordt's baseline study.

Key Assumption: The chronology of landscape transformation (including the timing of cut-and-fill and colluvial deposition episodes) can be determined from geomorphic and chronometric investigations, and such episodes can be correlated on the basis of evidence from soils, sedimentology, stratigraphy, and other geomorphic data.

Subsidiary Questions

SQ-3.1: Is there a chronological sequence of distinct alluvial deposition units (or remnants thereof) in the smaller drainages?

Relevance: If such a sequence can be identified, it can serve as a data base for assigning sites in the smaller drainages to different time periods for survey, prospecting, and dating purposes.

SQ-3.2: Are there distinct paleosols in alluvial formations in the smaller drainages?

Relevance: If distinct paleosols can be identified in alluvial deposition units in the smaller drainages, they may serve as a basis for estimating the age of sites buried in those units, for identifying palimpsest surfaces, and for correlating geomorphic events in multiple locations.

SQ-3.3: Is there a sequence of distinct colluvial episodes at upland/lowland interfaces?

Relevance: If such a sequence can be identified, it can serve as a data base for assigning sites in the smaller drainages to different time periods for survey, prospecting, and dating purposes.

SQ-3.4: Are there distinct paleosols within colluvial formations?

Relevance: If distinct paleosols can be identified in colluvial units, they may serve as a basis for estimating the age of sites buried by those units, for identifying palimpsest surfaces, and for correlating geomorphic events by identifying the same paleosol in multiple locations.

SQ-3.5: How does the timing of geomorphic events in smaller drainages and colluvial contexts correlate with events in the major drainages?

Relevance: Correlation of geomorphic events will make it possible to establish a basic chronological background for geomorphic change against which environmental and cultural change can be gauged.

Data Requirements

Geomorphic Data: Data on soils, sedimentology, stratigraphy, and correlation of stratigraphy of colluvial units and alluvial units in smaller drainages must be mapped for Fort Hood. Depositional history of these units must be correlated to each other and to the depositional history in Nordt (1992). It is desirable to refine Nordt's chronology by increasing the number of dates at the bottom and top of the units he has identified.

Chronometric Data: Chronometric data is essential to place colluvial and alluvial depositional events into a chronological framework. Dates should be obtained from the bottom and top of each unit and, where possible, from the bottom of overlying units to determine the time limits of deposition and surficial stability (Matthews 1985). Dates should be taken at vertical intervals within units in order to identify changes in deposition rates (cf. Ferring 1986). Dates from materials which can be tightly linked to archaeological features in the stratigraphy may be a primary source for these chronometrics (cf. Dean 1978). In many cases, it will be necessary to use soil organic matter as a source of chronometric data. Because Nordt (1992) notes some discrepancies between soil and charcoal dates, it may be useful to determine whether there is a consistent, statistically quantifiable difference between radiocarbon dates from charcoal and soil organic matter in order to make the latter more reliable when organic matter is the only datable material available (cf. Haas et al. 1986).

5.1.1.3 Summary of Chronological Markers Domain

This domain establishes basic chronological indexes against which to make judgments about the age of sites otherwise lacking chronometrically datable artifacts. A critically evaluated set of temporally-diagnostic artifacts is crucial for determining whether adaptive change corresponds to stylistic change (see 5.2.3) and for determining whether the appearance of temporal diagnostics at Fort Hood bears any relationship to their appearance elsewhere in the state. A very well dated sequence of geomorphic events for Fort Hood will not only serve as a basis for placing gross chronological limits on sites; it also will serve as a valuable basis for managing cultural resources. A detailed geomorphic data base will enable CRM managers and researchers to identify landscape features that are both likely and unlikely to be relevant to archaeological problems that refer to specific time periods, especially with respect to identifying surfaces with low probabilities of having single-component sites which are most likely to yield evidence from short-term occupations. Furthermore, pursuit of data on geomorphic chronological markers provides an excellent framework within which to pursue paleoenvironmental data necessary for this research design.

5.1.2 Fundamental-Research Domain: Paleoenvironmental Reconstruction

The cultural ecological foundations of this research design regard change in environmental conditions as a primary source of change in human adaptive systems. Consequently, paleoenvironmental reconstruction is an essential component of this research design because without it, there is no data base against which to make judgments about the relationships between human activities and the environment.

As a fundamental domain, paleoenvironmental reconstruction is oriented around establishing the nature of the nonhuman environment in order to identify the conditions to which humans had to adapt. This is not to deny that humans were an integral part of the environment or that they had no impact on the environment (Butzer 1982). Rather, it is to make a heuristic distinction that (somewhat) simplifies the description and explanation of human ecology by first isolating its nonhuman components and then placing the human components in context. Thus, the object of this domain is to obtain as detailed an understanding as possible of the environmental processes with which humans interacted, including attempting to model patchiness in physical and ecological conditions that might have affected decision makers attempting to extract a living from the environment. The basic questions in this domain concern themselves with paleoclimate, paleotopography, and paleoecology, all of which are interrelated subjects that in turn reflect heuristic divisions made to (somewhat) simplify the research process. As with the "Chronological Markers" domain above, this section may be skipped unless the reader is interested in knowing what our rationales and methods are for dealing with paleoenvironmental reconstruction.

5.1.2.1 Paleoclimate

Discussion

Climate must be regarded as a principal background condition of human adaptation because it is a systemic component of all the major environmental subsystems. Changes in climate have more or less predictable direct and indirect effects on geology, geomorphology, soils, plant and animal communities, and the productivity of ecosystems on which humans depend. Consequently, from the cultural ecological perspective of this research design, reconstruction of paleoclimates and climate change is an essential component of the study of human adaptations in general and at Fort Hood in particular. The methods listed below do not provide an exhaustive list of possible approaches to climate reconstruction. However, they do provide a list of realistic possibilities which hold considerable promise for deriving fairly fine-grained paleoclimatic models.

Basic Question 4: Was there climate change over time in the Fort Hood area?

The answer to this question is trivially yes. Nordt (1992) argues plausibly that at least some of the geomorphic changes in Fort Hood are climate driven. Bryant and Holloway (1985) present pollen evidence for climate change across Texas and North America during the period of archaeological interest at Fort Hood. However, the climate record for Central Texas is not particularly fine grained with respect to variations that could be relevant to adaptive change, and there are some significant divergences between interpretations (cf. Story 1990; Black 1989). Consequently, an effort must be made to obtain more detailed climate data.

Key Assumption: Paleoclimates can be reliably reconstructed on the basis of floral, faunal, geomorphic, and geophysical data.

Subsidiary Questions

SQ-4.1: What temperature characteristics are reflected in the proportions of various ostracode species in alluvial depositional units, and do changes in the ostracode assemblages indicate changes in average temperature over time?

Relevance: Ostracodes are aquatic invertebrates adapted to specific, often very narrow temperature regimes (Califano et al. 1964). The proportions of ostracode species are a direct reflection of temperature conditions, and individual species are indicators of minimum and maximum temperatures (Delorme 1989). Short-term change in temperature has a direct impact on ostracode populations so that a profile of change in ostracode assemblages correlated with an alluvial deposition sequence can provide a means for plotting the changes in temperature that accompanied deposition (Delorme 1989).

SQ-4.2: What salinity characteristics are reflected in the proportions of various ostracode species in alluvial depositional units, and do changes in the ostracode assemblages indicate changes in average salinity over time?

Relevance: Ostracodes are adapted to specific, often very narrow salinity regimes (Delorme 1989). Salinity is inversely related to rainfall such that periods of greater rainfall correspond to periods of lesser salinity as a result of dilution of stream discharge by precipitation (Kornicker 1964). The proportions of ostracode species reflect general salinity conditions, and individual species are indicators of minimum and maximum salinity. Short-term change in rainfall has a direct impact on ostracode populations so that a profile of change in ostracode assemblages correlated with an alluvial deposition sequence can provide a means for plotting the changes in rainfall that accompanied deposition (Löffler 1986).

SQ-4.3: Do faunal remains (other than ostracodes) show change in climatically sensitive species?

Relevance: The presence of climatically sensitive fauna in a given context places limits on the range of climatic values that could have occurred during the time that context was formed. If climatically sensitive species are present in the faunal assemblage and then disappear, their disappearance may indicate that again, a crucial climatic threshold was crossed (Butzer 1982). If climatically sensitive species are absent and then appear, their appearance may indicate that a climatic threshold was crossed. When faunal materials are recovered from archaeological contexts, interpretation of climate change must eliminate change in cultural selection patterns as the cause of appearance/disappearance. Even if change in cultural selection patterns cannot be eliminated, sensitive fauna may provide corroborating data for conclusions drawn from other climatically relevant data sets.

SQ-4.4: What oxygen isotope characteristics do ostracodes have?

Relevance: Oxygen is incorporated into carbonate materials (e.g., ostracode valves, soil carbonates, speleothems) during formation (Siegenthaler and Eicher 1986). Oxygen isotopes vary in proportion in carbonate materials as a function of temperature so that materials formed under different temperature regimes have predictably different oxygen isotope ratios. From these, it is possible to describe patterns of temperature change in precise values (Lamb 1977). Isotopic profiles of ostracodes correlated with alluvial deposition units can yield a measure of temperature change throughout the period of deposition (cf. Schwarcz and Eyles 1991). Oxygen isotopes, therefore, can provide an accurate, reliable means of reconstructing temperature-related aspects of paleoclimate and climate change.

SQ-4.5: What oxygen isotope characteristics do other faunal remains (e.g., land snails, beetles) have?

Relevance: Most faunal remains probably will be obtained from archaeological contexts. However, if samples of stratigraphically discrete faunal remains from short-lived species can be closely associated with well dated archaeological features, oxygen isotope characteristics of faunal material can yield information about average temperature during that animal's life span. Land snails (e.g., *Rabdotus*) should be especially amenable to climatic reconstruction via isotope analysis (Goodfriend 1992). This information can be collated into the isotopic record from other sources.

SQ-4.6: What oxygen isotope characteristics do pedogenic carbonate nodules and speleothems have?

Relevance: Isotopic profiles of soil carbonates and, especially, speleothems are known to record variation in temperature (Siegenthaler and Eicher 1986; Goodfriend 1992). Isotopic profiles from these sources, therefore, can provide temperature data that cover periods of erosion and/or stability of alluvial surfaces to fill in the gaps in ostracode profiles that result from gaps between alluvial deposition episodes.

SQ-4.7: Does diachronic variation in ostracode populations and/or oxygen isotope characteristics show a change in the pattern of temperature and/or rainfall extremes over time?

Relevance: Even under conditions of more or less stable long-term average temperature conditions, a change in the frequency and/or amplitude of oscillations around mean temperature and rainfall would have an impact on the composition of biotic communities and the productivity of an ecosystem (Smith 1977). Consequently, identifying the frequency and amplitude of changes in the pattern of temperature and rainfall extremes may be as important as identifying changes in means with respect to reconstructing paleoclimate (Butzer 1982).

SQ-4.8: Does pollen and phytolith data from noncultural contexts imply that there were changes in climate?

Relevance: Plant communities change in response to changes in temperature and rainfall. Consequently, the construction of pollen and phytolith profiles from noncultural contexts can demonstrate indirectly whether there were changes in the composition of the plant communities in Fort Hood and the surrounding region (cf. Butzer 1982; Ford 1988).

SQ-4.9: What composite reconstruction of paleoclimate can be derived from the ostracode, pollen, faunal, and isotopic evidence?

Relevance: A composite reconstruction can provide a basic model of climate change and variability within general trends. Producing the composite from a series of different data bases will help assure that the climate model which emerges during reconstruction is internally consistent as a result of emerging from mutually informative data sets.

Data Needs

Ostracodes: Intensive stratigraphic sampling for ostracodes at closely spaced vertical intervals in alluvial deposition units in a variety of drainages should be coupled with intensive chronometric sampling to place ostracode populations in a chronological framework. Given that the same ostracodes will be used for population- and isotope-based climate interpretations, the correlation of ostracodes to chronological sequence should provide a record of the temperature and rainfall patterns that accompanied deposition.

Faunal remains: Fauna other than ostracodes (e.g., snails, insects, small mammals) may have relatively narrow tolerances to climatic conditions (Butzer 1982). Such fauna may place limits on temperature and rainfall regimes corresponding to the time they were deposited (Elias and Van Devender 1990). Carbonatic shells of terrestrial fauna (e.g., land snails, beetles) preserved in alluvial sediments or other stratigraphic contexts also could serve as a data base from which to construct isotopic profiles of temperature change. Direct dating of such materials by AMS radiocarbon or other chronometric techniques can allow for construction of precisely ordered profiles of temperature change (Goodfriend 1992; Elias and Toolin 1990).

Soil and Speleothemic Carbonates: Speleothems, such as those formed from rainfall at driplines in rockshelters, should be sampled for oxygen isotopes. Speleothems are stratigraphic in nature, and oxygen isotope profiles from "deeply stratified" speleothems may provide both corroborative data for isotope profiles from other sources as well as bridges across gaps in ostracode profiles produced by gaps in the alluvial depositional record (Bradley 1985). Soil carbonates similarly can be useful for reconstructing gross temperature change (Bousman 1990). It is conceivable that a dated record of oxygen isotope change could be used as a cross-dating device (similar to dendrochronology) if sufficiently detailed data is forthcoming.

Pollen and phytoliths: Samples for pollen and phytoliths should be collected in the same way that ostracodes are sampled in alluvial deposition contexts. In addition, speleothems can be examined to determine whether they preserve pollen records that bridge gaps in the records from alluvial deposition units. If changes in oxygen isotope assays of speleothems correspond to changes in speleothemic pollen, the combination will be a powerful analytical device for paleoclimatic reconstruction, especially if the speleothemic stratigraphy can be placed in a chronometric framework.

5.1.2.2 Paleotopography

Discussion

Topography is a major influence on local variation in climatic, geomorphic, pedogenic, and ecological characteristics (e.g., biotic productivity and patchiness of distribution of biotic resources), and on human activities (Guccione et al. 1988). Paleotopographic studies complement paleoclimatic and paleoecological studies by providing data to be used as a form of experimental control for interpretation of paleoclimatic data. Furthermore, widespread changes in topography occur as a result of changes in climate and/or vegetation, and local to widespread changes can occur as a result of the impact of human activities (Blum et al. 1992). Still further, data on paleotopographic change can serve as an indirect means for interpreting paleoclimatic change (Bradley 1985). An understanding of paleotopographic change at Fort Hood, therefore, can be extremely useful for paleoenvironmental reconstruction because a knowledge of paleotopography is necessary to place other paleoenvironmental data in their appropriate contexts. An understanding of paleotopographic change also enables the analyst to identify archaeological contexts for which interpretation of cultural processes may be affected by palimpsest overprinting, geological reworking of archaeological materials, and wholesale destruction of possible archaeological contexts by massive landscape change (Schiffer 1987).

Basic Question 5: Was there topographic change over time at Fort Hood?

Again, the answer is trivially yes. However, the real issue to be resolved is largely to identify the details of paleolandscapes wherever such details are relevant to variation in microniches and to the patchiness of resources on the landscape, as these dimensions of variability ultimately are relevant to describing human adaptation and change in adaption (e.g., Turner and Klippel 1989; Rovner 1988). Note that whereas the focus on geomorphology in the "Chronological Markers" section is primarily chronological, the focus in this section is primarily processual.

Key Assumption: Prehistoric features of the landscape can be reliably reconstructed on the basis of geomorphic, geological, and geophysical data.

Subsidiary Questions

SQ-5.1: What topographic features characterized upland surfaces at various times prehistorically?

Relevance: The upland surfaces at Fort Hood currently have very thin soils in many places, a fact that influences the patchiness and productivity of biotic resources there. If these conditions did not exist prehistorically, then the distribution of biotic resources might have been much different. Therefore, identifying the paleotopographic characteristics of upland surfaces, if possible, would provide important data from which to interpret the paleoenvironmental characteristics of a large portion of the Fort Hood area.

SQ-5.2: At any given time prehistorically, did colluvial processes at the interface between upland

and fluvial surfaces create surfaces that would affect biotic diversity or patchiness?

Relevance: As topographic features, colluvial surfaces at the upland/lowland interface would be characterized by different slope, soil, sedimentary, and insolation characteristics that could lead to at least slight differences in biotic associations compared to adjacent scarp and alluvial surfaces (Ritter 1986; Brady 1990). If the characteristics of colluvial units were sufficiently different from those of the adjacent surfaces, the colluvial units could introduce localized heterogeneity of biotic productivity and/or diversity that would affect the patchiness of distribution of plants and animals (Smith 1977). A change in colluvial processes could, therefore, alter the local distribution of biotic resources by altering sedimentary and other characteristics of the colluvial surface.

SQ-5.3: What topographic features were produced by fluvial processes in large and small drainages at any given time prehistorically?

Relevance: Fluvial processes constantly modify the landscape, forming levees, point bars, and other features which differentiate the topography of valley surfaces (Schuum 1977). Some features, such as swales or oxbow lakes resulting from changes in channel location, create microenvironments that may support distinctive biotic communities or may create surfaces which were preferred for certain human activities. An understanding of fluvial paleotopography, therefore, is a necessary component for analyses of the distribution of resources and/or human activities.

SQ-5.4: What was the distribution of water sources in the Fort Hood area?

Relevance: Water is essential to the maintenance of biotic communities, and differential distributions of water lead to differential distributions of species. An understanding of the hydrology of Fort Hood, including the distribution of current and former springs, is essential to analyses of the distribution of biotic communities.

SQ-5.5: Can human influences on landscape change be identified in the prehistoric record?

Relevance: Human beings can have drastic impacts on their landscapes, impacts that can alter adaptive processes by altering one or more aspects of the ecological base. Typically, landscape impacts are attributed to agricultural adaptations more often than to hunter-gatherer adaptations (Butzer 1982). However, if human resource-exploitation activities were oriented at some point around processing large amounts of a concentrated resource in a short period of time, it is conceivable that they could cross hydrologic/biotic/geomorphic thresholds that would lead to landscape change. Note that answering this question will involve the integration of substantial archaeological data.

SQ-5.6: What was the surface distribution of geological materials on the prehistoric landscape at any given time?

Relevance: Most major, basic features of the landscape (e.g., rock outcrops) were established in geologic time before the appearance of humans, so this question is in some respects trivial because it is unlikely that significant geological change has occurred during the period of archaeological interest. However, the materials exposed during the period of archaeological interest are variable, and may have been differentially selected by humans (Dickens 1992). Furthermore, differences in geology correlate with differences in soil formation and other factors that affect biotic communities (Ritter 1986), and soil formation processes are significant within the period of archaeological interest (Nordt 1992). Hence, an understanding of variation in geological features may be crucial to understanding the distribution of biotic regimes and raw materials for human activities.

Data Requirements

Data for paleotopographic reconstruction are largely geomorphic and can be collected in conjunction with activities that collect data on geomorphic chronological markers and/or archaeological data.

Paleotopographic data from off-site contexts is essential. For purposes of paleotopographic reconstruction, culturally sterile stratigraphy below sites can be considered to be off-site contexts temporally displaced from the sites overlying them.

Uplands: A primary goal is to locate dolines (karstic depressions) on upland surfaces. Dolines may preserve a substantial stratigraphic record of upland landscape conditions (Ritter 1986). Suitable dolines must have preserved stratigraphy unaffected by military training activities. Primary data include sedimentary and stratigraphic data relevant to deposition and erosion, pedogenic data relevant to soil structure development and morphology, and chronometric data relevant to soil formation and deposition/erosion.

Colluvial and Fluvial Contexts: Primary data includes sedimentary and stratigraphic data relevant to depositional environments, pedogenic and morphological data relevant to identifying incipient and developed paleosols, spatial data relevant to the distribution of distinct features, and chronometrics to place features in a chronological framework (Ritter 1986; Birkeland 1984). Data on facies relationships between colluvial and alluvial sediments may provide information about patterns of upland erosion. Soil micromorphological data may be especially valuable for obtaining details on changes in short-term variability of depositional regimes (Courty et al. 1989).

Hydrology: Primary data includes sedimentary and depositional data (including precipitated chemical sediments at springs) that establishes locations, durations, and velocities of flow from ground and rainfall sources. Spatial distribution of points where rainfall transported from small ephemeral streams is concentrated on alluvial or other surfaces may identify locations of greater vegetation cover (cf. Malmer and Regnéll 1986). Such a distributional map, as it evolves during ongoing research, may help identify locations of microniche variability.

Nonbiological Resources: Primary data includes spatial data on the distribution of sources of lithic materials, especially cherts, with distinctive physical and geophysical characteristics (cf. Banks 1990; Dickens 1992). Consequently, it is necessary to characterize physical and geophysical variability in lithic resources. Primary data also includes spatial data on the distribution of soils and sedimentary units relative to bedrock in the Fort Hood area, and correlation of soils/paleosols to geologic features (Ritter 1986). Such a distributional map, in conjunction with a hydrologic map, may help identify locations of microniche variability.

5.1.2.3 Paleoecology

Discussion

Whereas the previous two sections deal largely with nonbiological aspects of the environment (even though paleoclimate reconstruction relies in part on biological data), this section concerns itself with reconstruction of the biotic communities of Fort Hood. Reconstruction of paleoecological relationships establishes the nature of the resource base from which human communities selected certain elements for use. In conjunction with paleoclimatic and paleotopographic data, paleoecological data may, in some cases, allow for the reconstruction of microniches, which may in turn serve as a basis for discussing the patchiness of resource distribution, which in turn will serve as an element from which to infer human adaptive strategies. Furthermore, paleoecological reconstructions can serve as measures of climatological regimes and climate change in the absence of more direct evidence.

Basic Question 6: Has there been change in ecological communities over time at Fort Hood?

Key Assumption: Paleoecological relationships can be reconstructed on the basis of floral, faunal, and isotopic data.

Subsidiary Questions

SQ-6.1: What were the kinds and proportions of pollen in noncultural settings at any given time in the Fort Hood area?

Relevance: Pollen profiles from noncultural settings record changes in the composition of the surrounding plant community. As a result, it is possible to reconstruct the vegetation assemblage of an area, in many cases down to the species or genus level. Change in pollen profiles often can be interpreted reliably as corresponding to change in the general character of an area's vegetation (Bryant and Holloway 1985). At present, pollen data relevant to Fort Hood has been obtained from only a few sites, some of which are distant to Fort Hood and some of which may be heavily influenced by cultural selection factors because pollen was obtained from occupational levels of rockshelters (Story 1990; cf. Ford 1988). Furthermore, major portions of the stratigraphic columns from which pollen data has been obtained are poorly dated, so the pollen record can at best demonstrate general trends (cf. Story 1990).

SQ-6.2: What are the kinds and proportions of phytoliths (arboreal/nonarboreal, long/short grass) in noncultural settings at any given time in the Fort Hood area?

Relevance: Phytolith analysis, although still in its youth as an analytical technique, can provide information about the basic nature of a plant community at least down to the level of distinguishing between forested and grassy environments (Rovner 1988). Analysis of the stable carbon isotope characteristics of phytoliths can overcome some of the limitations of morphological ambiguities of phytoliths by providing a more direct measure of the vegetational characteristics of a phytolith catchment (Kelly et al. 1991). Phytolith analysis, therefore, can be useful for identifying basic shifts in the vegetation community.

SQ-6.3: What are the carbon isotope characteristics of ostracodes and soil organic matter in the Fort Hood stratigraphy?

SQ-6.4: Shifts in the basic vegetation of a drainage basin can be recorded in the carbon isotope characteristics of the tissues of ostracodes that feed on organic detritus in streams (Schwarcz and Eyles 1991) and in the soil organic matter that accumulates on aggrading and stable surfaces (Cerling et al. 1989). Profiles of change in carbon isotope characteristics, therefore, may record basic shifts in the vegetation of Fort Hood.

SQ-6.5: What specific vegetation characteristics can be extrapolated from the presence of narrowly adapted faunal species at any given time in Fort Hood?

Relevance: Some fauna (e.g., beetles, snails) may be closely associated with certain plants or vegetation communities. In such cases, it may be possible to infer in some detail the nature of the nearby ecology (Hoganson and Ashworth 1992; Elias and Van Devender 1990; Goodfriend 1992). If a sufficiently detailed record can be obtained at many locations on Fort Hood, it may be possible to map biotic patchiness at a relatively fine-grained level. It may also be possible to describe the microniche or microcatchment areas for specific locales.

SQ-6.6: What composite reconstruction of paleoecology can be derived from the floral, faunal, and isotopic evidence?

Relevance: A composite reconstruction of paleoecology will show the overall synchronic and diachronic variation in plant and animal communities in the Fort Hood area. Producing the composite from a series of different data bases will help assure that the ecological model which emerges during reconstruction is internally consistent as a result of emerging from mutually informative data sets.

Data Requirements

Sampling conditions are the same as for the paleoclimate section, with phytoliths and soil organic matter being sampled identically to pollen and ostracodes. Whenever possible, soil organic matter should be step-fractionated and radiocarbon dated to yield subsamples with different mean residence times for comparison of carbon isotopes of different age distributions (Ellis 1992).

5.1.2.4 Paleoenvironmental Synthesis

Discussion

Each of the previous three sections establishes independent lines of evidence and/or data from which to reconstruct certain aspects of paleoenvironmental conditions. It is necessary, therefore, to collate the results from each section into a unified whole that describes paleoenvironments as fully as possible in terms of general trends and (as much as possible) localized variation (e.g., Rovner 1988). Three related basic questions are relevant to the reconstruction of the paleoenvironment. Note that all three are different sides of the same triangle, differentiated largely in terms of scale.

Basic Question 7a: What composite reconstruction of paleoenvironment emerges from the paleoclimatic, paleotopographic, and paleoecological reconstructions?

Basic Question 7b: What level of paleoenvironmental variation can be discriminated at the Fort Hood level from the reconstruction?

Basic Question 7c: What level of microniche variability can be discriminated at various locales within Fort Hood?

Relevance: Integrating the results of paleoclimatic, paleotopographic, and paleoecological reconstructions will provide a comprehensive data base on which to base descriptions and explanations of human adaptive behavior. The process of integrating the various reconstructions will simultaneously illuminate general trends and provide for a maximum degree of resolution of local variation.

Data Needs

Substantial progress in the reconstruction of paleoclimate, paleotopography, and/or paleoecology is necessary for a paleoenvironmental synthesis.

5.1.2.5 Summary of Paleoenvironmental Domain

Paleoenvironmental reconstruction is necessary because the natural environment provides the array of possible edible materials from which hunter-gatherers choose for consumption. Hence, understanding the difference between what was available and what was actually chosen for subsistence is a major factor in understanding hunter-gatherer adaptations and the potential environmental reasons for change in subsistence. Paleoenvironmental synthesis can begin with data from short segments of the stratigraphic record and/or from a relatively limited array of data sets if necessary. Thus, it is possible for paleoenvironmental research to be conducted in conjunction with archaeological survey, testing, and mitigation activities. However, an active paleoenvironmental research program that *precedes* survey, testing, and/or mitigation projects can assist CRM managers and researchers by identifying points at which climatic or other environmental change should lead to adaptive change as a result of significant change in the resource base. For example, if geomorphic research has identified depositional units of the right age to contain relatively rapidly buried archaeological deposits that correspond to paleoecological change, then such archaeological deposits are extremely valuable as sources of data for evaluating adaptation in conditions under which the theoretical perspectives of this research design predict adaptive change should occur because of changes in the array of possible subsistence resources.

5.1.3 Fundamental-Research Domain: Subsistence Bases at Fort Hood

Discussion

In most research designs, the "Subsistence" section collapses at least two research topics into one by including the identification of subsistence resources and the description/explanation of subsistence strategies in the same analysis. However, identification of the subsistence resources that actually were used is logically prior to beginning the discussion of subsistence strategy, and the description of a subsistence base can be complex enough by itself to warrant individual treatment. The complexity of describing a subsistence base follows from the fact that identifying an item with *potential* economic value in an archaeological context is not the same thing as identifying something that is in archaeological context *because* of its potential economic value (Ford 1988). Thus, describing the subsistence resource base is a matter of establishing a human rather than natural origin for the potentially economic items in an assemblage. Furthermore, it is necessary to have a description of change in the actual resource base before it is possible to explain cultural change in terms of changes in resource exploitation (Flannery 1986). Further still, describing a subsistence strategy is a high-level analysis that relies on inferences from an array of data of which the subsistence base is but one data source (Winterhalder and Smith 1981; Jochim 1976). Consequently, identifying the subsistence resource base is treated as a fundamental domain in this research design in order to establish a set of reliable empirical claims about the nature of exploited resources before going about the task of describing or explaining the decision-making structures, technologies, and other elements that went into exploiting the resources.

Note that this domain addresses only biological resources used for food, despite the fact that items like lithic resources are directly related to the subsistence process. The equivalent treatment of lithic resources and nonfood biological resources has been deferred to a subsequent domain ("Technological Apparatus in the Fort Hood Area") under the assumption that, because raw materials are part of the apparatus that serves as the means for acquiring biological resources, the raw materials selected for use in food-getting and food-processing occupy different subsystems from the subsystem occupied by the raw materials selected for metabolism. Thus, "subsistence base" refers to biological resources used for food.

Basic Question 8: Was there change in the subsistence base actually exploited by inhabitants of the Fort Hood area?

Relevance: The answer to this question almost certainly is yes, but so little subsistence information for Central Texas has been definitively corroborated by direct data that much of the subsistence base can be regarded as effectively unknown (see 4.1.3 and 4.1.5 above). Furthermore, given that there is wide environmental variability across Central Texas, it is likely that the subsistence base at Fort Hood could have a number of similarities to the subsistence base elsewhere, and yet still differ in enough respects to constitute a different adaptation. Consequently, identifying season-to-season patterns and long-term patterns of stability and change in the subsistence base is a major research objective to be achieved under this research design.

Key Assumption: Among the potential resources identified in a paleoenvironmental reconstruction, it is possible to distinguish exploited resources from natural background noise on the basis of nonrandom co-occurrences, contextual data, taphonomic data, and other grounds.

<u>Subsidiary Questions</u>

SQ-8.1: Does the pollen and phytolith assemblage within a site differ significantly from the contemporary assemblage outside the site?

Relevance: If the pollen and phytolith assemblage within a site is statistically different from that outside the site and potentially economic species are nonrandomly overrepresented in the within-site assemblage, then there is good reason to believe that the difference between the assemblages resulted from cultural selection processes, especially if other lines of evidence also point toward nonrandom overrepresentation of potential economic species. Overrepresentation of species with potential food value is good reason to believe those species formed part of the subsistence base (cf. Hastorf and Popper 1988).

SQ-8.2: Does the macrobotanical assemblage within a site differ significantly from the contemporary assemblage outside the site?

Relevance: If the macrobotanical assemblage within a site is statistically different from that outside the site and potentially economic taxa are nonrandomly overrepresented in the within-site assemblage, then there is good reason to believe that the difference between the assemblages resulted from cultural selection processes, especially if other lines of evidence also point toward nonrandom overrepresentation of potential economic species (cf. Hastorf and Popper 1988).

SQ-8.3: Do vertebrate or invertebrate faunal remains within a site show evidence of use by humans?

Relevance: If faunal remains show taphonomic evidence of use (e.g., cut marks, burning) by humans, there is sufficient reason to believe those species formed part of the subsistence base.

SQ-8.4: Are vertebrate or invertebrate faunal remains within a site inappropriate for the microniche contemporary to the site?

Relevance: If faunal remains with evidence of human use are found in nonrandomly high numbers in an archaeological context that was an inappropriate microniche for the species (e.g., a cluster of clams on a terrace surface), there is sufficient reason to believe that species formed part of the subsistence base.

SQ-8.5: Do charred seeds and plant parts with known food uses occur within a site at a nonrandomly high rate relative to their proportion of the flora represented in contemporary pollen/phytolith profiles?

Relevance: If seeds or other plant parts from potential food species occur in sites at a rate that is nonrandomly high in comparison to the floral community reflected by off-site pollen/phytolith evidence, there is good reason to believe that the overrepresented species were part of the subsistence base.

SQ-8.6: Are charred seeds and plant parts within a site inappropriate for the microniche contemporary to the site?

Relevance: If charred floral material with known food value is found in a site in an inappropriate microniche (e.g., upland species in riverine sites), there is good reason to believe that the species formed part of the subsistence base.

SQ-8.7: Is chemical evidence of food sources present in archaeological contexts in nonrandomly high amounts compared to contemporary off-site contexts?

Relevance: Presence of lipids and/or proteins (or the decompositional products thereof) in archaeological contexts may constitute evidence of subsistence resources if it occurs in concentrations higher than in off-site contexts, especially if it occurs on tools (Marchbanks 1989; Collins et al. 1990).

SQ-8.8: Does the floral and/or faunal content of coprolites represent a nonrandomly small array of the species in the contemporary paleoenvironment?

Relevance: If the floral/faunal content of coprolites represents a nonrandomly small array of contemporary species and if species with potential food value are nonrandomly overrepresented within the array in coprolites, there is good reason to believe that the overrepresented species comprise part of the subsistence base (Bryant 1974).

SQ-8.9: What seasonality characteristics accompany the floral and faunal evidence?

Relevance: For any given floral or faunal species which can be inferred to be part of the subsistence base, identifying the season(s) within which that species was exploited serves as the basis for modeling the year-round nature of the subsistence base. If after accumulation of a large data base the identified subsistence base is shown not to contain elements from one or more seasons, the absence of such elements may prove to be a crucial element in the interpretation of adaptive strategies (see 4.1.4.2 above).

SQ-8.10: What are the trace element and carbon and nitrogen isotope characteristics of human bone from the Fort Hood area?

Relevance: Human tissues, including bone, acquire trace element content and carbon and nitrogen isotope characteristics that reflect diet. Isotopic and trace-element analyses can identify (within certain limits) gross dietary composition in terms of the basic proportional contributions of animals and C3, C4, and CAM plants (Krueger and Sullivan 1984; DeNiro 1985). Isotopic and trace-element signatures of human bone can in turn be analyzed in conjunction with other subsistence data to model diet at more detailed levels (Huebner 1991).

Data Requirements

Floral Subsistence Base: Pollen, phytolith, and macrobotanical samples must be collected from on-site contexts, including features and less discrete contexts. Data from tight stratigraphic contexts will serve as the best basis for modeling subsistence-resource bases. Samples from less discrete contexts (e.g., interstitial matrix in burned rock mounds) are certain to represent mixed assemblages, but may nonetheless provide significant evidence of the subsistence base if they show nonrandomly different composition and nonrandomly high economic content relative to off-site assemblages. Thus, in the early stages of implementation of this research design, it may be useful to use large amounts of interstitial fill from palimpsest burned rock middens to obtain ethnobotanical samples within which edible materials are identified for species, anatomical part, and seasonality characteristics. By directly dating such edibles via AMS radiocarbon techniques, an initial temporal model of the subsistence base can be constructed from which to derive specific test hypotheses about the subsistence decisions that accompanied burned rock midden accumulation. This initial model can in turn enable CRM managers and researchers to assign higher or lower preservation priorities to portions of the archaeological record on the basis of their likelihood to address specific resource-exploitation issues. Samples from less discrete contexts will be more useful when obtained from identifiable natural stratigraphic contexts formed under rapid depositional conditions that minimize palimpsest accumulation of floral materials. In all cases, care should be taken to collect samples as free from postdepositional disturbance as possible. Furthermore, it will be desirable to collect living species from which to construct comparative collections for phytoliths if the interpretive value of phytolith analyses is to be maximized (cf. Kelly et al. 1991). Note that a comparative data base from off-site contexts is necessary to derive maximally confident statements about the subsistence base (Ford 1988).

Faunal Subsistence Base: Evidence of faunal subsistence resources will be obtained from on-site features and from less discrete on-site contexts. In order to maximize the possibility of locating remains from small vertebrates, fine screening should be employed (cf. Sanchez and Shaffer 1992). In order to identify potential insect resources, coprolite evidence would be preferred (Bryant 1974). In all cases, preferred contexts are stratigraphic natural levels sealed by rapid burial. Documentation of evidence of rodent disturbance is essential with respect to identifying possible reliance on rodents for subsistence.

Chemical Evidence: Sediment samples should be collected from on- and off-site contexts for assays of lipid and protein content. Chemical studies will be most relevant to testing Creel's hypothesis that burned rock features were oriented largely around acorn processing. Because acorns have very high lipid content (Turner 1989), acorn bulk-processing stations should be expected to accumulate lipids (and decompositional products thereof) at higher than natural rates as acorns from many trees were concentrated in a relatively small area. Although failure to locate high lipid concentrations assignable to acorn processing would not falsify a dependence on acorns, it would constitute evidence which weakens hypotheses that burned rock features resulted primarily from large-scale harvest of acorns by collectors or aggregated foragers, especially if lipids and/or proteins assignable to nonacorn sources constitute a significant portion of the chemical record.

Isotopic and Trace Element Studies: Human bone from in situ burials is the most desirable data base for isotopic and trace element studies. However, if bone specimens are large enough for chronometric dating as well as isotopic and trace element assays, bone from disturbed contexts can provide information about diet at a given time, even though the dietary information will not be assignable to an artifact assemblage.

5.1.3.1 Summary of Subsistence Domain

Identification of the subsistence resource base is a crucial element of the research design because the location and nature of subsistence resources is a major determinant of hunter-gatherer behavior. The subsistence resource base (in an area and at specific sites) is a direct, if also partial record of the exploitative decisions made by human beings. Therefore, the subsistence data collected from various sources provides direct information from which to establish the spatial and temporal distribution of exploitative decisions. Consequently, the data obtained in this domain is roughly equivalent to a catalog of subsistence goals toward which people directed their activities and for which they employed technologies. Thus, by the time research in the paleoenvironmental and subsistence domains is well advanced, the researcher has in hand evidence for the nature of the environmental context of human activity and for the patterns of subsistence choices they made from that context.

5.1.4 Fundamental-Research Domain: Technological Apparatus in the Fort Hood Area

Discussion

This section comprises the basic data collection method for operationalizing the form of technological analysis to be pursued in this research design (see 4.2.3.2 above). The concept of technology outlined above (see 4.2.3.1) distinguishes the physical components of technology from the knowledge and organizational components. Indeed, the robusticity of the concept as a theoretical guide to model-building emerges from its capacity to force the analyst to distinguish between hardware and other elements of technology, and between the goals a technology serves (e.g., getting specific food resources) and the physical instruments (e.g., tools, raw materials, fuels) produced, used, and consumed in that technology. By focussing attention on the fact that some technologies are support technologies for other technologies, the concept also forces the analyst to recognize that some artifacts (or attributes of artifacts) relate most directly to tool production, whereas others relate most directly to tool use and still others relate most directly to materials consumed in tool- and commodity-production processes.

Thus, in an archaeological framework, the concept of technology is a theoretical device which forces the analyst to explicitly recognize the fact that raw material procurement, tool production, and tool use occupy different sequential positions in a given technology, and that an analysis of tools must order artifacts (or attributes of artifacts) into appropriate subsystems of an overall technological system. Consequently, this domain will be divided into sections concerned with artifact production, tool use, and consumables. The outcome of answering the basic and subsidiary questions in each section provides the basic data for analyses of the apparatus component of technological systems used by inhabitants of the Fort Hood area. A synthesis of the data accumulated in this domain involves focusing on tentative identification of technological apparatus which may be directed toward exploitation of distinct subsistence resources and, subsequently, testing the validity of these apparatus against subsistence evidence. The synthesis, which in the "Site Function I" domain below, is the basis for beginning to identify adaptive strategies.

Note that in what follows, certain biological artifacts (e.g., wood charcoal) typically examined in a context of economic species will be regarded as technological in nature because their use is instrumental in commodity production rather than being the object of direct consumption in subsistence. Thus, fuels, lithic raw materials, and other materials can be analyzed in equivalent terms as elements of technological subsystems. Also note that items such as burned rock and features such as hearths also will be regarded as artifacts that are technological in nature.

5.1.4.1 Tool Production

Discussion

The nature of tools is one of the defining characteristics of a technology. However, part of the archaeological problem to be resolved before identifying the nature of tools is to identify the set of artifacts produced via human agency and, thence, to identify tools from among the artifacts produced by human agency. This section, therefore, addresses the production processes and morphologies of manufacture-modified artifacts in order to describe the array of objects produced for various purposes in the adaptive process. Manufacture-modified artifacts are artifacts that acquire their non-natural attributes via direct human agency as opposed to acquiring them coincidentally in a human activity. For example, stone can acquire attributes of flakes and battering marks via human agency, but flake attributes are a direct outcome of lithic reduction, whereas battering marks are coincidental to it. Note that this section can include artifacts with idiotechnic and sociotechnic functions as well as more straightforwardly economic functions, although the identification of function is not part of this section. Also note that not all tools are subject to analysis under this basic question because some tools (e.g., hammerstones) may enter the technological system without manufacture-modification and, therefore, without being "produced" in any sense beyond merely being picked up.

Basic Question 9: What are the morphologies of manufacture-modified objects produced in the Fort Hood area at any given time, and what techniques were used to produce them?

Relevance: A description of the kinds of human-made objects in an assemblage and the ways those objects were produced is a basic element of any technological analysis of subsistence because one must first identify manufacture-modified artifacts before one can determine their place in a technological system. A manufacture-modified artifact's place in a technological system can be as a byproduct of a production process, as in the case of debitage. Distinguishing between byproducts and tools in the case of informal tools can only be accomplished by the analysis of use characteristics, which is the subject of Basic Question 10 below.

Subsidiary Questions

SQ-9.1: Were manufacture-modified artifacts with recurring morphologies produced at any given time at Fort Hood?

Relevance: The answer to this question is certainly and trivially yes. However, aside from projectile points and a few other artifacts (e.g., "Waco sinkers") it is not clear what morphological types recur within the assemblage of manufacture-modified artifacts. Hence, it is necessary to discover whether there are unrecognized classes of manufacture-modified artifacts within which distinctive types ultimately can be identified as tools to some useful level of precision. Furthermore, the morphology of a manufacture-modified artifact can have important influences on that artifact's suitability for an intended function if that artifact was intended to serve as a tool. Note that morphology can refer to attributes such as edge angle, edge shape, mass, and other elements of an artifact's shape or size, and morphological similarities may be confined to commonalities of one or two such elements on otherwise dissimilar artifacts.

SQ-9.2: What array of techniques were used to produce manufacture-modified artifacts at any given time at Fort Hood?

Relevance: An understanding of the techniques of artifact production is ultimately necessary if the analyst is to understand tool function because the techniques of tool production are the steps by which a producer establishes the basic characteristics of tool morphology and suitability for an intended use. Hence, an understanding of artifact production techniques may serve as a basis for determining whether morphology and/or suitability for an intended use were related to a series of tool-production decisions. Furthermore, it is necessary to discover whether formal tool classes such as projectile points and ceramics are characterized by locally peculiar production techniques that may imply local cultural or environmental influences on tool making. Note that production technique can refer to the steps employed to maintain or recycle a tool.

Data Requirements

Data for answering this question will come from technological analyses of artifact production in which the analyst describes the steps by which an artifact was manufactured. Relevant data can be obtained using lithic classification schemes that rely on mass analysis of debitage (e.g., Ahler 1972) and general formal properties of lithic reduction systems (e.g., Sullivan and Rozen 1985) to distinguish between assemblages that do and do not reflect statistically identical reduction activities from site to site. Stage analyses can be used in conjunction with replicative studies to identify production trajectories for specific lithic tool classes (e.g., Crabtree 1972; Shafer and Hester 1983; Cotterell and Kamminga 1987) and for pottery (e.g., Ellis 1992; Rye 1981; Reina and Hill 1978). Metric analyses and typological studies can be used to describe morphological characteristics of lithics (e.g., Futato 1977, 1983; Kennedy and Lin 1988; Turner and Hester 1985) and ceramics (e.g., Hagstrum and Hildebrand 1990; Rice 1987). Data on performance properties of raw materials can be drawn from experimental and replicative studies (e.g., Bronitsky 1986).

For most purposes in this research design, the most useful source of data for technological analyses is discrete occupational contexts that minimize the impact of palimpsest overprinting. Such contexts will assure as much as possible that associations sought in the substantive research domains (section 5.2.1) result from functionally related processes rather than accidental juxtapositions. Caches of tools and/or other artifacts also will be very useful, especially if they can be associated with either discrete occupations or short-term site-formation episodes that limit the range of possible associations with other aspects of a site's assemblage. Features themselves (e.g., hearths) should be described in terms of their properties as tools, and burned rock midden studies should focus on burned rock as either the in situ or secondary remains of technologies.

There are some purposes for which technological data from less discrete contexts may be valuable. Technological analysis of typologically identifiable artifact classes (e.g., projectile points and ceramics) will be a primary means for identifying communities of producers who implemented adaptive strategies (see sections 4.2.3.3 above and 5.2.6 below). In order for the data bases of typologically differentiated artifacts at Fort Hood to be suitable for statistical comparisons of identity and difference in other areas of the state, it is necessary to have data bases as large as possible. To the extent that cultural processes in the Fort Hood area perpetuated relatively localized procedures for making any given artifact type, then the diachronic assemblage for given types at Fort Hood should show aggregate characteristics that differentiate Fort Hood from other areas. Thus, assemblages of typologically distinct *and* temporally-diagnostic artifacts obtained from palimpsest contexts will provide a comparative technological data base for assemblages of similar artifact types both from more discrete sites on Fort Hood and from other areas of the state. Comparative assemblages of this kind will serve at least as a basis for initial models of the long-term procedural variability of typologically distinct artifacts at Fort Hood, and may serve as a comparative basis for determining whether Fort Hood occupies a position within a single community's historical range or occupies a zone of overlap of neighboring communities with distinct long-term approaches to production of similar artifacts.

5.1.4.2 Tool Use

The attributes of artifact use are distinct from the attributes of artifact morphology and artifact production because the latter are acquired during manufacture (or maintenance), while the former are acquired after manufacture (and maintenance). The analysis of artifact use, therefore, is distinct from the analysis of artifact morphology/production because the period of artifact use refers to a different subsystem of the overall technological system. Note that artifacts which may not have been manufacture-modified (e.g., hammerstones) are subject to analysis under this topic. In such cases, the artifact enters the technological system directly from nature without passing through a tool production subsystem. Strictly speaking, such tools are identifiable only on the basis of their use attributes. Also note that in the case of recycled artifacts, the attributes resulting from use before recycling are analytically distinct from the use attributes acquired after recycling. For example, use-wear attributes resulting from cutting are unrelated to use-wear attributes from drilling for a knife that was recycled into a drill.

Basic Question 10: Are artifacts characterized by different use attributes at any given time in the Fort Hood area?

Relevance: The answer to this question is trivially yes. However, in order to identify as closely as possible the actual functions of artifacts, it is necessary to identify the modifications that occurred as a result of use. Indeed, an analysis of artifact use may be the only means for identifying actual tools among morphologically indistinct, informal artifact classes. Answering this basic question entails that the analyst classify artifact types on the basis of functions inferred from use-wear attributes and/or residue studies. Identification of use-wear and/or residue characteristics that can be correlated with specific behaviors is sufficient reason to regard an artifact as a tool. Note that no subsidiary questions emerge from this basic question because answering the basic question amounts (tediously, but nontrivially) to documenting the detectable kind(s) of use, if any, to which each artifact was put.

Data Requirements

Data to answer this question will be derived from use-wear and residue studies that match experimentally derived use-attributes to attributes observed on archaeological artifacts (Hayden 1979; Tringham et al. 1974; Hally 1983; Schultz 1992). Burned rock is a special case of an artifact category in which an object enters the technological system directly from nature with little or no modification prior to use. Burned rock, to the extent that it is part of a technology (e.g., a heat transfer technology?), is modified by use via thermal processes and acquisition of residues from burning or other processes. Because most current knowledge of the burned-rock mound phenomenon is based on spatial, ethnobotanical, and ethnohistoric data, there is little direct knowledge of burned rock as an element of a technological apparatus. It seems apparent enough that burned rock generally belongs to a heat-transfer technology, but it is necessary to (1) corroborate this if it is true, and (2) try to identify what specific heat-transfer use(s) were performed. The two most likely, on the basis of ethnohistoric data, are stone boiling and stone baking (Creel 1991; Peter 1982). Use-analysis of burned rock will revolve largely around residue studies and taphonomy under various thermal conditions (Collins et al. 1990; Lintz 1989).

5.1.4.3 Consumables in the Technological System

Discussion

"Consumables" in the technological system can be construed as raw materials used for tools and materials consumed in an unmodified (or indeterminately modified) state during the process of producing commodities for subsistence. The economic value of consumables in a technological system follows from their status as items desired not primarily for their intrinsic value, but rather for their instrumental value in the production process. For example, chert is a consumable in the tool production process because of its value as a raw material from which to make durable tools, and wood may be a consumable during the food preparation process because of its value as a source of heat for cooking. Furthermore, the procurement of consumables can be assumed to reflect decisions that were affected by geographic distribution of consumables relative to the geographic distribution of the activities for which consumables were procured. Thus, the principal attributes that relate to consumables are the performance properties that make them appropriate raw materials for a production process and the provenance characteristics that correlate with their distribution.

Basic Question 11: What materials were consumables in the subsistence technological system at any given time at Fort Hood?

Relevance: The relevance of this question resolves down to two basic issues, namely, documenting the materials actually chosen for some use by inhabitants of the Fort Hood area and, ultimately, providing a data base from which to draw inferences about the nature of the technological apparatus in various subsystems at Fort Hood.

Subsidiary Questions

SQ-11.1: What specific chert sources were exploited for raw materials for tool production?

Relevance: Raw materials for a given purpose are often chosen according to specific criteria, which may include criteria of expediency and/or immediate availability as well as functional suitability for an intended production process or tool category (Dickens 1992). Even if every Fort Hood chert source was exploited for raw materials so that the entire range of cherts was chosen, it remains a possibility that particular cherts were chosen for specific applications. It is necessary to identify the cherts that were chosen before it is possible to identify associations between cherts and specific tools or specific applications of tools.

SQ-11.2: What nonlithic materials and lithic materials other than chert were exploited for raw materials for tools?

Relevance: The relevance is basically the same as above. However, understanding the nature of burned rock middens and whatever technological system(s) they were related to will involve attempting to determine if there are any detectable preferences for rock sources. It also will be desirable to determine whether lithic raw materials for metates reflect any preferences.

SQ-11.3: What are the performance properties of the materials exploited as raw materials for tools?

Relevance: If particular raw materials were chosen for particular purposes, the criteria for selection may pertain to suitability for a given tool-production process and/or tool use. Thus, the hardness, tensile strength, workability, and other characteristics of a material may have been influences on choice of consumables. In the case of burned rock, expediency (in the form of distance from source to place of use) is likely to have been the main criterion for choice of raw material type. However, if burned rock is part of a heat transfer technology, thermal performance properties may have influenced the size, shape, or other morphological characteristics of selected resources. Rock used to line hearths also may have been chosen for specific reasons related to thermal performance. To the extent that food processing technologies relied on cooking with heated rock, an understanding of food processing technologies may depend on an understanding of the functional capabilities of rock used in the construction and/or use of cooking features.

SQ-11.4: What kinds of wood (or other materials) were used for fuel?

Relevance: Identifying the kinds of wood (or other materials) used for fuel serves as a basis for reconstructing the activities leading up to the actual use of fuel in any technology that involves fire at one or another stage of the production process.

SQ-11.5: What are the performance properties of the wood types selected for fuel?

Relevance: Different kinds of wood (and other materials) burn hotter, easier, or longer than other kinds. These performance properties may be influences on selection when fuel is needed for a particular purpose.

Data Requirements

Analyses of consumable-sources can be based on more or less standard ethnobotanical procedures (e.g., Hastorf and Popper 1988) and on provenance studies of lithic and clay resources (e.g., Latham et al. 1992). Although a qualitative provenance and performance-properties study has been done on Fort Hood cherts (Dickens 1992), it is necessary to build quantitative data bases amenable to rigorous statistical evaluation of chert procurement behavior and performance properties. Quantitative provenance data for chert also will be extremely useful for charting trade and/or transhumance patterns between Fort Hood and elsewhere (e.g., Williams-Thorpe et al. 1991).

Whenever possible, samples for botanical consumables (e.g., wood for fuel) should come from discrete stratigraphic contexts or from features to maximize the possibility of linking them with particular production processes and technologies. Archaeomagnetic data (Collins et al. 1990) and taphonomic experimental data (Lintz 1989) will be useful for determining the performance properties of rock as a heat transfer agent, and, in conjunction with data on the performance properties of fuels, will make it possible to estimate the amount of fuel consumed to heat a given mass of rock, which in turn may make it possible to model wood-procurement behavior (cf. Minnis 1985) and human/forest ecological relations.

5.1.4.4 Summary of Technological Apparatus Domain

The technological apparatus domain provides much of the basic data needed to implement the form of technological analysis described in section 4.2.3.2. By amassing a cumulative data base of the technological attributes present at various sites on Fort Hood, the analyst will be in a position to identify, inasmuch as possible, the distribution of specific tool-production, tool-use, and consumable-procurement/use activities that took place on the Fort. Within the form of technological analysis to be used in this research design, the distribution of such activities is a major datum in the analysis of decision-making structures because the distribution of activities directly reflects (at both the Fort Hood and site levels) how decision-makers balanced various technological activities against each other in their day-to-day and season-to-season behavior.

5.1.5 Summary of Fundamental-Research Domains

To the extent that chronometric, paleoenvironmental, subsistence, and technological data are available at any given time, the analyst will be able to infer not only the nature of the adaptation(s) in place on Fort Hood at any given time, but also to describe and explain the reasons for adaptive change over time. Working through the fundamental domains, therefore, establishes the foundational data on which inferences about adaptive processes and change in adaptive processes are based. These data sets provide the basic empirical premises for arguments whose conclusions are (1) statements about systematic relationships between artifacts which in turn serve as (2) empirically justified premisses for arguments about systemic processes that account for the systemic relationships between artifacts.

To the extent that data accumulation has been successful and comprehensive in each domain, the following data bases have been acquired:

- A set of artifactual and geomorphic time markers has been documented. During the course of this documentation, artifact assemblages other than temporal diagnostics also have been dated on the basis of their contextual relationships to temporal diagnostics, correlatable geomorphic features, and the chronometric data used to establish the dates for chronological markers.

- A wide array of interrelated paleoclimatic, paleotopographic, and paleoecological data have been documented. During the course of this documentation, these paleoenvironmental data have been placed in a chronological framework to the extent that they have been dated on the basis of their contextual relationships to temporal diagnostics, correlatable geomorphic features, and the chronometric data used to establish the dates for chronological markers.

- A data base of subsistence resources has been documented. During the course of this documentation, geographic variation in the subsistence resource base has been placed in a paleoenvironmental framework to the extent that environmental and subsistence data have been collated. By virtue of having identified much of the subsistence base in reference to the paleoecological base, geographic variation of subsistence resources has already been collated with paleoecology. Change in the subsistence base has already been collated with chronological markers to the extent that subsistence data has been collected from dated contexts.

- A data base of the range of technological attributes of artifacts has been documented. This data base has three components that contain, respectively, morphological attributes of manufacture-modified artifacts, use-wear and residue attributes of use-modified artifacts, and a catalog of sources and performance properties of raw materials consumed in various activities.

The information in the fundamental domains should be integrated as much as possible into Fort Hood's Geograhic Resourses Analysis Support System (GRASS) mapping/information system. Mapping geomorphic chronological markers will make it possible to assess the value of particular sites and landscape features in terms of the likelihood that they contain discrete occupational episodes. It also will be extremely useful to integrate subsistence and technological data into the GRASS system in order to give researchers the capacity to visualize the distribution of various aspects of tool production, tool use, and consumable use, especially in conjunction with distributive data on paleoenvironmental conditions and temporally-diagnostic artifacts. The ability to visualize these relationships graphically can be an important tool for postulating reasonable working hypotheses about the spatial and temporal distributions of evidence of particular decisions made in particular environmental contexts. Given that individual CRM activities will not be implemented under more or less emergency conditions that characterize projects like reservoir mitigations, the ability to visualize the continual development of various archaeological and environmental data bases will provide an ongoing platform for evaluating sites (or portions thereof) in terms of their potential for adding relevant new data. This in turn will provide an important datum for CRM managers and researchers who must balance the current scientific value of cultural properties against fiscal realities that govern preservation and mitigation. Thus, including as much paleoenvironmental, subsistence, and spatial information as possible into the GRASS system will make it a powerful tool for making CRM decisions.

5.2 SUBSTANTIVE-RESEARCH DOMAINS

Having established basic data sets relevant to the theoretical perspectives of this research design, the analyst is in a position to begin modeling adaptive behavior. The following substantive-research domains begin the process of building on the basic data assembled in the fundamental domains. The order of the following domains proceeds from the level of most basic to most derivative in the sense that the topics of earlier substantive domains establish the empirical and inferential foundations for subsequent domains. Hence, the substantive domains are ordered in terms of a logic of discovery to be followed in building models of human adaptation rather than being ordered in a more traditional format that distinguishes between, say, subsistence and settlement patterns as discrete subject areas. The substantive domains are ordered as follows with a view to the eventual null hypothesis that the inhabitants of Fort Hood employed a foraging subsistence strategy.

Architecture of the Substantive-Research Domains

Testing begins (section 5.2.1) with an examination of site function in terms of relationships between tools and subsistence resources that can be substantiated by recurring associations. Hypothesis testing starts by assuming that tools and consumables (or, more specifically, suites of technological attributes) are associated with subsistence resources in a one-apparatus/one-resource technology, and continues until no associations can be found between technological attributes and either resources or other technological attributes. The result is that testing identifies (1) the functions which can be assigned to resource-specific apparatus, multiple-resource apparatus, and apparatus of support-technologies, and (2) the apparatus to which no discernable function can be assigned. It follows from identifying the discernable function(s) of apparatus at any given site that one has identified at least part of that site's function.

Testing for site function (or, perhaps more precisely, site function*ing*) continues in section 5.2.2 with an examination of the organizational properties of individual apparatus identified in the previous domain. Using a combination of subsistence, technological, and paleoenvironmental data, hypothesis testing determines the spatial relationships between different segments of each discernable apparatus in order to determine whether individual apparatus are organized along forager or logistical lines. Testing in this domain connects apparatus and organization into technologies and thereby establishes the data base on which to make judgments about how individual sites functioned as well as the data base from which to make judgments about technological stability and change.

The previous substantive-research domains are largely atemporal. Hence, section 5.2.3 places the technological data from section 5.2.2 in a chronological framework. Testing is oriented around determining whether change in technology (i.e., in apparatus and/or organization) and/or subsistence coincides with change in temporally-diagnostic artifacts. Testing therefore correlates changes in individual technologies and subsistence resources with chronological index markers and, by default, with other technologies and subsistence resources. As an incidental byproduct, testing determines whether identifying change in temporal diagnostics is a reasonable approach to defining periods of adaptive stability and change at Fort Hood by determining whether there is any relationship between technological practices/subsistence bases and temporal diagnostics.

On the basis of the results of testing in section 5.2.3, it is possible to begin identifying adaptive strategies. In section 5.2.4, testing is directed toward identifying temporally-specific arrays of technologies and subsistence resources that may comprise distinct adaptations. As such, testing identifies candidates for distinct adaptive "phases" that may be characterized by stability or incremental change in the decision-making structures employed during a given time span. Testing continues in section 5.2.5 by determining whether the phases identified in section 5.2.4 reflect groups organized in a predominantly forager or predominantly collector organization. By the time testing in section 5.2.5 is complete, the researcher will have determined the extent to which adaptive phases can be identified on the basis of stability and change in technology (including apparatus and organization) and subsistence, and models of adaptations will be as developed as available data permit.

Having identified adaptations in the previous domains, it is necessary to begin modeling similarities and differences between adaptations at Fort Hood and elsewhere. Section 5.2.6 places the history of adaptation at Fort Hood in a regional context. Major goals of testing in this domain include identifying adaptive communities, and examining the relationships between communities occupying Fort Hood and those occupying other nearby and distant areas. The major problem to be addressed in this domain is whether or not the archaeological record at Fort Hood for any given time period reflects resource exploitation by a local group, a series of local groups, and/or people exploiting Fort Hood on a transhumant basis. The primary means for accomplishing this goal is identifying regional variation in the distributions of artifact types, of distinct procedural approaches to production of typologically distinct artifacts, cherts from Fort Hood sources, and ceramics. The identification of communities serves as a basis for isolating as much as possible the territories within which people pursued their goals and transmitted their technological knowledge, which in turn provides the data base from which to explain (in section 5.2.7) whether adaptive variability at any given time and over time is a matter of environmental variability, or exploitation of the Fort Hood environment by members of numerous groups, or both. Section 5.2.7, consequently, synthesizes comparative data derived in section 5.2.6 to model the environmental and sociocultural influences on adaptation and adaptive change at Fort Hood. By the time testing in section 5.2.7 is complete, the researcher will have reconstructed and explained the history of adaptation at Fort Hood to the maximum extent possible given the currently available data.

Note that the order of the substantive domains and the fact that each domain builds on previous domains should not be construed as a commandment to refrain from working on later domains before work in previous domains has yielded conclusive results. It is expected that at any given stage of implementation of this research design, data is likely to be missing or ambiguous at crucial points. This research design anticipates the necessity of filling in missing inferential links on the basis of reasonable hypothetical constructs where hard data is lacking in order to make as much progress as possible from whatever data is in hand at any given time. The structure of this design is predicated on the assumption that CRM procedures will identify and allocate field and laboratory research projects on the basis of priorities that emerge from ongoing activities at Fort Hood rather than on the basis of priorities that emerge from the needs of the archaeological community (i.e., that archeologists will adapt themselves to CRM managers' needs more than vice versa). Consequently, this research design anticipates that archaeological progress at any given point will emerge as a function of filling in inferential gaps as CRM needs make data available. Indeed, this design further anticipates that attempting to work in later substantive domains before reaching conclusive results in earlier domains will be useful for identifying specific data needs to be pursued as CRM priorities make field research opportunities available. In other words, this research design is predicated on the assumption that an inability to draw conclusions from available data is in itself a substantive conclusion because it directs subsequent research toward activities to fill in the needed data. This assumption also implies that recognition of the limitations of current data to support descriptive and explanatory models of adaptation and adaptive change will be valuable to CRM managers and researchers with respect to evaluating cultural properties relative to current scientific needs. Hence, the testing architecture of this research design has built into it an implicit means for determining what is the current state of the art for Fort Hood prehistory at any given point during implementation, and for determining the value of particular sites relative to the state of the art.

5.2.1 Substantive-Research Domain: Site Function I--Identifying the Apparatus of Subsistence and Nonsubsistence Technologies

Discussion

Given the cultural ecology perspective of this research design, an understanding of subsistence technologies is central to the problem of understanding adaptation in the Fort Hood area. Given the technological perspective adopted herein, understanding subsistence technologies is in turn a matter of identifying the apparatus and organization used to exploit subsistence resources under the assumption that certain types of knowledge unify tools and organizations in structured patterns of behavior that accomplish subsistence goals. Although an archaeological program cannot unearth knowledge, it can unearth evidence of patterned decisions, including patterned decisions made for the purpose of fulfilling subsistence goals. Indeed, within the cultural ecology perspective of this research design, identifying the set of patterned subsistence-oriented decisions comprises much of the object of research because patterned subsistence-oriented decisions comprise much of any human adaptation.

Consequently, a major testing goal of the research design is to identify subsistence technologies by identifying apparatus and organizations directed toward exploitation of subsistence resources. Within this goal, identification of the apparatus of subsistence is logically prior to identification of the organization of subsistence because the former provides the hard evidence from which the latter is to be inferred. The evidence for subsistence apparatus consists of technological and subsistence data developed in the fundamental domains. However, the evidence in these data sets is mute in and of itself until one uses an implicit or explicit analytical framework first to identify items (i.e., tools and consumables) used as instruments in resource exploitation and then to assign subsistence functions to these instruments. If a consistent set of items is nonrandomly associated with a subsistence resource or resources, then there is reason to believe those items comprise at least part of the apparatus for exploiting that resource (or set thereof). Items that do not have nonrandom associations with subsistence resources comprise the data base within which the analyst is most likely to find support-technologies such as tool-production technologies. Thus, the attempt to identify subsistence technologies also involves attempting to identify nonsubsistence technologies.

This domain identifies the apparatus of various technological systems, where the apparatus of a technological system is defined as the tools and consumables employed for the accomplishment of a particular goal (or set of goals). The approach involves a form of attribute analysis. If any combination of attributes of morphology, production technique, tool use, and/or consumables (hereafter, "technological attributes") identified in the technological fundamental domain reflects decisions made for a specific purpose, then there should be consistent, nonrandom associations among at least some sets of technological attributes. If any of these nonrandom associations are directed toward the exploitation of a specific subsistence resource (or set of resources), then there also should be nonrandom associations between specific subsistence resources and specific sets of technological attributes. If consistent, nonrandom associations can be located, these associations constitute candidates for the apparatus of technological systems in which activities are linked in a decision-making process oriented toward a subsistence goal. If no associations can be drawn between subsistence resources and sets of technological attributes that otherwise appear to have systemic integrity, the analyst may have reason to believe that the apparatus of a tool production or other nonsubsistence technology has been identified.

Having identified the various technologies (inasmuch as possible given the availability of suitable kinds and amount of data), the analyst is in a position to determine what activities occurred at any given site. Given that the identification of activities performed at a site is the same thing as the identification of site function, the identification of site function therefore follows more or less immediately from identifying nonrandom associations between technological attributes and subsistence data. This includes identifying some apparatus, such as tool-production technologies, as not having direct subsistence applications by virtue of not having consistent associations with subsistence resources. Thus, having identified subsistence and nonsubsistence technologies, the analyst need only identify which technologies are evident at a given site in order to determine the function or functions that can be assigned to it on the basis of available evidence.

The hypotheses below (and their respective test implications) comprise an integrated architecture for identifying the apparatus of technologies by identifying technological attributes that can be closely associated with a single subsistence resource (under Hypothesis 1), a consistent combination of several resources (under Hypothesis 2), or a variable combination of subsistence resources (under Hypothesis 3). The combined testing procedure from Hypothesis 1 through Hypothesis 3 discloses the limits within which claims about relationships between tools and subsistence resources are sustained by the data at hand, which in turn establishes the inferential limits within which subsistence functions can be assigned to sites lacking adequate subsistence data. Hypothesis 4 completes the inferential mechanism by providing a means for identifying apparatus of nonsubsistence technologies, including apparatus used in support roles in subsistence technologies.

5.2.1.1 Hypothesis 1

Each specific resource has a distinct, identifiable apparatus for exploiting it.

Relevance

If a desired subsistence resource cannot be harvested and consumed without using some apparatus, then people exploiting that resource will develop and apply a technology for harvesting and preparing that resource for consumption. Consequently, the apparatus of a technological system (e.g., a complex of support- and use-technologies) can be expected to have sequential, systemic links that reflect the sequence of activities which must be performed to exploit that resource. The specific form and content of the apparatus component of that technology can be assumed to reflect requirements imposed by the nature of the resource and the methods for harvesting and consuming it because resource exploiters can be assumed to apply their knowledge of the necessary activities to the acquisition of appropriate means to accomplish those activities in the resource exploitation process.

To identify an apparatus directed toward a specific subsistence resource, it is necessary to determine whether its presence is predicted by the presence of a specific subsistence resource. In order for an apparatus to be associated with a specific subsistence resource, each of its constituent elements must also be associated as well. Therefore, the following test implications form a series of steps which a given set of morphological, tool-production, and other attributes identified in the technological fundamental domain must survive in order to be identifiable as a specific apparatus directed toward a specific subsistence resource. Failure to survive some of the steps may falsify an element's membership in a technological system devoted to the exploitation of a specific resource by implying that it is an element in a more generalized apparatus. Indeed, if a given technological element fails some of the implications under Hypothesis 1, that failure points directly to alternative hypotheses (and test implications) which may account for that element's relevance (or irrelevance) to subsistence resources.

Test Implications

TI-1.1: The presence of remains of a specific subsistence resource nonrandomly predicts the presence of a specific set of technological attributes.

Relevance: Achieving a subsistence goal involves making a series of decisions that extends step-wise from procurement of raw materials for tools through making tools through using tools to consumption of the subsistence resource. These decisions are sequentially and systemically linked by virtue of being directed toward the subsistence goal. At least some of these links should appear in the archaeological record as the apparatus of technological systems associated with evidence of a specific subsistence resource. If the apparatus of a technological system is oriented toward a specific subsistence resource, then application of that apparatus will be systematically associated with attempts to achieve that goal, which entails that archaeological evidence of a resource (when such evidence is preserved) is likely to co-occur with evidence of the apparatus used to procure and/or process that resource. The more specialized the technological system, the more specific the association should be between a specific subsistence resource and an apparatus. Thus, the more specialized the technological system, the more specific the association between technological attributes and subsistence evidence should be.

Since TI-1.1 is a test implication for a hypothesis that refers to a specialized one-apparatus/one-resource (also referred to as "OA/OR" hereafter) correspondence, failure to nonrandomly predict a specific set of technological attributes from a specific subsistence resource would falsify Hypothesis 1 by implying that no apparatus can be associated with a specific subsistence resource in a one-apparatus/one-resource system. Indeed, if no single resource predicts a consistent set of technological attributes, then on the basis of available data, it is not possible to assert that there are any one-apparatus/one-resource relationships in the subsistence system, which in turn implies that all subsistence apparatus are multipurpose apparatus serving relatively broad subsistence goals. (If TI-1.1 is falsified for a particular set of technological attributes, go to Hypothesis 2.) However, if a specific subsistence resource nonrandomly predicts the presence of a specific suite of technological attributes, there is good reason to test further whether this suite of attributes reflects a decision-making structure directed toward the predictive resource.

Note that this test implication is exploratory by virtue of testing all possible tools and consumables against subsistence data. Underlying this test implication, however, is the implicit null hypothesis that the co-occurrence of any resource x and any technological attribute y is the outcome of a random process. By requiring nonrandom prediction it establishes a statistical criterion for judging whether there is a relationship between a specific subsistence resource on one hand, and a specific pattern of tool making, tool using, and/or consumable use on the other. Thus, this test implication identifies specific test criteria that must be met in order to justify assertions that certain tools and resources are related as a function of using the former to exploit the latter. Any set of technological attributes that survives this test implication is a potential apparatus for exploitation of the specific resource that predicts its presence and, hence, an apparatus to be tested further for a one-apparatus/one-resource correspondence.

TI-1.2: In an apparatus identified in TI-1.1, no element's presence is nonrandomly predicted by the presence of a second subsistence resource.

Relevance: For Hypothesis 1 to be true, the presence of any given apparatus cannot be predicted by the presence of more than one subsistence resource because prediction by more than one resource undermines the one-to-one correspondence between an apparatus and a resource and, hence, any basis for asserting that an apparatus is directed toward exploitation of a specific resource. Thus, Hypothesis 1 is falsified for any apparatus (or element thereof) that fails TI-1.2, which implies that the apparatus (or element) is directed toward a combination of resources. Note that falsification does not by itself negate the association between the apparatus (or element) and the resource. Rather, it falsifies a one-to-one correspondence association, which only implies that the apparatus (or element) has a nonspecific application vis a vis the initially predictive resource. Therefore, TI-1.2 distinguishes artifacts that have apparently specific subsistence applications from artifacts that have possibly related, but nonspecific subsistence applications. (If TI-1.2 is false for an apparatus or element thereof, go to Hypothesis 2 in order to test for specificity of the apparatus/resource relationship.)

Also note that any apparatus which survives both TI-1.1 and TI-1.2 may serve as the basis for inferring by strong induction that identical apparatus located in contexts lacking subsistence data were used to exploit the same subsistence resource. Therefore, TI-1.1 and TI-1.2 form the basis for assigning subsistence activities to sites lacking direct evidence of subsistence resources. The strength of the induction is increased if some of the evidence used to identify apparatus under TI-1.1 consists of subsistence-resource residues on artifacts. This feature of the domain is especially relevant to the place of burned rock middens in Central Texas prehistory. If Creel's (1986, 1991) "acorn hypothesis" is true, then the presence of acorns must predict the presence of burned rock middens, but no other subsistence resource can predict burned rock middens. If more than one subsistence resource predicts the presence of burned rock middens, the acorn hypothesis is severely weakened. Similarly, Prewitt's (n.d.) "sotol hypothesis" would be severely weakened if any resource other than (or in addition to) sotol nonrandomly predicts the presence of burned rock middens.

Summary of Results from Testing Hypothesis 1

If Hypothesis 1 is tested for every individual subsistence resource, the results of testing under TI-1.1 through TI-1.2 yields:

- a catalog of the specific one-apparatus/one-resource technologies (if any) that can be identified on the basis of current subsistence data and, hence, can serve as a strong inductive basis for assigning specific subsistence activities sites with identical apparatus;
- a catalog of technological attributes that cannot be assigned to a specific subsistence resource and, hence, a catalog of technological attributes which, because they fail TI-1.2, are candidates for testing under one-apparatus/several-resources hypotheses.

5.2.1.2 Hypothesis 2

Among the subsistence resources that are not exploited in one-apparatus/one-resource technologies, there are specific conjunctions of resources that have an identifiable apparatus for exploiting them.

Relevance

Hypothesis 2 concerns itself with any apparatus (or element thereof) for which Hypothesis 1 has been falsified because more than one subsistence resource predicts the occurrence of that apparatus (or element). Hypothesis 2 differs from Hypothesis 1 by virtue of specifying a one-apparatus/several-resources (also referred to as "OA/SR" hereafter) correspondence in which a consistent conjunction of more than one subsistence resource is exploited in a single technological system. Consequently, any apparatus (or element thereof) which survives the following test implications can be justifiably asserted to be a multipurpose apparatus that has several specific subsistence applications. Note that this hypothesis determines whether elements failing TI-1.2 have specific subsistence uses in addition to those identified under TI-1.1.

TI-2.1: The presence of remains of a specific conjunction of subsistence resources nonrandomly predicts the presence of a specific set of technological attributes.

Relevance: In a one-apparatus/several-resources technology, archaeological evidence of two or more specific resources (when such evidence is preserved) should co-occur with the specific apparatus used to exploit those resources. Nonrandom prediction of a specific set of technological attributes from a specific conjunction of subsistence resources implies that the attributes comprise an apparatus for exploiting that conjunction of resources, which warrants further testing. Falsification of TI-2.1 is sufficient ground to reject Hypothesis 2 for a given apparatus or element thereof. If an apparatus does not survive TI-1.2 *and* TI-2.1, then that apparatus either is used for generalized subsistence purposes, it is not used directly for subsistence purposes at all, or it is not identified correctly as the apparatus of a distinct technological system. If TI-2.1 is falsified for any apparatus or element thereof, go to Hypothesis 3.

TI-2.2: No subsistence resource predicts the presence of any element that survives TI-2.1 without also predicting the presence of all the other elements surviving TI-2.1.

Relevance: If an element of the apparatus that survives TI-2.1 is also predicted by a resource that does not predict the presence of all elements that survive TI-2.1, Hypothesis 2 is falsified for that element because a specific conjunction of resources has been demonstrated not to predict that element's presence. (If Hypothesis 2.2 is falsified for an apparatus or element thereof, go to Hypothesis 3.) Falsification of TI-2.2 entails that either a variable set of resources or no set of resources predicts the presence of an apparatus (or element thereof), which undermines the analyst's ability to assert an OA/SR correspondence of the kind specified by Hypothesis 2.

Note that any apparatus which survives both TI-2.1 and TI-2.2 may serve as the basis for inferring by strong induction that identical apparatus located in contexts lacking subsistence data were used to exploit the same subsistence resource. Therefore, TI-2.1 and TI-2.2 form the basis for assigning subsistence activities to sites lacking direct evidence of subsistence resources. The strength of the induction is increased if some of the evidence used to identify apparatus under TI-2.1 consists of subsistence-resource residues on artifacts.

Also note that the members of the predictive conjunction of subsistence resources may have biological features that make them amenable to a common processing technique (e.g., all are arboreal nuts, or all are grass seeds). If so, then there is reason to believe that the scientific biological taxonomy used to predict the apparatus obscures a single resource-category that served as the aboriginal criterion for matching resources and apparatus. If a common anatomical, morphological, or other biological attribute characterizes the members a predictive conjunction, the common attribute warrants returning to Hypothesis 1 and retesting under an alternative subsistence rubric (e.g., arboreal nuts) that includes all members of the predictive conjunction plus others with similar features. If retesting shows that the apparatus survives TI-1.1 and TI-1.2, the apparatus can be reclassified plausibly as an OA/OR apparatus that serves as a strong inductive foundation for assigning subsistence functions to sites without subsistence data. Note, however, that if retesting predicts a single apparatus from a reclassified group of resources that have common features but different seasonality characteristics, the differing seasonality characteristics ultimately undermine the inductive foundation for using the presence of an OA/OR apparatus to assign seasonality of occupation to sites lacking subsistence data.

Summary of Results from Testing Hypothesis 2

If Hypothesis 2 is tested for every conjunction of subsistence resources, testing under Hypothesis 2 yields the following additions to the catalog derived under Hypothesis 1:

- a catalog of the specific one-apparatus/several-resource technologies that can be identified on the basis of current subsistence data (including any specific multi-use elements that are used in conjunction with apparatus identified under Hypothesis 1) and, hence, can serve as a strong inductive basis for assigning specific subsistence activities sites with identical apparatus;

- additions to the catalog of one-apparatus/one resource technologies based on diverse species with common attributes that allowed for processing with a common apparatus;

- a catalog of technological attributes that cannot be assigned to a specific combination subsistence resources and, hence, a catalog of technological attributes which, because they fail TI-2.2, are candidates for testing under a one-apparatus/several-resource hypothesis that involves apparatus used to exploit a variable set of subsistence resources.

5.2.1.3 Hypothesis 3

Among the subsistence resources that are not exploited in one-apparatus/one-resource technologies or one-apparatus/several resource technologies identified above, there are variable sets of resources that have an identifiable apparatus for exploiting them.

Relevance

Hypothesis 3 concerns itself with apparatus for which Hypotheses 1 and 2 have been falsified because no single subsistence resource or specific conjunction of resources predicts the occurrence of a suite of technological attributes and, hence, an apparatus. Hypothesis 3 differs from the other hypotheses by virtue of specifying a one-apparatus/several-resources correspondence in which a consistent disjunction of more than one subsistence resource is exploited in a single technological system. For the purposes of this hypothesis, a disjunction of resources consists of a set of two or more subsistence resources, any one or combination of which predicts the presence of an apparatus. For example, under this hypothesis, the disjunction "sotol or acorns" would successfully predict the presence of burned rock and associated hearths just in case a nonrandomly high number of the contexts that contain remains of sotol, acorns, or both also contain burned rock middens and hearths. By specifying a consistent disjunction of subsistence resources, this hypothesis distinguishes apparatus with identifiable but relatively general subsistence applications (compared to the apparatus that survive testing under Hypotheses 1 and 2) from apparatus with unidentifiable subsistence applications or nonsubsistence applications.

Test Implication

TI-3.1: The presence of a set of technological attributes that fails Hypotheses 2 and 3 is not predicted equally well by every randomly selected disjunction of known subsistence resources.

Relevance: If the presence of an apparatus that fails Hypotheses 1 and 2 is predicted equally well by the presence of any randomly identified disjunction of known subsistence resources drawn from the list left over after Hypotheses 1 and 2, then that apparatus has no identifiable place in any specific subsistence technology because any old combination of resources is as successfully predictive as any other. This would ambiguously imply that the apparatus either has general utility in subsistence activities or is not implicated directly in subsistence at all (as in the case of sociotechnic artifacts). Falsification of TI-3.1 for a given apparatus, therefore, implies that the analyst cannot draw any conclusions whatever about that apparatus on the basis of subsistence data. In the event that TI-3.1 is not falsified for an apparatus, TI-3.1 will survive testing because some disjunction of subsistence resources predicts an apparatus's presence better than other sets of resources, which implies that the apparatus may be at least indirectly implicated in the exploitation of all of the members of the disjunction.

However, the capacity of an apparatus surviving TI-3.1 to provide an inductive basis for assigning subsistence activities is extremely variable. The larger the disjunction (i.e., the more subsistence resources it contains), the less well an apparatus can serve as a basis for assigning any particular subsistence activities to a site without subsistence data, especially if the array of resources in the predictive disjunction is diverse (e.g., a mix of nuts, seeds, and invertebrates). In this case, the apparatus/resource association has limited inductive value with respect to sites lacking subsistence data because the disjunctive nature of the predictive resources does not allow the analyst to infer exploitation of any definite resources from the presence of the apparatus. In such cases, it is likely that an apparatus predicted by the disjunction is actually composed of a set of indistinguishable apparatus whose elements cannot be assigned to their appropriate resources.

On the other hand, if all or most of the elements of the disjunction have common features (e.g., most are succulents), then there is reason to believe that an apparatus surviving TI-3.1 is a distinct apparatus for processing resources chosen for characteristics that do not match criteria expressed by biological taxonomic criteria. Such a case would warrant retesting the apparatus under Hypothesis 1 using an alternative classification (e.g., succulents) of the subsistence resources as the basis for identifying the apparatus. If retesting is successful, then the apparatus should be reclassified as a one-apparatus/one-resource apparatus. In the absence of reasonable grounds for retesting, the analyst should consider the possibility that technological attributes for which no associations can be identified by the Hypothesis 3 stage are associated with a support-technology such as tool production. (If no associations are identified under Hypothesis 3, go to Hypothesis 4.)

Summary of Results from Testing Hypothesis 3

Thus, testing under Hypothesis 3 adds to the conclusions (if any) derived under Hypotheses 1 and 2 a list of the technological attributes for which:

- no reasonable relationships can be substantiated between an apparatus and subsistence resources;
- only weak relationships can be substantiated between an apparatus and subsistence resources;
- additions to the list of one-apparatus/one-resource apparatus resulting from reclassification of predictive disjunctions of subsistence resources;
- indications that attributes unassociated or randomly associated with subsistence resources may comprise a nonsubsistence technology.

5.2.1.4 Hypothesis 4

Technological attributes that cannot be associated nonrandomly with subsistence resources comprise part of a tool- or consumable-production technology.

Relevance

A set of technological attributes that cannot be associated with subsistence resources cannot be assigned to a nonsubsistence technology simply by default because it is always possible that generalized, unidentifiable subsistence functions are responsible for the absence of significant associations. Hence, for any technological attributes failing Hypotheses 1 through 3, it is necessary to take a positive (rather than default) approach to identifying nonsubsistence technologies. Testing for technological attribute-to-attribute relationships that exclude subsistence data may allow the analyst to identify nonsubsistence technologies.

Test Implications

TI-4.1: There are mutually predictive associations of technological attributes that either never include use-wear attributes or only include use-wear attributes which cannot be acquired by use on known subsistence resources.

Relevance: If an artifact is not used in subsistence tasks, it cannot acquire use-wear attributes that derive from use in a subsistence task. If an artifact was not used at all, it cannot acquire use-wear attributes of any kind. Hence, classes of objects that either generally were not used or generally were not used for subsistence tasks will not have subsistence use-wear characteristics except as random occurrences. Apparatus in nonsubsistence technologies, therefore, should not have use-wear characteristics deriving from subsistence applications. This entails that nonrandom attribute-to-attribute associations which do not include subsistence use-wear attributes are strong candidates for the apparatus of identifiable support technologies, irrespective of whether or not they also are associated with subsistence resources.

For obvious example, the activity of acquiring raw materials for stone tools will leave in the archaeological record debitage and, perhaps, artifacts with use-wear derived from stone-on-stone battering. (If procurement involves no more than simply picking up loose stones, no direct evidence will enter the archaeological record, and assigning lithic-resource-procurement activities to sites will be a matter of provenance studies that match lithic consumables to source areas on the basis of geophysical and other evidence.) Shaping raw materials into tools will leave debitage, cores, artifacts aborted in mid-production, artifacts with use-wear derived from stone-on-stone battering or grinding attributes, and/or nonlithic artifacts with, for example, antler-on-stone wear attributes. Debitage and aborted artifacts, in these cases, will not have use-wear characteristics unless they enter another technology. Artifacts with no use-wear or with attributes derived from stone-working therefore comprise a basic data set within which to identify lithic tool-production technologies.

If it turns out that the presence of every subsistence resource nonrandomly predicts the presence of debitage (as probably will be the case) or other lithic artifacts with no use-wear attributes, then this fact will constitute a strong inductive basis for confirming the already obvious intuition that the activities producing debitage and unused stone artifacts are incidental to subsistence exploitation. However, these activities may be unevenly distributed in space so that various segments of the tool-production process occur in different places as a function of scheduling or other aspects of the subsistence process. If there are different statistically demonstrable associations of technological attributes (e.g., along size and/or morphological dimensions) within the assemblage of debitage and unused artifacts, these associations will constitute a strong inductive basis for concluding that distinct aspects of tool production were performed in different places. Distinguishing between lithic-procurement, lithic-tool-production, and lithic-tool-recycling activities will follow largely from demonstrating that there are nonrandom variations in the assemblage of debitage and unused lithic artifacts. To the extent that distinct tool-production trajectories are visible in the lithic assemblage, they too will be distinguished on the basis of nonrandom variations in the assemblage of debitage and unused lithic artifacts.

If any of these associations also have nonrandom associations with a subsistence resource and/or with the apparatus of an identifiable subsistence technology, then there is good reason to believe the analyst has identified a support-technology that goes along with a specific subsistence activity. Among the associations likely to emerge in this respect are rejuvenation technologies in which debitage is produced during maintenance of artifacts that already have use-wear attributes. If such associations occur, they probably already will be part of an apparatus identified under Hypotheses 1, 2, or 3. Note, therefore, that Hypothesis 4 provides an independent means for identifying the apparatus of support technologies associated with specific resources whenever technological attribute-to-attribute predictions identify associations that comprise a distinct subset of an apparatus identified by subsistence-to-attribute prediction. If such identifications are forthcoming, they will provide a means for discriminating between sites with both support- and resource-exploitation functions and sites with only one or the other function. Thus, even distinct apparatus that have been identified under Hypotheses 1 through 3 should be tested under Hypothesis 4 in order to determine whether the analyst can distinguish between subsistence and nonsubsistence elements. For any set of technological attributes that fail Hypotheses 1 through 4, no apparatus and, hence, no technological function is identifiable.

Summary of Results from Testing Hypothesis 4

Thus, testing under Hypothesis 4 adds to the conclusions derived from Hypotheses 1 through 3 (if any) a list of the technological attributes for which:

- probable nonsubsistence technologies are identifiable;
- nonsubsistence technologies are identifiable within apparatus identified under Hypotheses 1 through 3;
- no distinct technology is identifiable.

5.2.1.5 Summary of Results from Site Function I Domain

Testing in this domain yields a catalog of the justifiable claims that can be made about associations between tools and consumables on one hand, and subsistence resources on the other. The set of justifiable claims may change as data accumulates, and it is likely that few demonstrably supported associations will be identified during the early stages of implementation of this research design. Note that if no apparatus are identifiable from testing under Hypotheses 1 through 4, then the procedure itself implies that there is reason to believe a basic problem infects the identification of technologies and, hence, the identification of activities that took place at a given site. Even if no apparatus/resource associations are identified under Hypothesis 1, at least some reasonable associations should emerge under Hypotheses 2 and/or 3 if the failure of Hypothesis 1 follows from mismatches between scientific biological taxonomy and aboriginal criteria for using a specific apparatus for several subsistence species.

For example, if neither of the biological classes *Bison bison* or *Antilocapra americana* individually nor the conjunction of them together predicts the presence of projectile points in sites in prairie contexts, the category "large prairie mammal" (approximately equivalent to the disjunction "*B. bison* or *A. americana*") should predict the presence of projectile points if these large mammals were the typical prey of hunters and a large enough data base has been amassed in the subsistence fundamental-research domain. At the very least, some disjunction of faunal resources ought to predict the presence of projectile points. However, if the subsistence data base is large and neither a single faunal category nor a conjunctive or disjunctive set of faunal categories predicts an apparatus that can be associated with hunting and/or butchering and/or hide processing, then there is good reason to believe that the initial classification schemes applied in the technological fundamental-research domain are of dubious value, which would imply that alternative classification criteria are needed to identify apparatus/resource associations. On the other hand, if the subsistence data set is small, the failure to identify significant apparatus/resource associations by the end of testing Hypothesis 3 implies that no subsistence conclusions are possible because there is insufficient data. If no significant associations are identified by completion of Hypothesis 4, there is good reason to believe the technological classification schemes in the fundamental-research domain may be misconceived.

Hypotheses 1 through 4, therefore, comprise an inferential mechanism which has the capacity:

- to demonstrate which specific and general apparatus/resource relationships are sufficiently defensible to warrant assigning subsistence functions to sites;
- to demonstrate which apparatus/resource relationships are not defensible because they are not supported by the data;
- to demonstrate which nonsubsistence technologies are sufficiently defensible to warrant assigning nonsubsistence functions to sites;
- to indicate where an overall failure to identify demonstrable apparatus/resource relationships may be the result of using small and/or uncreatively classified subsistence data bases; and
- to indicate where an overall failure to identify demonstrable technologies may be the result of misconceived technological classifications.

If the analyst concludes that the failure to identify distinct subsistence technologies results from a small subsistence data base, then Hypothesis 4 provides a preliminary framework for exploring site function by identifying sets of technological attributes that are mutually and nonrandomly predictive. In the event that such sets are identified, they can serve two purposes. First, they establish the inductive basis for identifying sites with evidence of identical activities by identifying repetitive patterns of decisions that may be assumed within the theoretical assumptions of this research design to be directed toward a goal. Hence, identifying nonrandom co-occurrences of technological attributes identifies patterns of decision-making that may reflect the use of a single apparatus for a specific purpose, even though the purpose may not be identifiable. (Note that this procedure cannot identify spatially disjunct segments of an apparatus used in a process that involves different stages at different locations.) Second, to the extent that limited subsistence data is available, the conjunction of statistically insignificant subsistence data and mutually predictive technological attributes poses hypotheses for ongoing testing under Hypotheses 1 through 3 as subsistence data accumulates in the Fort Hood area. Consequently, Hypothesis 4 can serve as an initial testing framework within which very small amounts of subsistence data can nonetheless point toward productive testing that may eliminate some of the exploratory work required by Hypotheses 1 through 3. However, it is necessary to keep in mind that the inductive value of such apparatus/resource associations is so weak that assigning subsistence functions on the basis of these associations is unwarranted until they can be bolstered by demonstrations that the associations are sustainable under statistical testing.

Data Requirements for Hypotheses 1 through 4

At any given time during the implementation of this research design, the bulk of the data for Hypotheses 1 through 4 exists in raw form in the subsistence and technological apparatus fundamental domains (sections 5.1.3 and 5.1.4). The testing structure in Hypotheses 1 through 4 implies certain data management criteria. The technological and subsistence data obtained in the fundamental domains should be compiled in a relational data base which allows the analyst to readily identify co-occurrences of subsistence resources and technological attributes on an inter- and intrasite basis. Distinguishing intrasite distributions will be especially important because differential intrasite distributions of technological attributes and subsistence resources may point much more directly toward identification of specific apparatus/resource associations than attempting to sort out such associations only at the site level. Moreover, data should be compiled in a manner that anticipates accretional additions to the data base during the ongoing conduct of research because the initial stages of implementation of an ongoing CRM program (in contrast to the more or less immediate requirements of salvage programs) can be expected to yield data bases too small for identification of statistically significant associations. As additions to the data base produce increasingly well-defined apparatus/resource associations, these associations should be entered into Fort Hood's GRASS system in order to establish a basis both for analyzing the distribution of associations and for identifying data gaps which may affect the CRM evaluation of site potential amidst developing scientific understandings of apparatus and subsistence resources. Hence, it is necessary to establish a system for updating the content of GRASS files to reflect increasing levels of development of knowledge of apparatus/resource associations.

As noted in the fundamental domains, data from discrete contexts will comprise a more powerful basis for identifying apparatus/subsistence associations than data from less discrete contexts. On the other hand, however, immediate progress can be made in advancing the burned rock midden problem by obtaining large amounts of ethnobotanical and faunal data from mixed palimpsest middens and then dating edibles by AMS radiocarbon techniques. Given that little is known about the details of subsistence-related aspects of burned rock middens (section 4.1.2), this procedure can provide an initial data set that identifies putative site-level associations between resource-choice and seasonality decisions on one hand, and the accumulation of burned rock, on the other, within an absolute chronometric framework. By specifically targeting mixed midden deposits for initial model-building of resource/burned rock associations, the relatively high costs of ethnobotanical analysis and AMS dating can be offset by: (1) short-term savings accrued by acknowledging that the lack of tight within-site context obviates any significant value to be obtained from cost-intensive excavation by horizontal-stripping techniques and detailed artifact analyses; and (2) long-term savings accrued by going into future excavations of more discrete sites with initial models of resource/burned rock associations already in hand. An expenditure of this sort in the early stages of implementation of the research design can therefore establish a range of testable hypotheses of the relationships between middens and specific subsistence resources. These hypotheses can serve in turn as guides for identifying specific management and excavation criteria relevant to the ongoing evaluation of both other palimpsest middens and more discrete middens. Such a process removes from the CRM inventory a site that has scientific value relative to the current state of the art, but is not particularly worth saving *ad infinitum*. Simultaneously, using such sites in this manner is cost-effective because it avoids having to use other, more scientifically valuable sites for exploratory model-building (cf. Black 1989), thereby enabling CRM management activities and funds (including "hidden costs" of preservation; Carlson and Briuer 1986) to be focused more directly in the long run on topics that advance our understanding of the details of adaptations at Fort Hood.

5.2.2 Substantive-Research Domain: Site Function II--Spatial Organization of Individual Technologies

Discussion

Having identified the apparatus of various technologies in the previous domain (section 5.2.1), the analyst is in a position to begin fleshing out the organizational component of the technologies to which the apparatus belong. Within the theoretical assumptions of this research design (see sections 4.2.3.1 and 4.2.3.2), the apparatus and organization of a technology are different aspects of the same phenomenon owing to the fact that both are indispensable instruments for accomplishing a goal. Consequently, identifying the organizational properties that are associated with any given apparatus identifies part of the means by which goals are met.

Spatial data is the primary basis for inferring organization from apparatus. At any stage of a production process, people can be moved to resources or resources to people, each of which structures tool--and consumable--use behavior in distinct ways that affect how other activities can be performed. For example, if a subsistence resource is available for a very limited period of time in a very limited spatial distribution, moving people to that resource limits opportunities to exploit other resources which may be available in other places simultaneously. Thus, an apparatus organized to move people to resources automatically produces different results than the same apparatus organized to move resources to people. Consequently, understanding how individual apparatus are organized in space is essential to understanding how applications of different apparatus were organized vis à vis each other, which in turn is essential to understanding the nature of an adaptation. This domain can be considered to be an extension of testing for site function because it provides the basis for ultimately determining how any given site functioned among other sites by determining whether individual technologies were forager- or collector-organized.

5.2.2.1 Hypothesis 5

All stages of a one-apparatus/one-resource subsistence technology typically were organized to move people to resources.

Relevance

If all stages of an one-apparatus/one-resource subsistence technology typically were performed in the same place, it may imply that people were moved to that resource. This may further imply that unless there is evidence to the contrary, a primary influence on the organization of the technology was that all the tools and consumables necessary for exploiting the resource were either available at the place of exploitation or were portable enough relative to the importance of the resource to warrant moving them there.

Test Implications

TI-5.1: The presence of each element of an apparatus that survives Hypothesis 1 (i.e., an OA/OR apparatus) nonrandomly predicts the presence of the other elements of that apparatus.

Relevance: Components of an apparatus may be used more or less in concert during activities directed toward a single end result. Use in such a manner should make it more probable for items used in the same process to enter the archaeological record in tandem rather than in conjunction with items used in other processes. If people are moved to a subsistence resource, it is likely that the activities to exploit and consume that resource will take place there. Consequently, if all elements of an apparatus surviving Hypothesis 1 also survive TI-5.1, the analyst has good reason to believe that those elements usually were used together during resource exploitation, which implies that people typically were moved to the resource if other factors do not imply otherwise.

TI-5.1 is falsified whenever elements of an apparatus that survives Hypothesis 1 are not mutually predictive. Falsification of TI-5.1 for an element is sufficient ground for asserting that the element is not a component of the same stage of resource production as the other elements, and that the nonmutually predictive elements are not used in the same locations. Falsification of TI-5.1, therefore, implies that at least part of the resource-exploitation process involves moving resources to people. Note that falsification of TI-5.1 does not affect the acceptance of Hypothesis 1. For example, the apparatus used for initial butchering at a kill site and the apparatus used to finish butchering and/or to prepare meat for consumption are systemically related components of a meat-consumption technology. The locations of these activities may be different so that evidence of these activities enters the archaeological record in different places. TI-5.1, therefore, tests for the existence of sequentially linked, but spatially disjunct, segments of a technology directed toward a specific subsistence resource. The identification of spatially disjunct elements of an OA/OR technology constitutes *prima facie* evidence that the technology was collector-organized because it shows that resources were moved to people during at least part of the resource-exploitation process.

Falsification of TI-5.1 also does not affect the apparatus/resource associations identified in Hypothesis 1. For example, if an element fails TI-1.2 but survives Hypothesis 2 (i.e., if that element is shown to be used for exploiting a specific combination of resources that includes the resource that defines an OA/OR apparatus), then TI-5.1 does no more than to show cases where resource-specific and multipurpose elements of an OA/OR apparatus typically co-occur or do not co-occur. Therefore, TI-5.1 shows where a multipurpose element of an OA/OR apparatus typically is used in conjunction with one or more stages of another subsistence technology. This information would constitute an important piece of data for sorting out technology-to-technology organization.

TI-5.2: The presence of any apparatus surviving TI-5.1 typically does not occur in a site with paleoenvironmental characteristics incompatible with the resource exploited by the one-apparatus/one-resource apparatus.

Relevance: It is possible for an OA/OR technology to be applied in an organization that moves resources to people. Definitive evidence of such a case would be the presence of an OA/OR apparatus in a paleoenvironment that was incompatible with the habitat of the exploited resource (e.g., clams associated with their apparatus in upland sites). Falsification of TI-5.2 therefore implies that an OA/OR technology was organized to move resources to people. It also implies that an apparatus for procuring the resource remains to be identified in other paleoenvironmental contexts. However, note that surviving TI-5.2 only modestly corroborates Hypothesis 5 for a given OA/OR apparatus because the same resource can be procured in nearby and distant procurement locales simultaneously.

5.2.2.2 Hypothesis 6

All stages of a one-apparatus/several-resource subsistence technology identified under Hypothesis 2 typically were organized to move people to resources.

Relevance

If all stages of an OA/SR subsistence technology typically were performed in the same place, it may imply that people were moved to that resources. This may further imply that unless there is evidence to the contrary, a primary influence on the organization of the technology was that all the tools and consumables necessary for exploiting the resources were either available at the place of exploitation or were portable enough relative to the importance of the resources to warrant moving them there.

Test Implications

TI-6.1: The presence of each element of an apparatus that survives Hypothesis 2 (i.e., a one-apparatus/-several-resource apparatus predicted by a conjunctionof subsistence resources) nonrandomly predicts the presence of the other elements that apparatus.

Relevance: As in Hypothesis 5, use of a single apparatus for exploitation of several resources should make it more probable for items used in the same process to enter the archaeological record in tandem rather than in conjunction with items used in other processes. If people are moved to the locale of a combination of subsistence resources, it is likely that the activities to exploit that resource will take place there. Consequently, if all elements of an apparatus surviving Hypothesis 2 also survive TI-6.1, the analyst has good reason to believe that those elements usually were used together during resource exploitation, which implies that people typically were moved to the resources if other factors do not imply otherwise.

TI-6.1 is falsified whenever elements of an apparatus that survives Hypothesis 2 are not mutually predictive. Falsification of TI-6.1 for an element is sufficient ground for asserting that the element is not a component of the same stage of resource production as the other elements, and that the non-mutually predictive elements are not used in the same locations. Falsification of TI-6.1, therefore, implies that at least part of the resource-exploitation process involves moving resources to people. As with TI-5.1, falsification of TI-6.1 does not affect the acceptance of Hypothesis 2 because TI-6.1 tests for the existence of sequentially linked, but spatially disjunct, segments of a technology directed toward a specific combination of subsistence resources. Falsification of TI-6.1 also does not affect the apparatus/resource associations identified in Hypothesis 2. For example, if an element fails TI-2.2 but survives Hypothesis 3 (i.e., if that element is shown to be used for exploiting one or more specific resources in addition to those that define an OA/SR apparatus), then TI-6.1 does no more than to show cases where resource-specific elements of one OA/SR apparatus typically co-occur or do not co-occur with elements of another OA/SR apparatus. Therefore, TI-6.1 shows where an element of an OA/OR apparatus typically is used in conjunction with one or more stages of another subsistence technology. This information would constitute an important piece of data for sorting out technology-to-technology organization.

TI-6.2: The presence of any apparatus surviving TI-6.1 typically does not occur in a site with paleoenvironmental characteristics incompatible with any of the specific resources exploited by the one-apparatus/several-resources apparatus.

Relevance: It is possible for an OA/SR technology to be applied in an organization that moves resources to people. Definitive evidence of such a case would be the presence of an OA/SR apparatus in a paleoenvironment that was incompatible with the habitat of at least one of the exploited resources. Falsification of TI-6.2 therefore implies that an OA/SR technology was organized to move at least one resource to people. It also implies that an apparatus for procuring the "imported" resource(s) may remain to be identified in other paleoenvironmental contexts. However, note that surviving TI-6.2 only modestly corroborates Hypothesis 6 for a given OA/SR apparatus for the same reason that TI-5.2 only modestly corroborates Hypothesis 5.

5.2.2.3 Hypothesis 7

All stages of a one-apparatus/several-resource subsistence technology identified under Hypothesis 3 typically were organized to move people to resources.

Relevance

The relevance of Hypothesis 7 is the same as for Hypothesis 6.

Test Implications

TI-7.1: The presence of each element of an apparatus that survives Hypothesis 3 (i.e., a OA/SR apparatus predicted by a disjunction of subsistence resources) nonrandomly predicts the presence of the other elements of that apparatus.

Relevance: As in Hypothesis 6, use of a single apparatus for exploitation of a variable set of resources should make it more probable for items used in the same process to enter the archaeological record in tandem rather than in conjunction with items used in other processes. If people are moved to a locale to exploit a variable combination of subsistence resources, it is likely that the activities to exploit that resource will take place there. Consequently, if all elements of an apparatus surviving Hypothesis 3 also survive TI-7.1, the analyst has good reason to believe that those elements normally were used together during resource exploitation, which implies that people typically were moved to the resources if other factors do not imply otherwise.

TI-7.1 is falsified whenever elements of an apparatus that survives Hypothesis 3 are not mutually predictive. Falsification of TI-7.1 for an element is sufficient ground for asserting that the element is not a component of the same stage of resource production as the other elements, and that the nonmutually predictive elements are not used in the same locations. Falsification of TI-7.1, therefore, implies that at least part of the resource-exploitation process involves moving resources to people. As with TI-6.1, falsification of TI-7.1 does not affect the acceptance of Hypothesis 3 because TI-7.1 tests for the existence of sequentially linked, but spatially disjunct, segments of a technology directed toward a variable combination of subsistence resources. Falsification of TI-7.1 also does not affect the apparatus/resource associations identified in Hypothesis 3.

TI-7.2: The presence of any apparatus surviving TI-7.1 typically does not occur in a site with paleoenvironmental characteristics incompatible with any of the specific resources exploited by the OA/SR apparatus.

Relevance: It is possible for an OA/SR technology to be applied in an organization that moves resources to people. However, because an OA/SR apparatus identified under Hypothesis 3 cannot be asserted to be directed toward a specific resource, definitive evidence of moving resources to people is more variable. If an OA/SR apparatus is located in a paleoenvironment that was incompatible with the habitat of all the exploited resources, TI-7.2 and, hence, Hypothesis 7, are falsified, implying that an OA/SR technology was organized to move resources to people. It also implies that apparatus for procuring the "imported" resources may remain to be identified in other paleoenvironmental contexts. However, it is possible that a disjunction of resources from mutually exclusive habitats can identify an apparatus under Hypothesis 3. If such an OA/SR apparatus is located in a paleoenvironmental context that is compatible with at least one of its resources but not with all of them, then TI-7.2 and Hypothesis 7 can be falsified definitively only in specific cases where evidence of the "imported" resource is found along with the apparatus. Note, therefore, that surviving TI-7.2 only weakly corroborates Hypothesis 7 for a given OA/SR apparatus, not only for the same reason that surviving TI-6.2 only modestly corroborates Hypothesis 6, but also because falsification can be definitive only in conjunction with evidence of subsistence resources.

5.2.2.4 Hypothesis 8

All stages of a technology identified under Hypothesis 4 typically were organized to move people to resources.

Relevance

Hypothesis 4 identifies nonsubsistence apparatus and distinct components of subsistence apparatus. Hence, to the extent that data allow, Hypothesis 4 isolates the apparatus of support-technologies and the constituent components of subsistence technologies. Both of these involve procuring the raw materials which comprise the consumable components of their respective apparatus, in which case the organization of a given nonsubsistence or subsistence technology can involve moving people to consumables or consumables to people. In this case, moving people to consumables means moving them to locales where the consumables for a support technology are available. If people are moved to consumables in order to produce the apparatus of their support and subsistence technologies, then all of the activities associated with producing an apparatus may take place at the locale where the consumables are procured. However, procuring consumables may be organized into a distinct task whereby only a minimum number of activities are performed to transform consumables into a form that is compatible with their eventual use(s), but portable enough to be taken to other places where the rest of the activities related to producing an apparatus are performed. Indeed, the spatial relationship between the places where consumables are procured and the places where they are incorporated into an apparatus is a primary datum for determining how tool production is organized vis à vis subsistence technologies. For example, lithic procurement could involve only limited reduction at the source in order to provide portable materials for further reduction elsewhere.

Test Implications

TI-8.1: Each identifiable production stage for an apparatus that survives Hypothesis 4 occurs in a place where the consumables for that apparatus occur.

Relevance: If each production stage for an apparatus occurs where its consumables are procured, then the production of an apparatus is organized to move people to consumable resources. If TI-8.1 is not falsified for an apparatus, it implies that the location of the consumables is a primary determinant of the organization of technologies that produce apparatus for other purposes. For example, if slab-lined hearths nonrandomly occur at locations where the slabs were procured, it implies that the organization of hearth production involves moving people to resources. If TI-8.1 is falsified, it implies that the organization of apparatus production is not determined by the location of consumables except to the extent that procuring consumables is limited by their spatial distribution. For example, if large numbers of amorphous flake fragments but very few cores and/or aborted tools are found at chert outcrops, it implies that chert consumables were integrated into a tool-production process that moved resources from the place they were available to the place(s) where people made tools. Furthermore, if apparatus-production debris is located at a distance from the source(s) of consumables, TI-8.1 is falsified.

5.2.2.5 Hypothesis 9

Each apparatus is coupled with a specific organization to constitute an identifiable technology.

Relevance

An apparatus is associated with an organization to constitute a technology. To the extent that an apparatus is consistently associated with an organization, the two are integrated in a consistent decision-making pattern that reflects a consistent application of tools, consumables, and social roles which together comprise a distinct subsystem within an adaptation. If there is no consistency of association between apparatus and organization, then there is reason to believe that no consistent decision-making pattern unites apparatus and organization, in which case the absence of consistency is an item to be explained in terms of adaptive strategy and/or environmental variability.

Test Implications

TI-9.1: Each identifiable apparatus is associated nonrandomly with a particular organization.

Relevance: If an apparatus survives TI-9.1, then it was applied in a consistent organization. This implies that the apparatus and organization were components of a technology based on a specific (and, for us, unknowable) body of environmental and social knowledge. As such, a technology whose apparatus survives TI-9.1 is likely to have adaptive significance as a technology that was selected because it had a high probability of meeting goals in a predictable environment. On the other hand, if an apparatus fails TI-9.1, it was not applied in a consistent organization, which may imply (in the absence of evidence to the contrary) that a specific apparatus and a flexible organization were components of a technology likely to have adaptive significance because it had a high probability of meeting goals in an unpredictable environment. Thus, variability of organization associated with a specific apparatus implies that the composition of a technology (as a combination of apparatus, organization, and knowledge) was directly related to its adaptive significance vis à vis an unpredictable environment or resource. Evidence to the contrary would consist of a demonstration (Hypothesis 11) that randomness of association follows from diachronic variation in organization; or a demonstration that randomness of association follows from the influence of the organizational properties of another technology; or a demonstration that paleoenvironmental conditions were not unpredictable.

5.2.2.6 Summary of Results from Site Function II Domain

By the time testing under Hypotheses 5 through 9 is complete, the analyst has accumulated a catalog of the apparatus and organizations of various technologies that can be identified on the basis of available evidence. This catalog places apparatus and their spatial properties into a framework that individually summarizes the material and organizational means for exploiting subsistence and nonsubsistence resources. Thus, this catalog contains the basic information needed to sort out adaptive strategies because it summarizes the array of identifiable technologies that comprise the repertoire from which adaptive choices were made. Hence, this catalog serves as the basis for identifying adaptive strategies by serving as the data base from which to identify the specific combinations of technologies that were integrated together to form an adaptive structure. However, note that, because time has not yet been incorporated into the analysis, it is possible that at least some nonrandom associations between apparatus and organization have been obscured by testing because an apparatus with a long duration of use could have been forager-organized early on and collector-organized later on with, perhaps, a mixed pattern in between. Consequently, before moving on to the identification of adaptations, it is necessary to determine the chronological status of combinations of apparatus and organization.

Data Requirements

The primary data requirements for identifying the organizations of individual technologies are well-developed inventories of apparatus/subsistence associations and maximally detailed paleoecological reconstructions. In the early stages of implementation, it is to be expected that an inventory of apparatus/subsistence associations is not likely to be available because of small subsistence data bases. However, an interim proxy data base would consist of mutually predictive associations of technological attributes that appear to represent distinct apparatus identified under Hypothesis 4 (section 5.2.1.4). In this case, distinct apparatus can be correlated with paleoenvironmental contexts in order to determine whether there are consistent apparatus/paleolandscape associations to which subsistence associations can be added later as prediction from the subsistence data base becomes more robust with the ongoing accumulation of new subsistence data.

This aspect of data requirements for inferring the organizations of technologies highlights the importance of integrating technological, subsistence, and paleoenvironmental data into Fort Hood's GRASS system in a manner that allows for ongoing revision of spatial relationships between technological and subsistence associations. For example, as data on the associations between various portions of bison anatomy and specific technological assemblages accumulates (cf. Speth 1983), plotting the spatial relationships between such associations will be an important element in determining whether bison kill sites, butchering sites, and consumption sites typically are or are not the same site. Plotting these technological and subsistence data against a paleoenvironmental reconstruction will help the analyst determine the degree to which residential and/or logistical moves were involved in bison procurement and consumption. For example, to the extent that kill sites are located on upland prairies and residential sites with evidence of bison consumption are located in riverine areas, a logistical organization for bison-consumption technology is supported by the data, especially if evidence of selective removal of portions of bison anatomy from kill sites corresponds to evidence of consumption of those portions at residential sites. Thus, in general, being able to update the spatial relationships between subsistence, technological, and paleoenvironmental associations will be an important tool for recognizing the organizations of individual technologies.

5.2.3 Substantive-Research Domain: Stability and Change in Technology and Subsistence

Discussion

Having identified the various subsistence and nonsubsistence technologies in the previous domains (Site Function I and II), the next stage in the reconstruction of adaptations in the Fort Hood area is to identify the periods of use of the various technologies. At any given time, the members of a given group of people have at their disposal a finite number of technologies that comprise the means by which they adapt to the environment. This domain, therefore, tests technologies (i.e., combinations of apparatus and organization) identified in the previous domains for their temporal properties. Since the analysis of adaptive change (within the theoretical assumptions of this research design) is a matter of first identifying distinct adaptations, a major task to be accomplished before distinct adaptations can be identified is to identify suites of contemporary technologies that reflect the means used to meet resource-procurement goals at any given time, and thence, to identify trends in the changing composition of suites of technologies over time. Furthermore, because the resources actually exploited comprise the set of objects toward which technologies were directed, it also is necessary to identify trends in the changing composition of the subsistence-resource base over time. Note that because technology-to-technology organization and seasonal organization have not yet been addressed, this domain cannot provide sufficient ground for actually identifying adaptations because, in principle, adaptations involve specific patterns of integration of technologies. (Indeed, before the seasonal and systemic organization of technologies can be addressed, it is necessary to find out which combinations of apparatus and organization co-existed and which did not.) Consequently, this domain establishes a baseline against which to identify adaptations by identifying times of stability and change in technology and subsistence that distinguish one adaptation from another. In other words, testing in this domain orders technological and subsistence data into a chronological framework from which the analyst may select possible candidates for distinct adaptations.

In essence, then, this domain is the first step toward construction of the equivalent of a local culture chronology in a research program that focuses on adaptation rather than sociocultural groups. As such, the equivalent of a Willey/Phillips-like local culture chronology derived in this and the next domain establishes the base of local decision-making structures which can be inferred from the evidence at any given time and which will serve as the object of explanation in later domains (contrast with Prewitt 1981, 1985). Thus, in what follows, the term "adaptive phase" refers to distinct, temporally-bounded adaptations (i.e., decision-making structures; see section 4.1.2.3), and not to Willey/Phillips-like sociocultural constructs (see sections 4.1.1.5 and 4.1.1.6). The identification of distinct communities is deferred to a later domain in order to determine whether the existence of distinct groups is a variable that accounts for stability or change in local adaptive phases identified at Fort Hood.

Note that although testing in this domain cannot positively identify adaptations, it can show whether temporal diagnostics comprise a suitable basis for identifying adaptations by showing whether or not the introduction of temporal diagnostics coincides with more widespread adaptive change. The testing mechanism below focuses on relationships between technologies, subsistence resources, and temporal diagnostics in order to provide a recognizable index against which to correlate stability and change in technologies and the subsistence-resource base. In the process of testing, all identifiable technologies and subsistence resources will be compared with temporal diagnostics in order to place change in technology (including organizational change) and change in emphasis on subsistence resources in a chronological framework. If the introduction of temporal diagnostics does not coincide with wider technological or subsistence change, there will be good reason to doubt their significance as indicators of substantial adaptive change and, hence, as boundary markers for adaptive phases (see section 4.1.1.4). In such cases, stylistic change independent of adaptive change becomes an item to be explained in a later research domain (section 5.2.7) in terms of ideological or sociocultural change (see section 4.2.3.4).

5.2.3.1 Hypothesis 10

The timing of technological change coincides with the introduction of at least one temporally-diagnostic artifact.

Relevance

Change in temporally-diagnostic artifacts (mostly projectile points) is generally construed in Central Texas archaeology to signify general cultural change (e.g., Prewitt 1981, 1985; Johnson 1987). For temporally-diagnostic artifacts to signify an *adaptive* shift (as opposed to an aesthetic or ideological shift), then a shift in temporal diagnostics must coincide with change in a major component of adaptation. One area where major adaptive shifts should be apparent is in one or more subsistence technologies. If the timing of change in temporal diagnostics does not coincide with the timing of more widespread technological change, then temporal diagnostics cannot be used to refer to specific adaptations either within the Fort Hood area or in comparisons between adaptations in Fort Hood and elsewhere. If the timing of change in temporal diagnostics coincides with more general technological change, then further testing may indicate that temporal diagnostics can be used to refer to adaptations within Fort Hood and in comparisons between Fort Hood and elsewhere. To the extent that projectile points comprise the primary data base for temporal diagnostics, this hypothesis will provide a basis for determining whether using projectile point types as primary definitional criteria for culture chronologies is a defensible procedure in research programs (such as this one) which focus primarily on the history of adaptation rather than the history of sociocultural groups. Hypothesis 10 assumes that the chronometric dates assigned to potential temporally-diagnostic artifacts in section 5.1.1.1 also are associated with other artifacts and subsistence data. Therefore, Hypothesis 10 assumes that non-diagnostic artifacts and subsistence data can be placed in a chronometric framework for comparison to temporal diagnostics.

TI-10.1: The date of initial appearance of a subsistence technology (i.e., combination of apparatus and organization) identified under Hypotheses 5 through 9 is statistically indistinguishable from the date of initial appearance of a diagnostic artifact identified in the fundamental domains.

Relevance: TI-10.1 is falsified in general if the date of initial appearance of every temporally-diagnostic artifact type does not coincide with the date of initial appearance of a subsistence technology. If so, then there is good reason to doubt that there is any association between shifts in temporal diagnostics and shifts in adaptation. However, TI-10.1 can be falsified in some details without being falsified in general. For example, there may be some cases where the introduction of a subsistence technology coincides with the initial appearance of a temporal diagnostic, and other cases where they do not coincide. If TI-10.1 is falsified for several specific subsistence technologies without being falsified for others, then technological change is not associated with change in temporal diagnostics for at least part of the cultural sequence at Fort Hood, in which case change in temporal diagnostics is not a general indicator of substantial adaptive change. If TI-10.1 is not falsified for subsistence technologies in general, there is good reason to suspect that change in temporal diagnostics is an indicator of adaptive change.

TI-10.2: If a subsistence technology that fails TI-10.1 involves an apparatus identified under Hypotheses 1 or 2, then the introduction of a temporal diagnostic must coincide with a change in organization.

Relevance: One-apparatus/one-resource and one-apparatus/several-resource technologies (if correctly identified under Hypotheses 1 and 2 respectively) are directed toward invariable subsistence resources. Hence, such technologies always reflect consistent resource-exploitation choices that are independent of the processes governing change in temporal diagnostics if one of these technologies fails TI-10.1. Consequently, any such apparatus is independent of the processes governing change in temporal diagnostics if a nonrandomly consistent organization is associated with it under Hypothesis 9, because a specific combination of apparatus and organization directed toward specific resources endures both before and after the introduction of a temporal diagnostic. Falsification of TI-10.1 for such an apparatus would also falsify TI-10.2 and Hypothesis 10 for that apparatus. However, if the introduction of a temporal diagnostic coincides with a change in organization of an apparatus identified under Hypotheses 1 or 2, then the temporal diagnostic coincides with wider technological change and is consistent with general adaptive change. The less across-the-board correspondence between the introduction of temporal diagnostics and either the introduction of resource-specific technologies or changes in the organization of resource specific technologies, the less reliable the relationship between temporal diagnostics and adaptations, and the weaker the inductive basis for assigning adaptive significance to a site on the basis of temporal diagnostics.

TI-10.3: If a subsistence apparatus that fails TI-10.1 is associated under Hypothesis 3 with a disjunction of subsistence resources, then the date of appearance of a temporal diagnostic must mark a nonrandom shift of emphasis from one part of the disjunction to the other part.

Relevance: Since all one-apparatus/several resource technologies identified under Hypothesis 3 involve prediction from disjunctions of resources that are independent of time, it is possible for Hypothesis 3 to derive associations in which the subsistence use for a single apparatus shifts from an earlier emphasis on one specific resource (or set thereof) to a later emphasis on another specific resource (or set thereof). If such a shift in resource emphasis coincides with the introduction of a temporal diagnostic, then the introduction of the temporal diagnostic is consistent with a general adaptive shift. For example, if the disjunction "acorns and sotol" predicts the presence of burned rock middens and hearths, and if introduction of a temporal diagnostic marks a break between an earlier association with sotol and a later association with acorns, then the introduction of the temporal diagnostic and the shift in subsistence emphasis are consistent with a substantial adaptive change.

If a shift in resource emphasis does not coincide with introduction of a temporal diagnostic, then the introduction of the temporal diagnostic bears no relationship to the adaptive change indicated by the shift in application of the apparatus. Falsification of TI-10.3 therefore implies that a shift in emphasis on subsistence resources is independent of a shift in temporal diagnostics, and that temporal diagnostics bear no relationship to a shift in adaptation.

TI-10.4: If a subsistence technology survives TI-10.1 and fails TI-10.3, then the date of introduction of a temporal diagnostic must mark a nonrandom shift of organization.

Relevance: Since all one-apparatus/several resource technologies identified under Hypothesis 3 involve prediction from disjunctions of resources that are independent of time, it is possible for Hypothesis 9 to derive random associations in which the organization of a single apparatus shifts from an earlier people-to-resource emphasis to a later resource-to-people emphasis (or vice versa). If such a shift coincides with the introduction of a temporal diagnostic, then the introduction of the temporal diagnostic is consistent with a wider adaptive shift. If not, then the introduction of the temporal diagnostic bears no relationship to the adaptive change indicated by the shift in organization of the technology. Falsification of TI-10.4 therefore implies that a shift in organization is independent of a shift in temporal diagnostics, which implies that temporal diagnostics do not signify wider adaptive change.

Note that this series test of implications also should be recast to correlate the initial appearance of temporal diagnostics with the *dis*appearance of subsistence technologies. In this case, if there are mismatches between diagnostics and the abandonment of a technology, then it is implausible to assert that the appearance of a diagnostic is related to the disappearance of a subsistence technology as a function of general technological change. Further note that both series of tests also should be applied to nonsubsistence technologies identified under Hypothesis 4 in order to place them in a chronological framework and to identify any possible shifts in support technologies that may relate to shifts in temporal diagnostics.

If there are serious across-the-board mismatches between the appearance of diagnostics on the one hand, and the appearance or disappearance of any given technology or changes in organization or subsistence emphasis on the other hand, then it is apparent that the evolution of a technology with temporally-diagnostic apparatus was more independent than co-evolutionary with respect to other technologies. Note that shifts in temporal diagnostics also are shifts in at least one aspect of technology, and if temporal diagnostics comprise the apparatus of a subsistence technology, then the value of the diagnostics as indicators of adaptive change can be assayed directly by determining whether diagnostic change coincides with change organization or in the resource exploited. For example, if change in temporally-diagnostic projectile points is not accompanied by change in hunted resources, then unless there is evidence of an organizational shift in hunting technology, the sequence of diagnostic projectile points cannot be asserted to reflect a change in adaptation, even if projectile points reflect change in delivery systems (e.g., from atlatl to bow). If projectile point change is accompanied by evidence of change in hunted species, then there is good reason to believe that the two are related. However, even if changes in points, hunting organization, and/or hunted species coincide, a general adaptive shift can be asserted confidently only if there are simultaneous shifts in other technologies.

5.2.3.2 Summary of Results from Stability and Change in Technology Domain

By the time testing under Hypothesis 10 has been completed (including the original and recast test implications), the analyst has at his/her disposal a chronological catalog of subsistence and nonsubsistence technologies which documents the matches and mismatches between shifts in individual technologies and temporal diagnostics for the Fort Hood area. Furthermore, by correlating the appearance and disappearance of individual technologies with the appearance of temporal diagnostics, the analyst by default also has correlated the appearance and disappearance of technologies and shifts in organization and resource emphasis with each other. If there are serious across-the-board mismatches, such that few subsistence technologies appear/disappear or few organization-/resource-shifts occur more or less simultaneously, then there is good reason to assert that the evolution of technology was more or less incremental. If technology evolved more or less incrementally, then adaptive change also must have been incremental. Hypothesis 10, therefore, not only establishes a chronological catalog of technology-to-diagnostic relationships, it also establishes a general chronological catalog (i.e., an occurrence seriation) of technology-to-technology and technology-to-resource relationships. This seriation forms part of the basis for identifying adaptations by establishing suites of co-existent technologies and subsistence-resource bases that can be examined for consistency of integration. Furthermore, working through Hypothesis 10 discloses any gaps that may exist in terms of statistically sufficient sample sizes in the technological and subsistence data bases for any given period of time.

Data Requirements

Data requirements for examining stability and change in technology and subsistence include well-developed catalogs of (1) descriptions of technologies (including their organizations and associated subsistence resources) and (2) temporally-diagnostic artifacts that have been critically evaluated against chronometric data. Hence, it follows that research in all previous domains must be well-advanced before substantive, highly corroborated results can emerge from this research domain. It therefore also follows that the identification of data gaps under Hypothesis 10 points toward resource management needs by identifying time periods for which subsistence and technological data are inadequate or redundant, which in turn may help CRM managers and researchers evaluate the importance of particular cultural properties relative to current scientific needs.

5.2.4 Substantive-Research Domain: Identifying Adaptations I--Temporally-Specific Arrays of Technologies and Subsistence Resource Bases

Discussion

Having identified various technologies and arranged them in a chronological order that notes the timing of shifts in apparatus, organization, and subsistence-resource emphasis, the analyst is in a position to identify determinate, temporally-specific arrays of technologies arranged in a determinate way to exploit a series of subsistence resources if any such arrays existed prehistorically. The purpose of this domain is to continue the process of identifying local adaptive phases defined in terms of the ways arrays of technologies were used to meet subsistence goals. This domain assumes that the analyst has identified from the seriation developed in the previous domain apparent shifts in technology (i.e., in apparatus and/or organization) or in emphasis on subsistence resources, and that these shifts are possible boundaries between adaptations. Testing attempts to determine whether apparent shifts in the seriation demarcate boundaries between distinct combinations of technologies and/or subsistence resources, irrespective of their chronological relationships to temporal diagnostics. For an adaptive phase to be identified according to the theoretical assumptions of this research design, it is necessary to identify distinct sets of means by which people adapted to the environment, distinct sets of subsistence resources that were exploited, or distinct sets of both. These sets reflect both the subsistence goals and decision-making structures used to meet those goals.

5.2.4.1 Hypothesis 11

Distinct arrays of technologies are temporally-bounded by other distinct arrays of technologies.

Relevance

A primary dimension for separating one phase from another is the array of technologies used at a given time. However, identifying a distinct array of technologies is only possible in comparison to previous and subsequent arrays of technologies. Hence, Hypothesis 11 involves determining whether an analyst's intuitions about technological shifts in the seriation are substantiated. Note that the term "distinct" implicitly refers to more or less invariable, stable arrays of technologies despite the fact that a variable array can be regarded as distinct in comparison to a relatively invariable array. Hypothesis 11, therefore, is a null hypothesis that seeks periods of technological stability, but does not expect to find them on a priori grounds. Rather, it assumes that attempting to find periods of technological stability is the most direct route toward determining whether such stability ever was a major feature of the history of adaptation at Fort Hood.

Test Implications

TI-11.1: For any period of time identified by the analyst as having a distinct array of technologies, the probability of occurrence of each apparatus is not equal to the probability of occurrence before and after that time period.

Relevance: If any intuitively identified time period is characterized by a distinct array of technologies, then each member of the array should be unlikely to occur in any other time period. Because one of the defining characteristics of a technology is its apparatus, this implies that an intuitively identified time period must contain a set of apparatus unlikely to occur in any other time period. This means that at any given level of data accumulation, p (observation of apparatus a at x number of sites) for the period of interest must be greater than p(observation of apparatus a at y number of sites) before and after the period of interest for every apparatus in the array during the period of interest. For each apparatus for which p(observation of apparatus a) is not greater during the period of interest, TI-11.1 and, hence, Hypothesis 11, is weakened. The greater the proportion of apparatus that fail TI-11.1, the weaker the basis for asserting that the period of interest constitutes a distinct phase unless organizational or subsistence factors indicate otherwise.

TI-11.2: Each apparatus that fails TI-11.1 has a different organization during the period of interest in comparison to its organization before and after the period of interest.

Relevance: Strictly speaking, an apparatus with one organization during one period and another organization during another period could be classified as two technologies within the theoretical assumptions of this research design. Hence, if one takes a "splitter" approach and identifies a distinct technology as a specific apparatus and a specific organization, any technology that fails TI-11.1 also fails TI-11.2 by default. However, in Hypotheses 5 through 7, organizations were associated with apparatus in an atemporal framework oriented around the null hypothesis that organization moved people to resources. This test implication is functionally equivalent to a test of Hypotheses 5 through 7 that includes a temporal dimension that therefore tests for associations between apparatus and people-to-resources organizations within a period of interest. Consequently, if the period of interest includes one or more apparatus that occur before and/or after the period of interest, nonrandom changes to or from a forager organization should coincide with the beginning and/or end of the period of interest if the period is a distinct phase. The greater the proportion of organizations that fail TI-11.2, the weaker the basis for asserting that the period of interest constitutes a distinct phase unless subsistence factors indicate otherwise.

TI-11.3: Each technology that fails both TI-11.1 and TI-11.2 was used to exploit a different subsistence resource during the period of interest in comparison to the resources exploited before and after the period of interest.

Relevance: To the extent that members of the array of technologies in the period of interest fail TI-11.1 and TI-11.2, the only grounds left for asserting that one has identified a phase consists of identifying differences in subsistence resources exploited using technologies with durations that extend before and/or after the period of interest. If technologies fail TI-11.1

and TI-11.2 but survive TI-11.3, then an otherwise stable technology is used for different purposes so that changes in purpose reinforce the analyst's judgment that he/she has identified a phase.

5.2.4.2 Hypothesis 12

Distinct subsistence bases are bounded in time by other distinct subsistence bases.

Relevance

Note that under Hypothesis 11, a definitive demonstration of a distinct adaptation would be forthcoming if every technology in the period of interest survives one of the test implications above, but only a weak demonstration that the period of interest is not a distinct phase would follow if every technology fails all the test implications. Moreover, it is unlikely that definitive demonstrations of distinct technological arrays will be found for much of the sequence if for no other reason than the existence of burned rock middens throughout much of the sequence implies that a single technology endured for a long time. Hence, technological change from time to time can range from "massive" technological change that involves "most" technologies to incremental change in the array of apparatus and/or organizations, within which array technological change is noticeable only cumulatively. The more technological change approximates incremental change, the more identifying distinct adaptations may be a matter of identifying changes in the subsistence resource base. Even if no distinct phases can be defined on the basis of different technological arrays, they may still be identifiable in terms of shifts in emphasis on subsistence resources.

Test Implications

TI-12.1: The array of subsistence resources exploited in the period of interest is nonrandomly different from the arrays before and after the period of interest.

Relevance: If the subsistence resource base in a period of interest has a significantly different composition compared to earlier and later resource bases, then there is good reason to believe that the period of interest is a distinct phase. If shifts in the resource array accompany at least a few shifts in the technological array, then there is sufficient evidence for identifying the period of interest as a distinct phase.

TI-12.2: There is a shift in degree of dependence on subsistence resources during the period of interest compared to before and after the period of interest.

Relevance: A shift from a low to a high dependence on a given resource (or vice versa), or from a random to a consistent dependence (or vice versa), is evidence of a shift in adaptation. If the period of interest is characterized by several such shifts, there is good reason to believe the period of interest is a distinct phase. Note that if shifts in dependence also coincide with shifts in technological and/or subsistence arrays, then there is sufficient evidence for identifying the period of interest as a distinct adaptation and, hence, a distinct phase.

5.2.4.3 Summary of Identifying Adaptations I

By the time testing under this domain is complete, the researcher has determined to the extent supported by current data which time periods are plausible candidates for adaptive phases and which time periods are not. Some phases may be characterized by incremental change in technology and/or subsistence, whereas others may be identified as phases in which a period of stability is bracketed by episodes of abrupt change. In either case, phases identified in this domain are at most tentatively identified until testing in the next domain (section 5.2.5) demonstrates the ways in which individual technologies are organized amongst each other in the pursuit of subsistence goals. Note that tentatively identified phases characterized by incremental technological and/or subsistence change are, strictly speaking, phases likely to represent periods during which a number of adaptations (i.e., decision-making structures) existed side-by-side or in rapid sequence. In the event such conditions are corroborated by accumulating evidence, an adaptive phase will not denote a single adaptation, but a period for which it is necessary to determine whether Fort Hood occupied part of the territory of a number of groups with different adaptations or the territory of a group undergoing adaptive change.

Data Requirements

Genuine progress in this domain depends upon the accumulation of substantial progress in all previous domains because the identification of supportable adaptive phases depends on data from a representative array of contemporary sites just as the definition of Willey/Phillips-like phases depends on data from a representative array of sites (cf. Willey and Phillips 1958; Trigger 1978; Willey and Sabloff 1980). Consequently, in the absence of progress in previous domains, a concerted effort should be made to identify the geomorphic and paleoenvironmental contexts most likely to provide previous domains with data that will flesh them out so that they may serve as a basis for identifying adaptive phases.

5.2.5 Substantive-Research Domain: Identifying Adaptations II--Adaptive Strategies

To the extent that data and testing in previous domains has led to the identification of likely candidates for adaptive phases in section 5.2.4, a basis has been established for identifying distinct adaptations characterized by their own peculiar approaches to decision-making. It is possible that testing in section 5.2.4 will show that change in technologies and/or subsistence bases was incremental for a substantial portion of the sequence. In this event, it is possible that no distinct phases other than phases defined as periods of incremental adaptive change will be identifiable on the basis of technological and subsistence data. However, adaptations based on stable or incrementally changing technologies and subsistence-resource bases could nonetheless be characterized by significant differences in the ways technologies are organized amongst each other. Thus, adaptations based on the same technologies and resources could be identified as distinct adaptations if they reflect different approaches to systemic organization of their constituent technologies.

The purpose of this research domain is to derive the maximum possible amount of supportable information regarding aboriginal use of specific locations for specific site functions, including multiple functions where applicable. Supportable inferences derived in this domain, based on information about technological and subsistence arrays derived in the previous domain, will allow for identification of land-use patterns which in turn constitute adaptive strategies. Part of the importance of land-use patterns involves discriminating the ways in which the inhabitants of Fort Hood distributed their various activities, not only in space relative to other activities, but also from season to season (Binford 1980). An understanding of the spatial and temporal distribution of activities provides direct insight into the aboriginal strategies that placed resource-exploiters with resources. These strategies themselves reflect decision-making structures that governed trade-offs between resource choices, mobility choices, and other factors (Savage 1990). They therefore also reflect the ways in which technologies were organized amongst each other and with respect to the resource base in order to meet goals. Consequently, the identification of land-use patterns is the same thing as the identification of the spatial and seasonal integration of subsistence and nonsubsistence technologies, which in turn is the same thing as the identification of adaptive strategies (cf. Butzer 1982).

The hypotheses below do not assume that temporally-specific arrays of technologies or subsistence bases have been identified in the previous domain, although they do assume that a period of interest in the previous domain is worth exploring because the absence of temporally-specific technology and/or subsistence bases may obscure higher level organizational differences. If distinctive, temporally-specific patterns of integrating technologies can be identified in a sequence that shows little, or only incremental, technological and/or subsistence change, the sequence of temporally-specific patterns of integration will comprise the sequence of adaptations. In such a case, the sequence will be characterized by different systemic organizations of an array of otherwise stable technologies and subsistence bases. In the event that temporally-specific technological arrays and/or subsistence bases have been identified in the previous domain, testing in this domain identifies the adaptive strategies within which distinct technological arrays were employed to exploit the subsistence base.

5.2.5.1 Hypothesis 13

During any given period of time, a forager strategy was used to integrate the members of the array of technologies.

Relevance

Two basic adaptive strategies have been identified for hunter-gatherers: forager and collector strategies (Binford 1980; Dennell 1983). Forager strategies move people to resources, and collector strategies move resources to people. (In previous domains, therefore, individual technologies already have been identified according to forager or collector organizations.) Furthermore, because resources are not uniformly distributed in space and time, and because resources at any given place and time occur in different absolute amounts, resource-exploitation activities may emphasize one resource at a time or several resources at a time. Thus, the specific ways technologies are organized relative to resources and to each other largely determines which resource opportunities are taken and which opportunities are foreclosed (Moore 1981).

For example, if a technology with a people-to-resources organization is used in a one-resource-at-a-time context, the one-resource-at-a-time strategy at least partially precludes opportunities to exploit other resources that might be available. If that same technology is used in a several-resources-at-a-time context among other such technologies, the several-resources-at-a-time strategy reduces the number of precluded opportunities by positioning exploitation activities in a place where several resources are available simultaneously. Both of these approaches are variations of a foraging strategy. If the same apparatus above is part of a technology with a resources-to-people organization used in a one-resource-at-a-time context, the one-resource-at-a-time strategy implies that there is some overriding reason to concentrate on a single, distant resource without changing residential location. If the same technology is used in a several-resource-at-a-time context among other such technologies, the several-resource-at-a-time strategy implies that there is some overriding reason to concentrate on a number of distant resources without changing residential location. Both of these approaches are variations of a collector strategy.

It is therefore apparent that for suites of technologies, an array of individual technologies (each of which has its individual organization) can be organized in a one- or several-resource-at-a-time strategy and a macrostrategy that places people either near a specific subsistence resource or in a position which, although it is not near a specific subsistence resource, can serve as a base for exploiting subsistence resources elsewhere. Hence, not only can individual technologies be organized around forager or collector strategies, but suites of forager- and/or collector-organized technologies can be organized at a higher level according to "macroforager" or "macrocollector" strategies. Each strategy balances technologies and residential moves against the spatial and temporal availability of subsistence resources, and each involves different decision-making structures that in turn reflect different information bases or criteria for making decisions (Moore 1981).

Note that the apparent simplicity of Hypothesis 13 masks a substantial amount of analytical complexity. This complexity follows from the fact that there are three primary dimensions along which archaeological evidence will support or falsify claims of a forager strategy. These dimensions are site specialization, site seasonality, and macro-organization. Each dimension is assayed below under a "subhypothesis."

5.2.5.2 Hypothesis 13a

Each site in a period of interest is specialized with respect to function.

Relevance

The degree to which sites have specialized functions is related to the organization of any given technology amidst other technologies. This follows from the fact that potential subsistence and other resources have distributions in space and time, and that an adaptive strategy which pursues its activities in a one-resource-at-a-time context may be characterized by specialized sites if it also is organized in a macroforager strategy.

Test Implications

TI-13.1: At any given site in a period of interest, a one-apparatus/one-resource apparatus does not occur with the apparatus of any other technology.

Relevance: For any site, TI-13.1 is not falsified just in case the only apparatus present belongs to a one-apparatus/one-resource technology. TI-13.1, however, can be falsified in several ways. Evidence of an identifiable OA/OR technology could co-occur with evidence of another identifiable subsistence technology, in which case TI-13.1 is false because several resources (or sets thereof) were exploited at the same place. Also, TI-13.1 could be falsified where an OA/OR technology occurs with an identifiable nonsubsistence technology. If the nonsubsistence technology involves rejuvenation of tools or production of consumables used in the OA/OR technology, then TI-13.1 is not false in any significant sense because the evidence supports a claim that the application of apparatus at the site was organized to meet a specific subsistence goal at the site. However, if the nonsubsistence technology is unrelated to the OA/OR technology, then Hypothesis 13 is false because the site had multipurpose functions. If an OA/OR technology occurs with substantial artifactual material whose technological attributes have unidentified associations, the site's single- or multipurpose status is unknown.

TI-13.2: Sites in a period of interest do not have a one-apparatus/several-resource apparatus identified under Hypothesis 2.

Relevance: Strictly speaking, the presence of an OA/SR apparatus, identified under Hypothesis 2, putatively falsifies Hypothesis 13 for that site because sites with OA/SR apparatus are by definition multipurpose sites in the sense that several subsistence functions take place there. Note, however, that if none of the elements in the predictive conjunction of subsistence resources are available in the same time of the year, TI-13.2 is not falsified.

TI-13.3: No site with a one-apparatus/several-resource apparatus identified under Hypothesis 3 occurs with more than one element of the disjunction that predicts the apparatus.

Relevance: OA/SR apparatus identified under Hypothesis 3 may not, by definition, be inferred to have resource-specific functions when they occur. Therefore, it is always possible for such an OA/SR apparatus to be accompanied by only one of its predictive resources (unlike apparatus identified under Hypothesis 2). If more than one of the predictive resources occurs with the apparatus, then TI-13.3 and Hypothesis 13 are false for that site.

TI-13.4: A nonrandom majority of sites with subsistence functions during a period of interest are sites for which TI-13.1 through TI-13.3 are not falsified.

Relevance: If TI-13.4 is falsified for any given period, it implies that the adaptive strategy involved organizing a series of technologies around occupation at most sites, which further putatively implies that site location generally was determined by a collector strategy that positioned people in a centrally located place from which to exploit a number of resources. If TI-13.4 is not falsified, it putatively implies that individual technologies were organized in a forager strategy that positioned people near each resource as it was exploited.

TI-13.5: If TI-13.4 is not falsified, then an insignificant number of the apparatus tested under TI-13.1-TI-13.3 have collector organizations identified in testing under TI-11.2 for the period of interest.

Relevance: If TI-13.4 is to strongly imply that subsistence was based on a forager strategy, then there must not be evidence that a significant number of the technologies used in the period of interest were organized to move resources to people. To the extent that individual technologies had collector organizations, testing under TI-11.2 will identify them as such if the data base is large enough. The more collector-organized technologies that are included in an array that survives TI-13.4, the less technologies were organized in a forager strategy in the period of interest. Note that if TI-13.4 is falsified, TI-13.5 can be reframed to show whether a significant number of technologies in the period of interest had forager organizations. An especially interesting case would be a conjunction of falsification of TI-13.4 with constituent technologies organized around people-to-resource patterns. In this case, it would appear that forager subsistence activities took place around a central location or a series of central locations, depending on the details of site locational data vis à vis available resources. Such a case would imply a relatively low-mobility forager adaptation. Thus, TI-13.4 and TI-13.5 together provide a way for determining the basic pattern of spatial mobility and integration of technologies that characterizes any period of interest. If these basic patterns change from period to period, then there is good reason to assert that the temporal boundaries between basic patterns demarcate phases irrespective of technological change or stability. If at least a few elements of the technological and/or subsistence arrays also change, then there is sufficient evidence for identifying a distinct phase.

TI-13.6: The apparatus of any identifiable nonsubsistence technology does not occur with the apparatus of any other technology.

Relevance: If the apparatus of a nonsubsistence technology occurs with the apparatus of any other technology, then the site is multipurpose, and Hypothesis 13 is false for that site. Falsification of TI-13.6 implies that consumables for nonsubsistence technologies were acquired and/or that tools were produced in conjunction with subsistence activities if the other technology is a subsistence technology. If TI-13.6 is not falsified, it implies that a collector strategy characterized nonsubsistence activities regardless of whether other technologies were integrated into a forager strategy.

Testing under Hypothesis 13a demonstrates the degree to which site specialization characterizes a period of interest. As such, Hypothesis 13a provides a basis for determining whether individual technologies were or were not generally organized around forager or collector or mixed applications. If a period of interest differs from previous and later periods on the basis of the proportions of its forager- and collector-organized technologies, there is reason to believe it may be a distinct phase. If other changes (e.g., subsistence resources) coincide with changes in degree of forager-/collector-organized technologies, then there may be sufficient evidence to identify a period of interest as a distinct adaptation. This information alone, however, is insufficient as a basis for identifying overall adaptive strategy for any period of interest because it does not deal with temporal integration of technologies.

5.2.5.3 Hypothesis 13b

Each site is specialized with respect to season of occupation.

Relevance

Regardless of the outcome of Hypothesis 13a, there may be distinct patterns in the seasonality of site occupation. If so, then a primary influence on the structure of an adaptation in a period of interest may have been seasonal availability of resources. A foraging strategy should be characterized by seasonally occupied sites to the extent that exploitable resources are not available year round in any given location. A foraging adaptation, therefore, could range from place-to-place movement to exploit single resources, to place-to-place movement to exploit suites of resources available in the same place. A collector strategy also can be characterized by seasonally occupied sites if no central locations are suitable as home-bases for year-round subsistence strategies. A collector adaptation, therefore, could range from a series of seasonally specific base camps to a single year-round base camp.

TI-13.7: A nonrandomly small number of sites in a period of interest have evidence of occupation during more than one season unless either the seasons are not consecutive or resources can reasonably be inferred to have been continuously available at most multiseasonal sites.

Relevance: If sites are occupied on a multiseasonal basis, that occupation pattern weighs against a forager adaptation because forager adaptations generally are considered to be characterized by high residential mobility (Binford 1982). However, in a forager strategy, sites may have multiseasonal occupations if people occupy them more than once to exploit resources that were not available at the same time. Consequently, if multiseasonal sites are occupied in nonconsecutive seasons, then that evidence supports a forager strategy by implying that occupation was interrupted to pursue resources elsewhere. On the other hand, if sites show evidence of occupation during consecutive seasons or evidence of, say, early and late summer occupation, then to be consistent with a forager strategy, there must be direct or plausibly inferable evidence either that subsistence resources were continuously available (including from short-term storage at multiseasonal sites) or that other sites generally were occupied and exploited during gaps in availability. Of course, technological and paleoenvironmental evidence of a collector strategy would negate a forager strategy. Regardless of whether the strategy was a forager or collector strategy, testing under TI-13.7 will demonstrate what basic pattern, if any, characterizes seasonal mobility during a period of interest. If there are significant changes in the pattern of seasonal mobility from period to period, it may provide reason to believe that the period of interest is a distinct phase. If in addition to changes of seasonal mobility there also are changes in technology, subsistence base, and/or site specialization patterns, there is sufficient ground to assert that the period of interest is characterized by a distinct adaptation and, hence, a distinct adaptive phase.

TI-13.8: Sites occupied during any given season are in a wide variety of paleoenvironmental niches relative to the breadth of the subsistence base.

Relevance: During a period of interest, a forager strategy should move people to different environmental niches unless the local environment is spatially and temporally-patchy enough to support a group in a single location. A collector strategy, by contrast, need not change locations on a seasonal basis until the logistical radius to a seasonal resource is too great to warrant maintaining the same residential location. Consequently, the greater the variety of paleoniches occupied during a given season, the greater the likelihood that the adaptation involved a forager strategy unless technological or other evidence implies otherwise. If a period of interest shows evidence of change in the variety of paleoniches occupied during a given season, then there is reason to believe the period of interest can be defined as a distinct phase. If in addition to changes in variety of seasonal paleoniches there also are changes in technology, subsistence base, site specialization patterns, and/or seasonal mobility, there is sufficient ground to assert that the period of interest is a distinct phase and, hence, a distinct adaptation.

5.2.5.4 Hypothesis 13c

During a period of interest, macroscale land-use is governed by a forager strategy irrespective of whether the use of individual sites was governed by forager, collector or mixed strategies.

Relevance

Macroscale land-use refers to the general pattern in which people are positioned on a landscape relative to resources. A macroscale forager strategy is one in which major residential moves are governed by the location of subsistence resources. If all individual technologies have forager organizations during a period of interest, macroscale land-use is a forager strategy by default because all residential moves are to subsistence resources. Another interesting default value for a macroscale forager strategy is the possibility that no major residential moves are made during any given year because subsistence resources are available within foraging distance year round. Still another macroscale forager strategy is major residential moves that position collector activities near a subsistence resource to be exploited. For example, if an adaptation involves long-distance transhumance to exploit prickly pear tunas, it has a macroscale foraging strategy even if all other resource-exploitation activities are organized according to collector strategies once the group has reached its destination. In such cases, if base camps in a collector adaptation are selected because they are at the site of a subsistence resource, then the adaptation involves a macroforager strategy for identifying residential locations and a collector strategy for exploiting additional resources. A macroscale collector strategy, on the other hand, would involve making major residential moves that place people near nonsubsistence resources from which they acquire subsistence goods via logistically organized technologies. An interesting default value for a macroscale collector strategy would involve making no major residential moves in order to remain near a nonsubsistence resource (say, a lithic raw material source).

TI-13.9: There is evidence that sites were occupied during each season during a period of interest.

Relevance: During a period of interest, if sites were occupied during all four seasons, there is good reason to believe that a macroforaging strategy involving long-distance transhumance was not employed unless evidence at a regional scale shows either that groups from different areas moved into the Fort Hood area while its usual residents were on a transhumant round elsewhere, or that transhumant groups from other areas alternated occupation in the Fort Hood area. If TI-13.9 is falsified, it implies that Fort Hood was occupied by transhumant groups unless there is reason to believe that sampling error and/or site visibility are responsible for nonrepresentation of one or more seasons in the archaeological record. (Note, therefore, that resolution of the results of this test implication emerge from testing hypotheses about the geographic distribution of communities in section 5.2.6 below.) If TI-13.9 is not falsified and there is no evidence for alternating occupation by transhumant groups from elsewhere, TI-13.9 implies that Fort Hood was occupied by a local group (or a series of neighboring or spatially interlaced local groups whose activities left a record equivalent to that which would be left by a local group) which used some other macroforager strategy or a macrocollector strategy.

TI-13.10: If TI-13.9 is not falsified, then paleoenvironmental data must support reasonable inferences that the environment typically was sufficiently productive in a period of interest to provide enough subsistence resources to support a group throughout the year.

Relevance: To support a claim that transhumance was not part of the macroscale adaptive strategy in a period of interest, it must have been possible to support a group year round. Paleoenvironmental data, therefore, must support a claim that on average, enough subsistence resources could have been harvested and processed to carry a group over seasons of low resource-availability. In Fort Hood, this is especially true for fall production. For example, it is widely believed that acorns were a major focus of fall subsistence activities in Central Texas (Weir 1976; Creel 1991). If acorns provided a major over-winter resource, then not only must there have been enough total acorn production to provide a group with an ample supply, the timing of maturity of the acorn crop must have been long enough to enable harvesters to amass and/or process a large supply before other animals and decomposition reduced the total supply. Thus, even amidst an extremely large amount of total acorn production, if acorns matured within a narrow window of opportunity, much of the crop could be effectively unavailable (Flannery 1973). Therefore, evidence of temporal patchiness (e.g., differential maturation along elevation gradients) for potential over-winter resources would support claims of year-round occupation, especially if evidence of storage technologies can be found at sites occupied in late fall or winter.

TI-13.11: If TI-13.9 and TI-13.10 are not falsified, either most sites are located near nonsubsistence resources (e.g., near lithic-resource outcrops) or there is evidence of sites occupied year round.

Relevance: If adaptations in Fort Hood are not organized around a transhumant macroforaging strategy in a period of interest, then they may be organized around a macrocollector strategy. If so, then because the macrostrategy did not involve transhumance, the archaeological record should show evidence of the functional equivalent of a group that conducted its collecting activities from base camps at nonsubsistence sites or from sites occupied year round, regardless of the local availability of subsistence resources. For example, if exercising control over lithic resources was an important feature of any given Fort Hood adaptation, sites with substantial evidence of collector-organized subsistence should be located very near LRP sites. Alternatively, if residential mobility was circumscribed by neighboring groups, then it would be likely for collector-organized technologies to be implemented from a long-term base camp (cf. Savage 1990). Note that presence of year-round base camps exploiting a seasonally limited local resource would be consistent with a macrocollector strategy in the sense that no major residential moves are made to place people near resources. On the other hand, if base camps are occupied year-round *and* local resources are exploited in all or most seasons, the macrostrategy is mixed. If base camps are not occupied year-round *and* usually are located near an exploited resource, a macroforager strategy governs site location for base camps. If long-term base camps with evidence of collector-organized technologies are not typical for a period of interest, then it is likely that a form of macroforager strategy governed land-use.

TI-13.12: If TI-13.11 is false, then most sites in the period of interest are not multifunctional sites.

Relevance: If TI-13.9 through TI-13.11 are false for a period of interest, then a form of nontranshumant macroforager strategy governed the integration of technologies and exploitation of subsistence resources. The primary remaining issue, therefore, is whether it was a low- or high-mobility macroforaging strategy. If most sites are multifunctional and/or multiseasonal (i.e., over consecutive seasons), then the macrostrategy governed site location in order to place subsistence activities in locations where a combination and/or a sequence of subsistence resources could be exploited, resulting in a relatively low-mobility foraging adaptation. Otherwise, it is likely that the macrostrategy emphasized a one- or few-resources-at-a-time pattern in a high-mobility foraging adaptation.

5.2.5.5 Summary of Results from Identifying Adaptations II

By the time testing under Hypothesis 13 is complete, the analyst has at her/his disposal a basic understanding of spatial mobility and integration of individual technologies, of seasonal mobility and integration of individual technologies, and of the macro-organizational properties of both. (Note, however, that conclusions regarding transhumance still require evaluation vis à vis regional data.) If there are changes in the pattern of any of these higher level organizational features from period to period, then these changes are sufficient to define the boundaries between distinct adaptations, even if technologies and subsistence bases are more or less stable. Of course, if significant technological or other changes coincide with changes in macro-organization, they reinforce the identification of distinct adaptations. Note, therefore, that if no distinct phases have been identified in previous domains, they may be identified in this domain. Also note, however, that it is possible that some phases will be defined in terms of stable combinations of technology, subsistence, and/or macro-organization, whereas others may be identified by periods of long-term incremental change.

Data Requirements

This domain, more than any other so far, highlights the need for effective integration of technological, subsistence, chronological, and paleoenvironmental data into Fort Hood's GRASS system because it shows that the success of this research design depends upon being able to identify spatial relations between sequences of activities that may have been spread out over a wide area at any given time of the year (cf. Savage 1990). It therefore also demonstrates that in addition to overlays that correlate technological and subsistence data to paleoenvironmental data, it is necessary to be able to stratify these data bases according to seasonality of site occupation and according to adaptive phases or arbitrary time periods if adaptive phases have not been identified. Indeed, spatial patterning by season and time period may be an important visualization tool for recognizing phases just in case any given adaptive shift was accompanied by a relatively radical shift in the ways the landscape was occupied season-to-season.

5.2.6 Fort Hood in Regional Context

Discussion

All previous domains involve description and testing of phenomena on Fort Hood, although they do not assume that phenomena elsewhere are irrelevant to Fort Hood. Indeed, in recognition of the fact that Fort Hood did not exist in a vacuum, it is necessary to place Fort Hood in a regional context for two reasons. First, Fort Hood may have been characterized at any given time by adaptations similar to, or different from, adaptations in other parts of Central Texas. In either event, a full understanding of Fort Hood prehistory would involve comparing it to the nature of regional adaptation as a whole, including whether or how Fort Hood occupants interacted with occupants of other areas. For example, if long-distance transhumance was part of the adaptation at any given time, then the occupants of Fort Hood also were the occupants of other areas, and understanding the nature of their occupation at Fort Hood can only take place in reference to their occupation elsewhere (Syms 1977). To test for long-distance transhumance, it would be necessary to identify complementary seasonal occupational gaps at Fort Hood and in an area away from Fort Hood, and to identify artifactual evidence that links the two areas (e.g., simultaneous occurrence of marine shells at Fort Hood and Fort Hood cherts in the distant area). (Note that if there is evidence of transhumance and there are no seasonal occupation gaps at Fort Hood at any given time, it will be necessary to explain why one group abandoned Fort Hood on a seasonal basis when another group was able to support itself there during the "off season.") If regional trade of chert was an element of the adaptation, then settlement within Fort Hood may only be intelligible with respect to the regional distribution of Fort Hood cherts, and it would be necessary to identify artifactual links that distinguish trade from either transhumance or large occupational territories.

Second, the factors that explain adaptive change in Fort Hood either do or do not explain it elsewhere in Central Texas and nearby areas. Regardless of whether or not adaptations in Fort Hood are similar to adaptations elsewhere, it is possible that the factors explaining adaptive change in Fort Hood also explain it elsewhere. Indeed, to the extent that climate change is responsible for adaptive change in Fort Hood, it *must* also explain events (or, at least, not contradict them) in relatively nearby areas if the explanation for Fort Hood is to be believable (Butzer 1982). Furthermore, it is possible that nonclimatic regional events may be responsible for adaptive change which cannot be explained on the basis of local evidence at Fort Hood. For example, an abrupt change of adaptation unaccompanied by significant environmental change could result from displacement of local residents by refugees from other areas that were affected by environmental change or by the expansion of adaptations from other regions (cf. Johnson 1990). The causes of such changes would not be visible at Fort Hood. Still further, causal models identified within the Fort Hood area could be local variations on regional phenomena. For example, population growth could explain an adaptive shift from the perspective of Fort Hood data, but the cause of population growth could be an influx of immigrants rather than a result of local reproductive demographics. (Just such possibilities may provide interesting avenues of inquiry for the Protohistoric adaptations in the wake of the Athapaskan and Commanchean influxes into the Southwest and Southern Plains.)

By the time testing in this domain begins, the analyst should have at her/his disposal a well-developed data base that includes a series of phases defined in terms of stable or incrementally changing technologies and/or subsistence bases, and distinct patterns of organizing those technologies amongst each other. It is possible that some time periods may be highly variable or ambiguous with respect to some or all of the above characteristics, especially because there has so far been no attempt to identify the possible influence of different groups on the history of adaptation at Fort Hood. Indeed, if Fort Hood was in the territory of more than one group at a time, the archaeological record could have been formed by people using different decision-making structures to fulfill different subsistence goals. (Prewitt [1981, 1985] necessarily implies such a conclusion by in a co-occurrence of different projectile point styles.) Hence, it is necessary to determine the extent to which impacts of occupations by members of different groups underlie patterning (or the lack thereof) in adaptations. The information needed to address this issue can come only from comparative studies that identify similarities and differences between Fort Hood and other areas at any given time.

Consequently, not only must Fort Hood be placed in a regional context, it also is necessary to determine exactly what region Fort Hood is part of at any given time and to examine that region in terms of its relationships to neighboring regions (Savage 1990; Crumley and Marquardt 1990). The basic problems to be resolved in placing Fort Hood in a regional context involve identifying communities of people whose historical geographic range included Fort Hood and, thence, to identify patterns of interaction between members of those communities and members of both neighboring and distant communities (Savage 1990). Because very little is known about Fort Hood, Central Texas, and neighboring areas in terms that would enable us at this point to provide a detailed architecture of the testing process which would place Fort Hood in a regional context, discussion of the hypotheses for this domain is necessarily general and will not include a series of test implications. The distribution of Fort Hood cherts will be a major element of the identification of communities. What follows, therefore, is a discussion of the basic lines of inquiry for identifying communities and their interaction with other communities.

5.2.6.1 Hypothesis 14

At any given time, Fort Hood was in the historical geographic range of a single community.

This hypothesis is a null hypothesis which, if it is not falsified, identifies at least part of the territory occupied for a period of time by people who transmitted from person to person and generation to generation a knowledge base that included both the decision-making structures and technological information needed to meet their subsistence and other goals (see section 4.1.2.3). This hypothesis will be falsified for any given period of time if it can be shown that Fort Hood was:

- a zone of overlap between two or more contemporaneous communities;
- occupied continuously by one community with seasonal transhumant visits by neighboring or distant communities; or
- not occupied continuously by any community, but alternately occupied by more than one transhumant community.

Testing Hypothesis 14 will involve test implications pertaining to the geographic distribution of typologically and/or technologically distinct assemblages of artifacts (Clark 1975; Johnson 1990; Ellis 1992). In other words, if Fort Hood is contained at any given time in a geographic area with assemblages that are distinct from those of other geographic areas, this outcome will support the null hypothesis. (Johnson [1990] has reported initial success in identifying localized variability in Late Prehistoric ceramics and Perdiz points, and Bousman [Britt Bousman, December 1992, personal communication to Ellis and Lintz] reports that Early Archaic points at the Wilson-Leonard site appear to have distinct morphological characteristics compared to such points elsewhere.) The larger the homogenous area that contains Fort Hood, the more likely it is that Fort Hood was transhumantly occupied if data within the geographic area show substantial evidence of seasonally-complementary occupation in different parts of the geographic range (cf. Ricklis 1992). However, if assemblages at Fort Hood show evidence of amalgamation of elements of typologically and/or technologically distinct assemblages that each have different geographic ranges outside the Fort Hood area, then the null hypothesis is false, and some form of interaction between communities (cf. Savage 1990) or overlapping transhumance (Syms 1977) was a historical feature of the history of adaptation at Fort Hood. In such a case, Fort Hood would be more or less on the periphery of at least one distinct territory characterized by a distinct assemblage.

In addition to identification of distinct approaches to artifact manufacture and use, the distribution of Fort Hood cherts will be an important data set for identifying the communities that occupied Fort Hood. At any given time, Fort Hood may appear to be in a large, technologically homogenous territory as a function of failure to identify locally distinct technologies, especially where tool production is largely expedient (cf. Bamforth 1986). In such cases, the smallest distinct community identifiable on technological grounds may include a number of contemporaneous communities who share enough information (via common ancestry, ongoing information exchanges, and/or fluid group membership) to blur smaller-scale social boundaries on an artifactual basis. However, within a large, technologically homogenous territory, the distribution of lithic raw materials should be variable if distinct communities within that territory had more or less distinct social boundaries (Bamforth 1986). The distribution of distinct lithic raw material types, therefore, offers an additional avenue of approach from which to attempt to identify relatively local communities.

5.2.6.2 Hypothesis 15

The regional distribution of Fort Hood cherts at any given time is characterized by spatial distributions in which there are distinguishable boundaries between lithic assemblages dominated by Fort Hood cherts and other assemblages representing greater variability of chert sources.

If Fort Hood was in the territory occupied by a local community, then there should be a gradient along which the proportional representation of Fort Hood cherts declines as a function of distance from chert sources on Fort Hood (Ericson 1977). However, the existence of such a gradient by itself would be insufficient as an indicator of community boundaries because chert is heavy, and members ranging over a large territory that includes Fort Hood can be expected to use their chert conservatively the farther from the source they are at any given time in their land-use rounds (cf. Bamforth 1986; Gould and Saggers 1985), although caching would ameliorate the need for, and extent of, conservation (Binford 1979). Conservative use notwithstanding, a community whose territory includes Fort Hood chert sources should show evidence of generally larger tools and generally lower rates of recycling of tools made of Fort Hood cherts than communities connected to Fort Hood cherts by trade relations. This would follow from the fact that members of the former community can plan on replenishing their raw material both more frequently and in larger amounts, whereas the members of the latter community have more restricted access, at least in terms of the amount available to them at any given time (cf. Binford 1979). Furthermore, members of the latter community will exploit (either by trade or direct procurement) cherts from other sources in amounts not directly available to members of the former community (cf. Renfrew 1977).

Thus, for both communities, social boundaries would affect access to differentially distributed cherts

(Bamforth 1986). Hence, one feature of the chert distribution that may help sort out community boundaries is the area-to-area pattern of tool size, recycling, and evidence of resource conservation in tools and debitage made from Fort Hood cherts. Still further, different Fort Hood cherts have different fracture properties that would be relevant to stone knappers, including different responses to heat treatment (Dickens 1992). Thus, members of a local Fort Hood community could be more selective in their choice of particular cherts (using them for a wide array of tools), whereas members of a nonlocal community could be inclined to reserve their Fort Hood cherts for particular applications in which workability of the chert (with its concomitant likelihood of production failure and its relative suitability for an intended use) is a key criterion for selection for a particular purpose (cf. Greiser and Sheets 1979). In this case, another indicator of community boundaries would be differences in tool-specific application for Fort Hood cherts.

Another feature of the chert distribution that affects identification of communities may be directionality of movement of the cherts available at Fort Hood and adjacent sources of chert (cf. Renfrew 1977; Ericson 1977). If the smallest technologically-identifiable community which includes Fort Hood is very large, the territory covered by one community within the technologically homogenous area may be distinguishable from that of another in the same area by virtue of a distribution of cherts that is not uniform in all directions away from the Fort Hood sources. Two neigboring, technologically indistinguishable communities that both have direct access to Fort Hood cherts could be distinguishable in terms of the directions (as well as distances) of movement of Fort Hood cherts in comparison to other cherts available at adjacent outcrops on the Edwards Plateau or in stream beds cutting through such outcrops. In other words, the distributions of *suites* of chert materials that include Fort Hood cherts may serve as a basis for identifying community boundaries. If each community habitually uses a different territory (Dennell 1983), then the directions of movement of suites of adjacently available Edwards Plateau cherts also should be different, with the Fort Hood sources occupying a location that is peripheral to the distribution of each suite of cherts.

It is unlikely that the distribution of Fort Hood cherts can, by itself, serve as a basis for identifying individual communities. However, it is likely that in conjunction with other data (e.g., technological data, evidence of conservative resource use), comparative chert distributions have significant potential for contributing to the identification of communities within which relatively high day-to-day and year-to-year interpersonal contacts lead to relatively localized patterns of behavior (cf. Bousman et al. 1990). Indeed, the attempt to identify communities is central to attempts to distinguish between large territories (transhumant or otherwise) and trade relations across wide areas because trade is archaeologically meaningful as an element of adaptive economics if, and only if, materials are exchanged between members of different functioning groups. In the absence of attempts to identify communities, widespread evidence of more or less identical technologies is likely (according to the analyst's intuitive inclinations) to be interpreted uncritically (1) as evidence for a single sociocultural group with a very large territory (which probably automatically involves transhumance), or (2) as evidence for the contemporary existence of an unspecified number of small, socioculturally related groups, or (3) as evidence for trade networks between unspecifiable groups. Such characterizations in the absence of identifiable local communities would be unfortunate because they would serve to explain away the absence of localized differentiation by offering positive claims which must themselves be based on knowledge of the distribution of communities in order to be supportable. Consequently, if it turns out that the smallest identifiable community covers an extremely large territory, this fact would be something to be explained in the next domain.

<u>Data Requirements</u>

The key data requirement for identifying communities at Fort Hood (and, hence, for establishing a basic framework for describing Fort Hood's regional context) is comparative typological, technological, and raw-material provenance data from Fort Hood and elsewhere. Progress in this domain, therefore, is largely contingent on similar progress elsewhere. Projectile points, some typologically distinct biface tools (e.g., Harahey knives), and ceramics at least initially will be the artifact classes most likely to show locally distinct typological and technological variability (Johnson 1990; Ellis 1992), although it is possible that nonformal flake tools also may show locally distinct patterns of size, form, use-wear, and other attributes that indicate transmission of technological knowledge in a relatively circumscribed group of people (cf. Sackett 1986; Lechtman 1977).

Quantitative provenance characterization data (see section 5.1.4.3) on Fort Hood cherts is necessary to trace the movement of these raw materials within and beyond the boundaries of Fort Hood. Characterization data on tools and debitage is necessary to establish or eliminate Fort Hood cherts as the raw material represented at sites on Fort Hood and elsewhere (Latham et al. 1992). Although it would be useful to have access to provenance characterization studies from lithic outcrops outside Fort Hood (Williams-Thorpe et al. 1991), the absence of such studies does not negate the value of characterization studies on Fort Hood artifacts because data on the proportions of Fort Hood and "exotic" cherts will nonetheless be useful for determining the extent to which occupants of Fort Hood relied on cherts from sources outside the Fort even if the precise location of those sources remains unknown until future archaeological projects outside the Fort provide the necessary provenance data.

In the context of attempting to identify communities, palimpsest burned rock middens can be a relatively valuable resource. Given the theoretical perspectives of this research design (see section 4.2.3), cultural processes are assumed to transmit technological knowledge (including formal and procedural stylistic standards) among individuals within a community (cf. Sackett 1986; Wiessner 1985; Lechtman 1977). If the knowledge transmitted in any given community is used to produce artifacts detectably different from those produced in other communities on the basis of different knowledge bases, then within that community's territory, the cumulative output of production ought to bear the earmarks of the community's standards and ought to be different from the cumulative output of other communities. Because burned rock middens tend to have large numbers of projectile points (Black et al. 1992) and, perhaps, other used tools and ceramics which also may eventually be shown to have locally diagnostic technological styles, more or less immediate returns can be achieved with respect to acquiring data bases from which initial models of localized variability can be constructed. Given that context is weak in such cases, modeling should be restricted to artifacts shown to have temporally-diagnostic properties in the fundamental-research domains. Note that if Fort Hood was in the overlapping range of more than one group, the comparative data base will help define the overlap zone between those groups. Hence, even though palimpsest burned rock middens have relatively limited potential for providing contextually discrete adaptive data (Black 1989; Collins et al. 1990), they have at least some value with respect to rapidly building data bases both for identification of communities in much the same way that they have value for rapidly building initial models of subsistence and seasonality choices (see section 5.1.3).

5.2.7 Explaining Adaptation and Adaptive Change

Discussion

To the extent that testing in the previous domains has been successful, the results are largely descriptive in the sense that they describe adaptations and detectable regional variation that can be attributed to the existence of more or less cohesive communities. Note that it is possible that the results of testing may show a history of largely incremental differences in adaptation. To whatever extent that adaptation changed prehistorically, the pattern of stability and change is something to be explained. Given the cultural ecology and technological perspectives of this research design, stability and change are assumed generally to be a function of culturally transmitted knowledge that works to meet short-term goals such that, once an adaptation (i.e., a decision-making structure) has taken root, it will tend toward stability until change in an environmental variable or variables causes a change in the nature of the adaptation by demonstrating to the people involved that their usual way of doing things does not work this year. Thus, the explanation for adaptive stability is sought in terms of the functional suitability of an adaptation to its environment, including the human environment. The explanation of adaptive change is sought in terms of changes in environmental variables and the alteration of adaptive strategies and/or technologies to meet those changes.

Note, therefore, that this research domain does not test cultural ecology or Winner's (1977) concept of technology for their truth or falsehood. Rather, these theoretical principles are organizing principles valuable only insofar as they make prehistory intelligible (see section 4.2.2). Thus, in explaining Fort Hood prehistory according to the theoretical perspectives of this research design, the theoretical perspectives provide the framework from which meaning is assigned to observed stability and change. Hence, to suggest that testing either confirms or falsifies the theoretical perspectives would be begging the question (Binford 1983b). The impetus to abandon cultural ecology or Winner's concept of technology can come only from a wider arena in which the perspectives not only are shown not to generate productive research with intelligible results, but also are shown to be less productive and to produce less intelligible results than an available alternative perspective (Lakatos 1978b). For example, if and when research within symbolic or other "post-processual" frameworks (e.g., Hodder 1986) demonstrates an ability (in Central Texas and elsewhere) to generate more interesting research with more intelligible results than the theoretical perspectives herein (cf Hodder 1991), then and only then will there be reason to abandon the present theoretical approach, and even then, not because the approach has been falsified, but rather because it has been outpaced.

Testing in this domain depends on the outcome of research in previous domains since those domains will determine just exactly what needs to be explained. That, unfortunately, means that it is difficult to specify hypotheses and test implications at this point in the design. Therefore, the following section will focus on the kinds of explanations to be pursued in order to illustrate the testing process instead of attempting to construct a comprehensive list of the explanatory statements to be tested. Note that in what follows, explanatory statements are cast as hypotheses. This move is both substantive and semantic because characterizing explanatory statements as hypotheses befits their nature as statements that always remain subject to falsification.

5.2.7.1 Hypothesis 16

An adaptation during a particular phase was stable because the subsistence base was stable and the adaptation provided an effective means for exploiting it.

If this hypothesis is a supportable explanatory statement, it will be explanatory if and only if there was no significant change in the subsistence base or the adaptation. This, of course, is the same thing as saying that the phase was a stable phase: a phase is by definition in this research design either an identifiable period of adaptive stability or an identifiable period of adaptive change, and functional considerations are built into data collection and testing that precede phase definition. Consequently, this kind of uninteresting explanation of stability follows from coupling functional explanation to theoretical assumptions that (1) an adaptation is the decision-making structure which people use to meet their goals in an environment, and (2) socialization processes transmit technological and other knowledge from generation to generation (cf. Salmon 1982). In other words, because the cultural ecology perspective expects adaptations to be stable if there is a stable subsistence base and because the cultural and technological perspectives expect successful knowledge to be passed down from generation to generation, the explanation of stability boils down to the notion that adaptations are stable because they work and there is no reason for individuals to adopt other known approaches or to try experimental procedures.

However, even in cases of stability, there may be things to explain, at least in the sense that explanations can be answers to "what" and "how" questions as well as "why" questions (Salmon 1982; Cohen 1978). For example, during a period of stability, it is an interesting issue to identify population levels (Hassan 1981), dietary composition and its ability to meet nutritional needs (Sillen et al. 1989), and the ecological energetics of specific adaptations (Winterhalder and Smith 1981). Indeed, answers to these "what" and "how" questions constitute necessary background information for explanations of subsequent adaptive change.

Furthermore, in cases of adaptive stability there may be "why" questions that require explanations. For example, if no localized communities have been identified in the previous domain, it is reasonable to ask why in order to reduce the likelihood of falling back on uncritically accepted conclusions that may follow from the failure to identify communities. Fort Hood cannot be expected to enclose the area exploited by a single community, but it may be quite reasonable to expect Fort Hood (at approximately 878 km^2) to be the equivalent of a territory occupied by a community for a large part of the year. In comparison, a !Kung San group centered around the Dobe waterhole ranged across a territory of approximately 320 km^2 during the two years Yellen (1976) observed them, and the Nunamiut observed by Binford (1981b) occupy annual ranges of approximately 4,274 km^2. Thus, on one hand, Fort Hood is 2.75 times the size of the range needed by approximately 35 people to survive in the Kalahari Desert, and 0.21 times the size of a Nunamiut territory (also exploited by about 35 people), whereas on the other hand, it is better watered by springs and perennial streams than the Kalahari and biologically more productive than the Subarctic. Consequently, if Fort Hood is located in a very large geographic area within which communities cannot be differentiated on technological grounds, it is necessary to see if there are other grounds for identifying communities.

5.2.7.2 Hypothesis 17

If Fort Hood is in a very large geographic area with no technologically distinguishable communities at a given time, then the large geographic area represents an area of long-term exploitation divided into areas exploited for several years at a time. Fort Hood is one such area.

Given that Fort Hood is geographically large enough and biologically diverse and productive enough to realistically serve as a territory that would support a small group of hunter-gatherers, it will be useful to start with the null hypothesis that Fort Hood was the geographic territory for a small group of people who exploited it for several years at a time before moving on to other areas which they also exploited for several years at a time (cf. Binford 1981b). Several lines of evidence would support the null hypothesis in the absence of technological evidence that distinguishes individual communities.

If paleoenvironmental data suggests that the environment at any given time was ecologically productive enough to support a community of a certain size at Fort Hood on a year-round basis during all but the worst years, then this fact (if true) implies that the costs and risks of moving to distant locales would be high relative to the costs and risks of shorter moves, because greater energy expenditures and lower levels of reliability of information accompany longer moves (cf. Binford 1978a; Moore 1981), especially given that chert resources are abundant on the Fort. The fluidity of group membership among hunter-gatherers is high, and even if a group confined its activities to the Fort Hood area, some of its members would be likely to visit, temporarily join, or mate with members of other nearby groups (Yellen 1976), carrying their technological and other knowledge with them so that information exchanges would be spread over a larger territory (cf. Johnson 1990; van der Leeuw 1981).

However, hunter-gatherers tend to occupy a more or less limited territory as a matter of habitual use (Dennell 1983), moving from time to time within that area as locally available resources are depleted beyond levels of convenient and reliable yields (Binford 1981b). Such a pattern could spread the members of a community over a wide geographic area in the course of generations so that annual ranges are reoccupied repeatedly in the long-run (Binford 1981b). Thus, certain conditions of fluid group membership and long-term land-use can make the historical boundaries of a community much larger than the historical annual range occupied by a group, which could be the reason why a large area is not divisible into identifiable communities. Consequently, if paleoenvironmental data implies that small annual ranges could be sufficiently productive on a long-term, sustainable basis to support a group, this evidence weighs against a large annual range because the data implies that local resource depletion may not have been an important motivation for long-distance moves.

Further evidence relevant to community territory could occur in the form of large cumulative bodies of seasonality, site-density, and AMS radiocarbon data. If a large, technologically homogenous geographic area (of which Fort Hood is only a part) shows evidence of occupations in all seasons during a given time span, the seasonality evidence would comprise prima facie evidence for more or less continuous occupation for each part of the area if site density is very high. However, if site density is low, a large, cumulative body of AMS radiocarbon dates for a given part of that area should show dates that cluster fairly tightly together but have minimal overlap with clusters of dates for other parts of the area if Hypothesis 17 is true. On the other hand, if a large, cumulative body of AMS dates shows that there are no detectable temporal gaps across a large area, such data would weigh against Hypothesis 17 and imply that the large geographic area was the territory occupied by an unspecified number of local groups because it would imply that the tempo of land use (i.e., the pace of repetitive occupation; Binford 1981b) was too high to reflect the activities of a small group of people spread over a very large territory in their lifetime range.

Furthermore, site-density data also may help define the boundaries of communities if at least some of the sites during any given time show evidence of being repetitively occupied base camps from which collector-organized technologies are implemented. (Such an outcome is likely because "pure" forager and collector organizations are unlikely.) Base camps are characterized by a foraging radius (within which nearby resources are exploited on a foraging basis) and a logistical radius (within which resources are exploited on logistical trips that send people out into the country for relatively extended stays; Binford 1980). To the extent that paleoenvironmental data allow, it is possible to model foraging and logistical radii in terms of expected returns on resources (Higgs and Vita-Finzi 1972; Savage 1990). Because groups tend to stay out of each other's foraging and logistical radii for residential purposes, clusters of more or less contemporaneous base camps will tend to be separated by procurement locations and, perhaps, buffer zones between groups' ranges (Savage 1990). Thus, a large area characterized by a distribution of more or less contemporaneous base camps and procurement locations that show evidence of occupation in all seasons may be divisible into local communities within which subsistence activities are pursued by small communities within a larger information-sharing community that may be the effective reproductive community (Savage 1990; Dennell 1983).

Another instance of adaptive stability that would require explanation may be cases where adaptive stability is not predicted by environmental conditions. For example, even if the subsistence base was stable in terms of composition and relative dependence on particular resources, the environmental base may not have been. Suppose sotol appears in the subsistence base throughout a phase. Also suppose that the climate changed gradually so that by the middle of the phase it was cool and wet enough to decrease sotol productivity significantly for the rest of the phase. In that case, although the subsistence base was stable and the means for exploiting it effective, it would be an interesting problem to explain why the adaptation was stable despite conditions for which theory predicts a high probability of adaptive change. Among the hypotheses to be explored in explanation of such anomalies would be statements such as:

5.2.7.3 Hypothesis 18

Alternative Hypotheses of Adaptive Change

Hypothesis 18a: Seasonal organization during sotol season throughout the phase focused most subsistence activities on other resources not affected by the climate change, so impacts on sotol productivity did not have an appreciable effect on the adaptation because it was a minor component of the subsistence base.

Hypothesis 18b: Population density was low enough that relatively high per capita sotol consumption was not limited by a decrease in the available supply.

Hypothesis 18c: Sotol was a 'stress' resource used only in drought years, and the conditions that fostered reliance on sotol temporarily increased its availability.

Any one of these hypotheses, if true, might account for stability under theoretically anomalous conditions unless there were other anomalies that remain unexplained. Thus, although the theoretical perspectives of this research design impose facile explanations on episodes of stability, the perspectives nonetheless also have the capacity to expose circumstances that are anomalous relative to theoretical expectations, and to stimulate alternative lines of inquiry for the explanation of anomaly. Therefore, provided the analyst approaches explanation of stability critically, any given explanation, although facile, provides a context within which to look for anomalies that may need to be explained. In such cases, evidence on demographics, paleoenvironment, social relations between communities, subsistence scheduling, and other aspects of adaptations will be crucial.

Note that some explanatory statements (such as Hypothesis 18c) used in the explanation of anomaly may themselves be hypothetical in the sense of being statements which, if true, would account for the counterintuitive phenomenon (Quine and Ullian 1977:66), but which also may not be assayable via test implications that can be falsified or strongly corroborated by direct empirical evidence. Thus, research in this domain may involve development (from ethnographic, ethnohistoric, and ethnological sources) of hypothetical middle-range theories that would have explanatory value if they were true (cf. Quine 1953; Kosso 1991). (Hypothetical constructs [e.g., "quarks" or "isolated ancestral populations"] occupy such a role in explanations in physics and evolutionary theory despite the fact that no one expects to observe them directly [cf., Gould 1989; Lakatos 1978b].) Alternatively, attempting in vain to explain anomalies may indicate that the explanation of locally anomalous phenomena is visible only at a regional scale (cf. Butzer 1982). The identification of anomalies during periods of stability therefore identifies issues to be addressed by further field and laboratory research, further synthesis of extant results at a local level, or synthesis at a regional level. Thus, even though the explanation of adaptive stability will be facile, fleshing out the operational details of stable adaptations will not be.

Unlike the explanation of stability, the explanation of adaptive change is unlikely to be facile. As an example, consider an explanatory statement regarding an abrupt phase change.

5.2.7.4 Hypothesis 19

An abrupt shift from incremental adaptive change in an earlier phase to a stable adaptation in the subsequent phase was caused by climatic change that crossed a threshold crucial to sustained productivity of a major subsistence resource in the earlier phase.

If Hypothesis 19 is a supportable statement, it is explanatory if and only if:

- the resource in question was a major subsistence resource in the previous phase; and

- the resource in question was not as widely available in the subsequent phase; and

- climatic data show temperature and/or moisture shifts that would lead to a dramatic decrease in the productivity of the subsistence resource; and

- adaptive change cannot be attributed either to displacement of the earlier adaptation via diffusion or to replacement of the local population by groups immigrating from areas outside the Fort Hood area; and

- adaptive change cannot be attributed to cumulative effects of incremental change in the previous phase; and

- the climatic shift occurs at or very shortly before the adaptive shift; and either

- the level of dependence on the subsistence resource was high enough relative to population levels that a decrease in consumption would produce nutritional stress and/or a reduction in byproducts used as consumables for other technologies; or

- the level of dependence on the subsistence resource was high enough that compensating for a decrease in consumption required exploitation of resources in alternative habitats, thereby foreclosing opportunities to exploit other resources that typically occurred in the habitat of the dwindling resource.

The foregoing statements constitute subsidiary hypotheses which, if they are true, would constitute a demonstration that Hypothesis 19 is supported by the evidence and, hence, is an explanation of adaptive change within the theoretical perspectives of this research design. Note that testing Hypothesis 19 for its explanatory value, however, opens it to falsification along lines that would establish an alternative explanatory statement which also is a cultural ecological explanation.

For example, suppose that the resource in question is sotol, but that during a long period of gradual climate change, the crucial climatic threshold which would drastically reduce sotol productivity was crossed shortly *after* the occurrence of abrupt adaptive change. Also suppose that the incremental changes in the previous phase include the gradual development of increasingly large-scale sotol-processing apparatus and a gradually increasing reliance on sotol for food and, perhaps, fiber. In this event, a historical dependence on sotol amidst increasingly-large-scale exploitation and gradual climate change that increasingly marginalizes sotol productivity produced the functional equivalent of crossing a crucial climatic threshold for sotol by establishing a positive feedback loop between climate-based and human-based natural-selection pressures. Thus, Hypothesis 19 would not be explanatory because although the explanation for why an adaptive shift was more or less inevitable is climatic, the explanation of why the phase shift occurred when it did is both climatic and anthropogenic, and would be fleshed out by whatever factors explain a historical dependence on sotol and incremental changes in sotol technology in the previous phase. Hence, addressing explanations such as Hypothesis 19 involves identifying not only what environmental, technological, and subsistence changes occur in which temporal order, it also involves identifying systemic linkages that implicate one or more changes in a causal role relative to other changes. Identification of these linkages is unlikely to be straightforward, even if a substantial data base is available.

Data Requirements

Resolution of explanatory hypotheses such as the above will rely on spatial and temporal analyses that link data from all of the fundamental- and substantive-research domains. Furthermore, resolution of events at Fort Hood can only occur in comparison to events outside of Fort Hood. This is not to imply that management of Fort Hood's cultural resources as a source of archaeological data requires application of Fort Hood funds to projects off of Fort Hood. However, it is to imply that developments in other areas will have an impact on the relative scientific value of Fort Hood properties during their ongoing management, and that the cultural properties on Fort Hood are as essential to understanding events elsewhere as events elsewhere are to understanding events on the Fort. Hence, the management of cultural properties at Fort Hood must be considered to be important at both local and regional levels, with the value of Fort Hood properties to the general development of regional prehistory being a function of the level of detail that can be achieved within the confines of the Fort.

Data requirements for explanation of adaptations and the history of adaptation at Fort Hood are basically the requirements of all previous domains plus the integration of the outcome of testing in previous domains. Spatial and chronometric data are especially important because these data will provide the means for addressing the impact of paleoenvironmental conditions on communities and contemporaneous communities on each other. Another major "data" goal is to develop ethnological middle-range theories of various scopes in order to make sense out of the archaeological data. Although this research domain does not (and cannot) test the basic theoretical premisses of the research design, it nonetheless continually tests a variety of models proposed and interpreted in terms of the theoretical premisses. To the extent that, say, models of burned rock midden function and formation fail to yield sustainable or plausible understanding of the technological systems that involved burned rock, it is likely that the middle-range theories used to interpret midden function (e.g., dump vs. intersecting hearths) may need to be revised on the basis of ethnographic, ethnological, and/or experimental evidence in order to posit more powerful conceptual constructs within which to address middens. In other words, because data are meaningless without middle-range theories, the attempt to make Fort Hood data more meaningful is likely to require the ongoing development of theories that make the archaeological record intelligible (cf. Collins 1991).

5.3 SUMMARY OF RESEARCH DOMAINS

Description and explanation of adaptive stability and change at Fort Hood and the integration of Fort Hood events into regional contexts are the goals of this research design. The research domains begin by addressing fundamental data issues. The identification of temporally-diagnostic artifacts and geomorphic features, the reconstruction of paleoenvironments and subsistence bases, and the identification of the basic characteristics of tools, tool-use, and raw materials used in production processes underlie all ecologically-oriented archeology (and other approaches as well). Given that interpretation of prehistoric events and processes cannot proceed without these kinds of data, they deserve explicit attention as objects of inquiry before one actually proceeds to do interpretation.

The substantive-research domains are arranged in an integrated architecture that starts with the most basic interpretive questions and moves toward the most complex. The identification of functionally related apparatus (i.e., tools and consumables) in section 5.2.1 is both logically and empirically prior to discussion in section 5.2.2 of the ways in which tools and consumables are organized into individual technological systems. These domains establish the nature of site function by providing the basis for determining what was done at a site and for determining whether portions of a given technological system were performed at the same or different sites. These two domains also are logically and empirically prior to the description of stability and change in technology and subsistence in section 5.2.3, which in turn must be prior to the identification in section 5.2.4 of sequences of temporally-distinct sets of technologies and subsistence resources that may comprise temporally-distinct adaptive phases. Because temporally-distinct sets of technologies and subsistence bases can in principle be organized in different ways, section 5.2.5 examines the structural organization of technologies and subsistence bases so as to complete the process of identifying adaptive strategies that may have characterized the occupants of Fort Hood at any given time. However, because an adaptive strategy identified in section 5.2.5 could be the aggregate result of activities by members of different communities whose members used different adaptive strategies at Fort Hood, it is necessary in section 5.2.6 to place Fort Hood in a regional context within which to determine whose territory included the Fort at any given time in order to determine the extent to which the history of adaptation at the Fort is also the history of a succession of or a competition between different communities. Finally, on the basis of work in previous domains, it is possible in section 5.2.7 to begin the explanation of adaptations and the history of adaptation at Fort Hood.

5.4 CASE STUDY CONCLUSIONS

This research design follows the advice of Collins (1991), Black (1989), Shafer (1986), and Peter et al. (1982) that archeological research in Central Texas will advance farther and faster by digging and analyzing fewer sites more imaginatively and in more detail than it will by digging and analyzing more sites by traditional methods. The research design implicitly follows this advice by identifying a broad range of data and analytical frameworks (some of which may correctly strike the reader as esoteric and ambitious) that should be applied to archeology at Fort Hood. The design also is predicated on the assumption that hunter-gatherers cannot be understood apart from the ways in which they used large numbers of places for different, often overlapping purposes (Binford 1983b). This means that the research design is therefore predicated on the additional assumption that the prehistory of Fort Hood cannot be written from the perspective of single sites because single sites will not contain more than a small portion of the relevant archeological record. The research design explicitly follows these assumptions because it requires that technologies and the spatial and seasonal distribution of activities be well understood prior to making firm empirical inferences about the nature of prehistoric events and processes at Fort Hood.

The combination of the advice and assumptions above appears to be paradoxical because the first advises us to work on small numbers of sites, whereas the others may call for work on large numbers of sites. However, the paradox disappears when one recognizes that they are complementary rather than contradictory. The advice implicitly directs our attention to sites that are significant precisely because they can advance research if they are creatively excavated and analyzed. In such cases, devoting resources to relatively esoteric research procedures can lead to the earliest possible resolution of major research issues (e.g., paleoclimatic reconstruction) on the basis of data from the smallest feasible number of sites. On the other hand, the assumptions direct our attention to the fact that the adequacy of existing knowledge is determined by how thoroughly previous research has covered its subject matter, in which case it is possible that "the smallest feasible number of sites" may still be a relatively large number of sites. In the case of Fort Hood, the data requirements of the research design establish the criteria for determining whether a site is worth protecting or excavating, and the cumulative outcome of applying the inferential structure of the research design determines whether enough data has been acquired at any given time to allow for resolution of empirical issues. Research designs for other installations should be used to perform the same functions even if they do not closely resemble the structure and content of this one.

This raises the possibility of objecting that this research design has unrealistic expectations of the amounts and kinds of data that will be forthcoming during ongoing implementation. To such objections, our reply is two-fold: (1) if you aim low, that is as high as you can hit without a lucky ricochet; and (2) archaeology at Fort Hood (and elsewhere) must be compatible with a long-term vision of CRM and scientific goals if it is to avoid squandering the archaeological record.

With respect to aiming high, this research design requires no more of the analyst than traditional approaches to archaeology. The Willey and Phillips (1958) and Midwest Taxonomic System (McKern

1939) procedures (with their attendant focus on typological studies; cf. Johnson 1989) have underlain Texas archaeology for decades, and they continue to structure research to a significant extent (Black 1989; Story 1990). Just as these procedures require the archeologist to build models of cultures one component and one technology at a time (Trigger 1978; Willey and Sabloff 1980), so does the present research design. Indeed, just as the Willey/Phillips procedures require the analyst to refrain from making sweeping generalizations until data from enough local contexts has been acquired to provide a sound foundation (Johnson 1987), so does this design. Furthermore, just as the typological focus of traditional approaches requires the analyst to produce rigorous artifact classifications (Dunnell 1971), so does the technological focus outlined in sections 4.2.4.2 and 5.1.4. Hence, the structure of the fundamental and substantive domains underlies a project that is not all that different in general terms from what is supposed to be done according to more conventional procedures. The main difference between this and most other research designs (regardless of their theoretical underpinnings) is that we have made explicit what most others have preferred to leave unsaid.

Furthermore, it is virtually certain that no single site at Fort Hood (or any other installation) will contain enough data to resolve any single issue detailed in the research design because no site can be expected to yield all of the kinds of data required. Indeed, as a result of the different ways and rates at which different sites form, even extremely valuable sites are at best likely to contribute relatively limited ranges and amounts of data. Thus, although the research design is intended for application at all sites, the design does not assume that to be significant a site must have all (or even most) of the specified kinds of data. Rather, the design assumes: (1) that the specific contextual circumstances and data content of a particular site make it more valuable for some problems than for others; (2) that the state of archeological knowledge at any given point in the implementation of the design determines which problems are more important than others; (3) that changes in the state of knowledge can change the relative value of particular cultural properties; and (4) that CRM personnel at Fort Hood can and should use this information to make policy decisions with respect to cultural properties in their jurisdiction. Research designs for other installations should be based on similar assumptions. Within these assumptions, the elements of a research design that can be productively applied at a given site will be applied, and the elements that cannot be applied will be passed over for eventual application at other sites.

The foregoing assumptions are compatible with the pursuit of long-term CRM activities. Since sites at installations such as Fort Hood will be managed on a long-term basis, the collection of excavated sites relevant to any given problem probably will grow incrementally, which entails that the data sets available for analysis also will grow incrementally. Consequently, we expect that progress in terms of demonstrable conclusions about the history of adaptation at any given time at Fort Hood will be slow until the data base for a given problem area reaches a "critical mass," and that early conclusions will be little more than speculative reports from which to derive working hypotheses to guide further research. Hence, although speculation on the basis of limited data is an effective means for generating very specific research questions to be investigated with specific field and laboratory methods, it is necessary to be patient to achieve substantive results. In other words, to avoid having last year's working hypotheses become accepted wisdom by virtue of repetition under citation rather than by virtue of ongoing research, it is necessary to take a long-term view of archeological model-building in order that we may fill in gaps as methodically as possible and thereby make cultural properties count for as much as possible relative to ongoing scientific developments.

6 IMPLEMENTING THE MANAGEMENT PROGRAM

Nicholas Trierweiler

This final chapter attempts to operationalize the new Fort Hood research design, presented in Chapters 4 and 5, within the general strategic approach outlined in chapter 1, and by applying the case-specific constraints and parameters discussed in Chapters 2 and 3. Section 6.1 explores the limitations of alternative data collection tactics in the general case as they relate to different classes of data needs. Next, section 6.2 synthesizes the data needs of the Fort Hood research design into a general and then specific Fort Hood model of assessing site data potential.

6.1 DATA LIMITATIONS

This section discusses the limitations, and advantages, of alternative data collection tactics as they apply to assessing site significance within a step-wise cultural resources management program. In the same way that Chapter 4 began by developing a robust theoretical research design by first examining some basic assumptions about the current state of knowledge, this section first examines in depth some of the very basic and fundamental aspects of various data collection strategies. Only by a very explicit understanding of terminology, assumptions, and strategies within the cost-benefit framework imposed by the limitations imposed on schedules and funding can the Fort Hood research framework be rigorously operationalized.

Each research question, hypothesis, and test implication specifies the several kinds of data which are required in order to satisfactorily address it. If a cultural resource property has enough of the needed data types, then it is judged significant and worthy of protection. The fundamental goal of the inventory and testing phases is, therefore, to find out whether or not a site has these needed data types. This section discusses the limitations posed by alternative field tactics in determining whether or not a given site has the necessary data potential to be judged significant.

To begin with, not all sites have the same data content (indeed this is the entire point). Some sites are rich in one kind of information and poor in another kind; some are especially appropriate for addressing one or another of the hypotheses while having no data with which to address others. This is to say that rarely will any site have *all* of the types of needed data with which to address *every* research hypothesis. As a consequence, the field tactics must be able to distinguish potential for each of the needed data types. Moreover, not all field tactics are equally good at discovering the various type of data. Some discovery tactics are focused on specific kinds of data and can not assess the quality, quantity or even the presence of other types of data. Finally, some tactics are more time consuming (i. e., expensive) than others.

Not all of the data types needed by a comprehensive research design can *or should* be sought during any given phase of significance assessment. Rather, a well managed cultural resource program should develop sequential sets of field tactics which target prioritized data needs. The data needs (and matching tactics) must be prioritized so that *essential* data sets, common to all hypotheses (e.g., intact and undisturbed deposits) may be assessed early in the evaluation process. For this reason, a phased approach to the evaluation of site significance makes sense because it allows sequential phases to target limited and logically prioritized data sets. A phased approach identifies the specific observations which are first necessary and then sufficient to assess the site's significance.

6.1.1 Inventory Phase Tactics

The inventory phase is commonly referred to as "survey" because the most common tactic used to discover cultural resource sites is the pedestrian survey. However, the phase itself should not be equated with survey tactics alone, because other kinds of discovery tactics are possible as well. The suite of discovery tactics includes various remote sensing approaches (e.g., aerial photography, ground-penetrating radar), sample excavations (e.g., backhoe trenching, auguring, shovel probing), intensive examination of linear stratigraphic exposures (stream and river banks, erosional and road cuts), and interviews of local key informants, in addition to the standardized pedestrian walkover.

Innumerable variations are possible within and among these tactical modes. For example, shovel probing may be conducted in conjunction with a pedestrian walkover, or alone. Similarly, pedestrian survey may be conducted using 15-m or 50-m intervals. Importantly, the choice of tactics *and the strategic mix of these* depend on recognized data gaps and data needs. It must be emphasized that inventory tactics which are well suited to one study area are not necessarily appropriate for another. Indeed, an unconsidered selection and implementation of inventory tactics can be a serious management error because the inventory may need to be repeated at a later time. For example, a pedestrian walkover in an area having recent sedimentation may locate *no* prehistoric sites because they are all buried, whereas a close inspection of stratigraphic exposures coupled with shovel testing and/or backhoe trenching may well discover numerous buried sites in the same study area.

Depending on parameters of the overall project (e.g., size of the study area, legal need for cultural resource management), the inventory tactics may be aimed at the entire study area or at selected portions of it. Under the latter option, a sampling design is needed which selects designated portions of the study area for inventory. These portions may be selected with respect to arbitrary strata (e.g. political subdivision, legal section) or with respect to natural or cultural variables (geomorphic landform, drainage system). For example, military bases are often subdivided into arbitrary management areas which can serve as the basis for a sampling design. Sample units based on natural context information are often more meaningful, as suggested in section 1.2. Regardless, sampling is often a useful management approach in situations where long-term management of cultural resources is foreseen. The management needs of destructive projects (e.g., reservoirs) necessitate an immediate and (relatively) rapid 100 percent inventory and significance evaluation. By contrast, progressively incremental sampling of a study area can be an efficient approach for non-destructive projects (e.g., military bases) which foresee no immediate destruction of sites, but which need long-term management of all resources.

Whether or not a sampling approach is used, each inventory tactic has its peculiar advantages and limitations. Two major data limitations are common to most inventory phases: the limited duration available within which to make observations, and the restricted subsurface perspective.

6.1.1.1 Duration of Observations

Common to all inventory tactics is the limited length of time that is actually spent making observations on each site. Hopefully, this is not because the inventory phase is shortchanged in terms of available effort: it is generally a function of the total size of the study area which must be inventoried and/or the total number of sites for which similar information must be collected. The length of time spent on any given site depends heavily on its size and complexity, but an inventory phase generally averages person-hours to collect the necessary observations for a given site, whereas a testing phase may spend person-days collecting more detailed data on the same site, and a data recovery phase may spend person-months on the site.

To compensate for this limitation, some types of observations may be made elsewhere after the site has been located. These include observations on collected artifacts as well as those made from maps, photographs, or other geographic informational systems. Thus, two methodologically different kinds of observations are possible during inventory: those observations which can only be made on the physical site, and those observations which may be made elsewhere. (Of course, this is also true for later phase as well, but the distinction is perhaps more important during inventory when the duration of on-site observation is tactically limited). Cross-cutting these methodological categories are the natural and cultural attributes of the site. This four-cell typology of observations is schematically represented in Table 6.1. The four types of observations are arbitrarily numbered 1 through 4 and examples of each type are given below. In this scheme, type 1 observations are those of natural context attributes which can only be made on the physical site. Examples include the types, quantities, and proximity of various resources (e.g., water, arable soil, plant and animal foods, raw lithic materials), as well as characteristics of the soil or sediment (type, age, depth) both on the site and surrounding it. While these kinds of variables are sometimes available in pre-existing GIS data bases, the data accuracy and resolution are usually not sufficient to allow detailed inter-site comparisons; actual on-site observations are generally needed at the very least to field-verify and/or refine such GIS data. For example, a pre-existing GIS data base may identify a particular geologic formation (e.g., Walnut clay, recent alluvium) or a soil series, but it probably can not specify precise soil depth (e.g., 40 cm on average) or soil profile type (e.g., A-Bt-C).

Type 2 observations are those made on cultural attributes and which can only be made on site. Examples are the numbers and sizes of each type of feature, the types and numbers of features, the types and numbers of artifacts, the spatial distribution of features and artifacts, and the horizontal extent and depth of cultural remains.

Type 3 observations are those made on the natural context attributes of the site but which may be made elsewhere from pre-existing data sources. Examples are the mean annual rainfall; the elevation, slope, relief, and aspect; the modern biotic communities; the precipitation; and the temperature. These data are available from maps, aerial photographs, published data tables, and are often in GIS format.

Finally, type 4 observations are those on cultural attributes of the site, but which may be made elsewhere. Examples include the mean width of a population of (collected) lithic biface flakes, the petrographic composition of a (collected) ceramic sherd, or the number and diversity of other sites within a given distance. These data are obtained through laboratory analysis of collected specimens and samples and through synthetic data analysis.

6.1.1.2 Subsurface Perspectives

A second major limitation common to most inventory tactics is their restricted perspective under the surface of any given site. Pedestrian walkovers typically record surface data only. While these data may be supplemented with subsurface inspection by means of shovel tests, backhoe trenches, and/or inspection of available exposures, inventories generally do not include *extensive* subsurface investigations for any site. These expanded windows into the subsurface character of sites generally must wait for subsequent testing or data recovery phases (if these phases are even needed on the site by the management process). By way of illustration, a 100 x 100 m site on which shovel tests (40-cm wide) are dug at 25-m grid spacing (15 total tests) has a total subsurface exposure of less than *three 100ths of one percent* (0.000024) of the estimated site area (10,000 m^2). Varying the spacing, depth, and diameter of on-site shovel tests negligibly affects the total subsurface window. Indeed, shovel tests employed during the inventory phase are *tactically* restricted in size and depth: sizes typically range from 25 to 50 cm in diameter, and depth is rarely greater than 100 cm below surface, and more typically 40 to 80 cm below surface. Because of these limits, the nature of data obtained from shovel tests is correspondingly limited.

Clearly, if due to depositional history, most of a given site is buried and is not visible on the surface, then its overall data potential must be inferred from surface indications and only supplemented with limited subsurface observations. Therefore, because much must be inferred from a small subsurface window, a primary data limitation during inventory can be attributed to *sampling error.* The most reliable inferences from shovel tests are the presence of subsurface cultural material and their depths. Artifact variability may be inferred and occasionally diagnostic artifacts are recovered. However, note that *ab-*

sence of subsurface material is not a reliable inference from shovel tests: lack of subsurface artifacts in shovel tests does not necessarily mean an absence of subsurface cultural material. Because of the sampling error, a sparse artifact distribution may not be detected at all, even for sites with otherwise outstanding information potential.

6.1.2 Testing Phase Tactics

The two management goals of an inventory phase are (1) to locate all cultural resource properties, and (2) to evaluate as many of these as possible with respect to significance. If, due to the data limitations inherent in the inventory phase, some sites cannot be conclusively demonstrated to have sufficient data content to be judged significant, then these must proceed to the next round of the management process, commonly referred to as the "testing" phase.

At this point, we should pause to re-emphasize the point that data obtained during an inventory or testing phase are collected solely in order to evaluate site significance, and *not to actually test any hypotheses.* While the substantive information collected during these phases is scientifically valuable in its own right, and while these data may ultimately be used to critically examine some of the research hypotheses, this is actually a side benefit of the management process. To repeat, within the context of a compliance program, the management goal of the inventory and testing phases is very simply to determine site data potential, and therefore significance, and therefore eligibility for protection and continued management as a valuable public resource.

This being said, the key differences between the inventory and testing phases are (1) the use of a expanded set of field tactics which allow a more detailed, intensive, and conclusive evaluation of data content, and (2) a reduction in sampling error by increasing the subsurface sample.

6.1.2.1 Manual Excavations

In many cases, the key limitation of the inventory phase which does not allow for a full determination of site data potential is the restricted subsurface perspective. In these cases, the set of tactics used for testing predictably consists of more intensive subsurface investigations. Very commonly, these consist of controlled manual excavations. So-called "test pits" are designed to reduce the sampling error of the inventory phase shovel tests: they are larger in cross section and can be dug deeper than shovel tests; the volume of material excavated is larger; the probability of encountering artifacts and/or features is enhanced; and site stratigraphy is often discernable on the vertical faces of the test pit. As an "industry standard," test pits generally measure 1 m^2 each and are excavated in sequential multiples of 10 cm (both of these standard measures are arbitrary). Depths of pits are determined by empirical site stratigraphy and can range up to 1.5 m or more below the surface of the site (or even deeper if accompanied by mechanical excavations and appropriate safety shoring).

The number and configuration of test pits must be determined on a case-by-case basis for each site; there is no single formula or ratio. The number and configuration of test pits is determined by (1) the missing, or unknown, data content (e.g., does the site have radiometric samples and macrobotanical remains?) in conjunction with (2) the overall size of the site and (3) the suspected internal diversity of features and artifacts. In general though, testing phase excavations predictably result in a greater subsurface sample than the inventory phase. For example, the 100 x 100 m site mentioned above might have 10 1 m^2 test pits, yielding a one-tenth percent (0.001) sample of the total site area, in contrast to the 0.000024 sample from the inventory shovel testing.

There is a good argument to be made that on military reservations, with the need for ongoing management of large numbers of sites, the number of test units should be the minimum number necessary to conclusively determine data potential and significance. If a site is judged to be *not significant,* then

Table 6.1 Categories of Observations Relevant to Determining Site Significance.

		RELEVANT DATA	
		Natural Attributes	Cultural Attributes
METHOD OF COLLECTION	On Site Observations	type 1 data	type 2 data
	Remote Observations	type 3 data	type 4 data

excavating more than the minimum number of tests necessary to achieve this determination wastes time and money which could be better invested in other, significant, sites. Further, if a site is judged to be *significant*, then excavating more than the minimum number of tests is wasteful of resources if the site can truly be protected and preserved. Moreover, if a significant site ultimately requires data recovery excavations, then excessive excavation during the testing phase is actually destructive because more methodologically refined tactics could enhance the extraction of data during subsequent data recovery excavations. The counter argument allows that more excavation during a testing phase allows for better planning of any subsequent data recovery phase. However, this is true only for those sites which actually proceed to data recovery excavations; if the purpose of a National Register of Historic Places (NRHP) testing effort is solely to determine site significance according to an explicit set of research criteria, then this additional "planning" work should more legitimately be conducted as preliminary field work within an actual data recovery phase itself, and only for those sites which must proceed to data recovery excavations.

To be certain, some cultural resource management plans may actually benefit by such an upfront loading of data recovery planning effort into the testing phase. Such projects are typically those for which protection and preservation of *individual sites* is not a likely option because of the planned destruction of all resources (e.g., new reservoirs). However, for the ongoing management needs of military installations, a careful step-wise process is more appropriate, and "data recovery planning" work should be conducted only during a formal data recovery operation, and then only for those sites which are actually threatened with adverse impacts.

As suggested above, formalized test pits are far better than are shovel tests in yielding meaningful data which bear on determining site significance. Still, test pits have serious limitations which do not allow them to inform on all data needs. Because of their limited horizontal size, test pits usually do not allow assessment as to whether buried artifacts or features may be spatially patterned in a meaningful way. Even if multiple test units are configured adjacently, rarely can the presence of subsurface spatial patterning be ascertained. Similarly, test pits do not allow a lengthy horizontal exposure of stratigraphy. Although vertical stratigraphy can often be discerned in the faces of test pits, overall site stratigraphy must be inferred between scattered profiles.

The arbitrary excavation levels (e.g., 10 cm) which are often used in test excavations can crosscut and obscure natural and cultural strata. If cultural strata are present, these must frequently be determined by a statistical analysis of the frequency distributions by depth of various artifact types. In addition, the thickness of levels and the horizontal size of the test pits effectively limit the precision of artifact provenience to 0.1 m^3 (barring those artifacts found and recorded *in situ*). Provenience precision can be increased by reducing the thickness of vertical levels and/or by reducing the horizontal sizes of the test pits. For example, using 5-cm levels and 50 x 50 cm units creates a precision of 0.00125 m^3. However, there is a point of diminishing returns because these tactics are far more time consuming. The point is, particular testing tactics should be intimately connected to discerning the missing data content of a site.

Further, the maximum depth of test pits is limited to about 1.5 meters below the surface (or less, depending on sediment type), without being augmented by mechanical excavations and/or by safety shoring. Deeper deposits must be investigated by "stepping down" multiple test pits and/or by mechanical excavations (see below). Indeed, manual test pits may be contraindicated for sites with very deep deposits overlain by non-cultural strata.

Finally, in order to maximize recovery of artifacts, the excavated sediments are almost always screened or sieved. This means that the sizes of recovered items, *and even the types of items*, is a function of mesh size. Typically, a 1/4-inch mesh (i.e., "hardware cloth") is used during testing phase excavations, although this is not a magic number. This mesh size usually misses the smaller kinds of artifacts such as tiny lithic finishing flakes or charred plant remains; a 1/8-inch or smaller mesh size is needed to recover these kinds of items, although even a 1/8-inch mesh can result in the loss of some relevant botanical or environmental data. However, there is a point of diminishing returns in reducing mesh size because of the increased field time necessary to physically screen the sediments. Water-based processing tactics such as flotation or fine mesh water screening can reduce total processing time and increase recovery of very small items, and is recommended for a sample of sediments excavated during the testing phase, especially those from feature contexts. However, intensive (i. e., 100%) use of these tactics is usually better suited to data recovery excavations where a wet-processing facility can be established onsite and all excavated sediments can be accommodated.

6.1.2.2 Mechanical Excavations

Because of these many limitations of manually-excavated test pits, some sites may require intensive mechanical excavations by a backhoe or similar device in order to fully assess data content and significance. Mechanical excavations are warranted on sites whose data potential cannot be determined because the suspected cultural deposits are deeper than the maximum depth of shovel tactics, or because the natural and cultural stratigraphy is unknown or unclear.

Mechanical excavations have clear data limits, too. In effect, they propose a strategic trade-off with manual excavations. They have far lower precision of provenience than manual excavations, but because they can proceed at a much faster rate, they allow a far greater depth and/or linear exposure of excavations. In this regard, mechanical excavations are most commonly used in order to increase the subsurface perspective. Mechanical excavations should not be used as a subsurface artifact recovery tactic because of the low precision of provenience data. Still, they can recover items in side walls or from backdirt piles. Artifacts found in trench side walls are especially valuable because they are usually in primary context. By contrast, artifacts in backdirt piles are always out of context and can rarely achieve precision greater than 20 cm vertical and 2 m horizontal, even if the operator carefully separates each bucket of fill.

Finally, it must be realized that mechanical excavations are highly destructive of data. They can completely destroy buried features before their presence is recognized. Within backdirt piles, artifact proveniences are usually hopelessly jumbled. For these reasons, mechanical excavations should be prudently limited.

6.1.2.3 Other Tactics

Certainly, manual and mechanical excavations are the most common tactics employed during the testing phase. Indeed, "testing" has at times come to be equated (erroneously) with excavations. However, other tactics may actually be better suited to determine the data content of a given site.

If the subsurface content of the site has been adequately inferred during inventory, or if it is irrelevant to the research questions, then no excavations may be warranted. Instead, intensive recording and/or collection of the surface artifact assemblage may be needed to document remaining uncertainties in overall data potential. Many of the data limitations associated with surface documentation are similar to those of excavated test pits. The total number, sizes, and configuration of surface sampling units must be determined case by case for each site on the basis of the missing (or unknown) data content (e.g., does the assemblage have more biface flakes or more core flakes?) together with the site size and diversity of artifacts. Again, the number of surface units should be the minimum number necessary to conclusively determine data potential and significance. Artifacts may either be recorded in the field or collected for later recording. As has been seen for many testing tactics, collection is a trade-off against in-field recording. If the artifacts are collected from the field, then their attributes can be carefully recorded under favorable laboratory conditions, but the data content of the actual site has been permanently altered. Moreover, all collected artifacts must be (at least, in most cases) curated in perpetuity, leading to significantly increased management effort. In contrast, a program of in-field recording of artifacts can proceed quickly but must be carefully designed to ensure that relevant artifact attributes are recorded in a rigorous and replicable manner.

Lastly, another primary tactical mode which can productively inform on unknown data content is the collection and analysis of "feasibility samples." These are often excavated samples of sediment which are collected and subjected to analysis of very specific "micro-" data sets such as radiocarbon, pollen, phytolith, soil chemistry, and macrobotanical content. These samples can contain small botanical and environmental "ecofacts" missed by screening. Presence of these data types may be needed to demonstrate a site's potential to address chronometric, paleoenvironmental, and economic research questions. For example, if a given site can be shown to have a preserved and stratigraphically separated pollen record, then it may meet key data needs for paleoenvironmental hypotheses; otherwise, the site may have no research potential and be judged not significant.

Because of the many data limitations associated with testing tactics, often a *mix* of these tactics can conclusively determine site data potential; the limits of one tactic can be offset with the advantages of another. Often, a plan of carefully placed manual excavations, supplemented by limited mechanical trenching and complemented with analysis of feasibility samples, is an optimal strategy. Nevertheless, it is usually not possible to collect sufficient data with which to evaluate a given site's potential to address *every* data need from *every* research question. For example, it is almost always impossible to determine whether or not a given site has multiple buried features, even during the testing phase. These can be extremely useful for addressing questions of intra-site spatial patterning and inferred social structure. While the presence of buried features may be demonstrated by sample excavations, and multiple features may be suggested by remote sensing technology such as ground penetrating radar, the actual presence of multiple buried features can rarely be conclusively demonstrated. This dilemma highlights the fact that a well managed testing program must focus on a *prioritized hierarchy of data needs*. If a given site has the data to address hypotheses A, B, and C, then it is judged significant, even through we might not know for sure whether or not it has the data to address D, E, or F. If, due to the limitations of the inventory tactics, some sites need testing, then the testing tactics should be selected and mixed so as to zero in on those site characteristics which constitute irreparable flaws (see below) in overall data potential.

6.2 ASSESSING SIGNIFICANCE

This section first develops a general model for the step-wise assessment of cultural resource significance. The general model is based on a "fatal-flaw" analysis in which failure to meet certain criteria is a sufficient reason to classify a site as not significant. The general model distinguishes two levels of fatal flaws. The first level is contextual and distinguishes between sites that do or do not have sufficient physical integrity to serve as sources of data. The second level is content-oriented and distinguishes between sites on the basis of whether their data sets are *essential* for addressing research issues or merely *useful* to address the research issues. It is argued that the absence of physical integrity and the absence of certain essential data are irremediable deficiencies in the total information value of a site. The general model is then applied to the specific case study of Fort Hood. This application integrates the data needs specified in Chapter 5 with the impacts and landscape discussed in Chapter 3, and filters these through the data limitations noted in section 6.1

6.2.1 A General Model of Significance

Within the context of the Section 106 process, the significance of each cultural resource is determined by an evaluation of its unique and individual potential to address the important questions which have been formulated in the research design. This research potential is assessed by matching the known *or suspected* data content of the site against the previously developed set of data requirements. If the site contains many of the types of data which are needed to address the research questions, then it has high research potential and is considered to be significant. If the site contains few of these types of data, then it has low research potential and is not considered significant unless the data it does have are relevant to an important (even if narrow) research issue.

It is necessary to note that a site with abundant artifacts does not necessarily have the potential to resolve any research issues. This is because artifacts are only as valuable as their capacity to describe and explain cultural processes and phenomena. In order to contribute, artifacts must have discernable relationships to other artifacts, and there are only two ways to establish these relationships. The first way is to examine the spatial patterning of artifacts at various sites. When artifacts co-occur repeatedly, it is plausible to infer that they were somehow associated together when they were used (assuming no post-depositional disturbances). As a result, it is important to know the stratigraphic relationships between artifacts. The second way is by laboratory techniques that allow for direct assignment of information to a particular time or area. For example, human bone (even from disturbed stratigraphic contexts) can be isotopically analyzed for dietary data and also radiometrically dated to place that dietary data in a chronological framework. Thus, depending on the nature of the problem to be addressed, data must be assignable to an artifact either by stratigraphic context or by direct assignment.

Nevertheless, in the absence of stratigraphic context, the overall value of any artifact is often reduced. As a consequence, the first level of the fatal-flaw analysis approaches site-assessment in terms of site integrity and stratigraphic context. If for whatever reason, stratigraphic relationships within a site are nonexistent, then this absence negates any artifact-to-artifact analyses, even if direct assignment of some data is possible. In such cases, the research value of the site depends on whether it contains artifacts (including faunal, botanical, and environmental ecofacts) that can be placed in a relevant research context via laboratory analyses. Otherwise, it is fatally flawed for contextual reasons because no matter how many artifacts may be there, they cannot be used to advance research.

The analysis of fatal flaws in data *context* is closely linked with the notion of data relevance. The second level of the fatal-flaw analysis involves evaluation of sites with respect to their data *content*. Within any research design, not all data needs are equal in importance. As has been suggested in the previous discussion on data limitations, it is necessary to distinguish those data sets which are *essential* to test hypotheses from those which are merely *useful*. Essential data sets are those that can be used to test hypotheses established in the research design, even if no single site can be expected to provide enough data to resolve a hypothesis. For example, faunal and floral data are essential to test a hypothesis about subsistence resources, although no single site will ever contain a full enough data set to illuminate the nature of the entire subsistence base.

Useful data sets, on the other hand, contain either data that are overwhelmingly redundant with respect to the current state of knowledge, or data that would be useful if they could actually be harnessed. For example, if the state of knowledge were such that there were no interesting hypotheses that can be addressed with a new collection of stone flakes dating to A.D. 200, then it would be redundant to collect more flakes of that age despite the fact that it might be useful to know another detail about their distribution. Thus, an assemblage which is dateable from geomorphic context but which contains *only* flakes would be fatally flawed with respect to its research value, even if the stratigraphic context was pristine.

Similarly, it is entirely feasible to analyze lipid residues on artifacts in order to identify some aspects of subsistence behaviors. However, the use of lipids is hampered by a current (1993) and widespread lack of laboratory facilities conducting this type of analysis, which means that a perfectly useful class of data is effectively unavailable. As a result, if the research value of a site depends exclusively on lipid analysis, then it may be fatally flawed with respect to significance unless there are other classes of essential data at the site.

This two-level fatal-flaw approach allows early and rapid identification of those sites with critical defects in their overall data potential, and for which no further management is needed. Appropriate tactics would be first geared to determining *the lack* of appropriate artifacts, features, or samples. If discovered early in the management process (i. e., during inventory), a site having this fatal flaw could be eliminated from further management, and time and money could then be more optimally allocated among the significant cultural resources.

A general step-wise model of determining significance is schematically represented in Figure 6.1. Note that this model is a heuristic device only; it does not include key *procedural* steps which are necessary for compliance with particular statutes and regulations. For example, the simplified model does not diagram the review process by which assessments of resource significance are accepted or rejected by the regulatory authority responsible for overseeing cultural resources compliance.

As suggested in Figure 6.1, all work takes place under the umbrella of the research design. The process begins during the inventory phase where, upon initial discovery, all cultural remains are matched against the site definition criteria. Non-sites (by definition) have no data content bearing on the research issues and are determined non-significant. Legitimate sites are first examined for contextual fatal flaws (if any). Sites with contextual fatal flaws (again, by definition) have no significance regardless of the amount of data actually present. Sites without contextual fatal flaws are then matched against *essential* data needs. If the site has data which can contribute to resolution of one or more hypotheses, then it is judged either to require testing or protection/mitigation.

Note that the fatal flaw analysis depends a great deal on the current state of the art as a result of the difference between essential and useful data. CRM activities in an ongoing research program (in contrast to short-term salvage programs) can expect to have durations within which the state of the art changes as a result of growth of knowledge, growth of analytical capacity, or both. It therefore is *possible* that during the long-term CRM process, growth of knowledge can reduce the significance of some sites, and it is *likely* that growth of analytical capacity will increase the significance of others. Hence, when assessing the current significance of sites, CRM managers and researchers should make pragmatic judgments about the value of sites relative to predictable future developments.

Table 6.2 presents an heuristic example of a cross-tabular approach which assesses the research potential of an imaginary site by matching observed or inferred data content to the essential data needs. In this example, three different hypotheses are each cross ranked by three kinds of data requirements. Shaded cells indicate that the data type is needed to address the hypothesis; unshaded cells indicate that the data type is not essential to the hypothesis. Within each shaded cell, a "yes" or "no" indicates whether or not the imaginary site contains (or is likely to contain) the data. The bottom row in the table summarizes the adequacy of the site to address each hypothesis. In

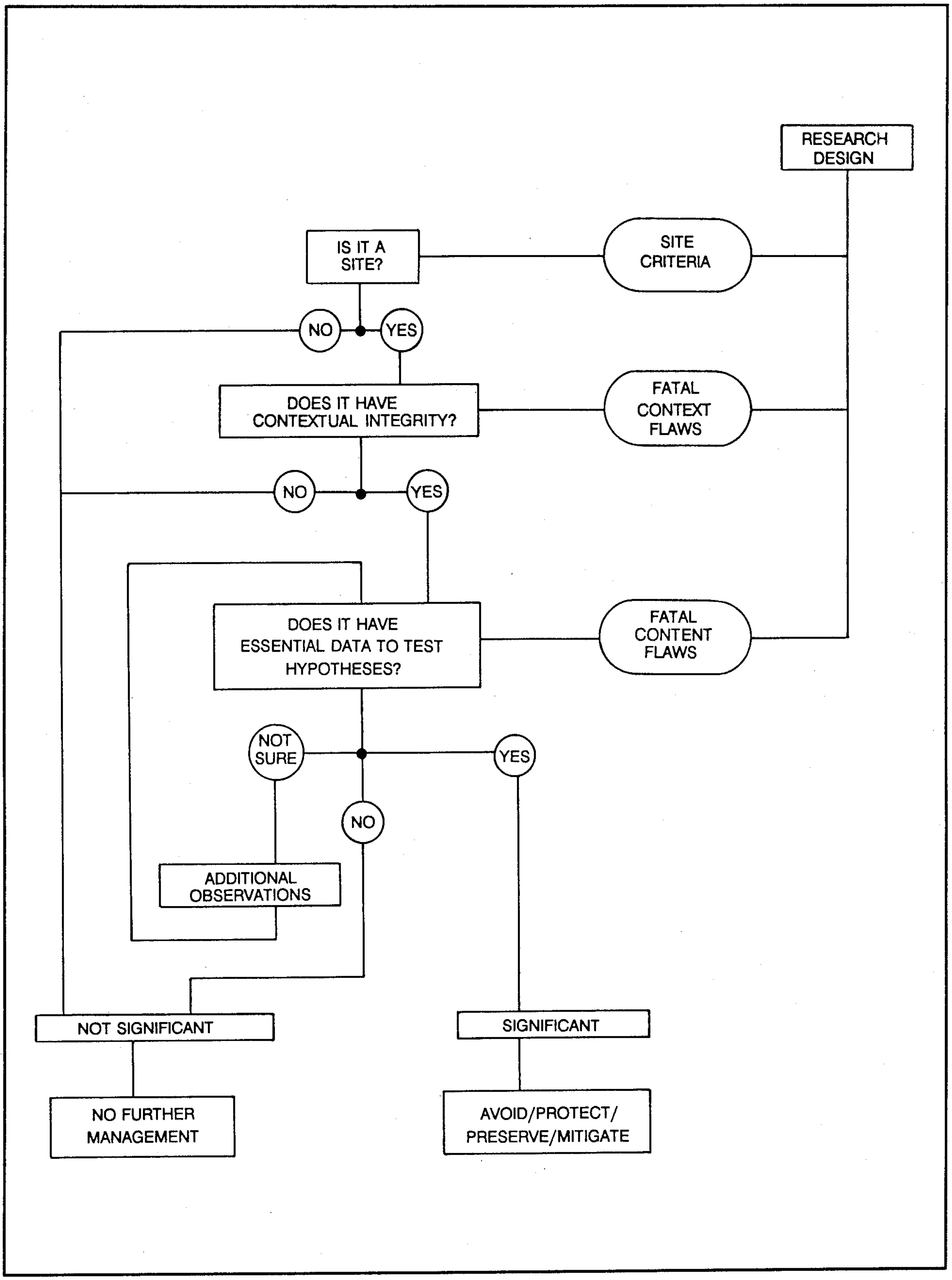


Figure 6.1 General Model for Assessing Significance.

Table 6.2 A Heuristic Approach for Assessing the Research Potential of a Site (shaded cells indicate data sets needed to address the hypothesis).

Type of Essential Data	Does This Site Contain the Data?	May the First Hypothesis be Addressed?	May the Second Hypothesis be Addressed?	May the Third Hypothesis be Addressed?
Radiocarbon Samples	yes	yes	yes	yes
Subsistence Remains	yes	--	--	yes
Ceramic Artifacts	no	--	no	--
Can Hypothesis be Tested?		yes	no	yes

this example, the imaginary site has chronometric samples and subsistence remains, but not ceramic artifacts. These data sets are essential to address the first and third, but not second, hypotheses. It is important to note that the operation represented in Table 6.2 does *not* actually test the hypotheses. Rather, the site is merely being evaluated for *potential* to test the hypotheses.

As discussed earlier in the context of data limitations, not all field tactics can inform equally on every data. For example, the suite of tactics which are effective during inventory can not always determine whether or not charcoal is present (unless features are exposed). Even subsurface shovel testing may not reliably determine the presence of buried bison bone on a site, unless a specimen is fortuitously recovered. As a result, the useful data needs for each hypothesis should be prioritized for field observations, just as the essential data needs were prioritized as fatal flaws. This calls for an identification of those essential data sets which have the highest likelihood of yielding reliable presence/absence observations during inventory. Data sets which are not readily or reliably discernable using inventory tactics should not serve as standards for assessing site significance because the failure to recover evidence of them in inventory is likely to result from sampling error.

Table 6.3 presents an example of the complete step-wise significance assessment for seven imaginary sites, beginning with identification of two fatal flaws, followed by observations of two data types that are likely to be recovered using inventory tactics, and then by observation of two data types likely to be recovered using testing tactics. Data types A, B, and C are essential data sets that can address research hypotheses. Data type D is merely useful data that cannot yet be harnessed to test research hypotheses.

In this example, contextual fatal flaws are found on site #1 and content fatal flaws are found on site #2. Both are assessed as not significant and require no further management. Sites #3 through #7 do not have the fatal flaws and are therefore examined for needed data types A and B. Site #3 does not have essential data and there is no evidence to suspect that essential data are present.

Therefore, site #3 is assessed as not significant, requiring no further management. Site #7 has all needed data types, is assessed as significant, and is recommended for avoidance, preservation, and protection. Sites #1 through 3 and site #7 are not tested.

Sites #4 and #5 do not disclose essential data during inventory, but are situated so that they are likely to have unobserved essential data that cannot be expected to be recovered using inventory tactics. These two sites therefore have uncertain significance and are recommended for testing. Testing focuses on data set C and D, which are data sets that are readily subject to recovery using testing tactics. Testing at

Table 6.3 A Generalized Step-wise Approach for Assessing Significance.

		Site #1	Site #2	Site #3	Site #4	Site #5	Site #6	Site #7
INVENTORY	Does Site have Contextual Fatal Flaw?	YES	NO	NO	NO	NO	NO	NO
PHASE	Does Site have Content Fatal Flaw?	NO	YES	NO	NO	NO	NO	NO
	Does Site have Data Type A?*	(not observed)	(not observed)	NO	unknown	unknown	unknown	YES
	Does Site have Data Type B?*	(not observed)	(not observed)	NO	NO	NO	unknown	YES
	Can Hypotheses be Addressed?	NO	NO	NO	unknown	unknown	unknown	YES
	Site Significance	Not Significant	Not Significant	Not Significant	Unknown Significance	Unknown Significance	Unknown	Significant
	Preliminary Management Recommendation	No further management***	No further management***	No further management***	Test for Significance	Test for Significance	Test for Significance	Avoid, Protect, Preserve, - or - Mitigate***
TESTING PHASE	Does Site have Data Type A?*	(not observed)	(not observed)	(not observed)	NO	NO	Yes	(not observed)
	Does Site have Data Type B?*	(not observed)	(not observed)	(not observed)	NO	NO	NO	(not observed)
	Does Site have Data Type C?*	(not observed)	(not observed)	(not observed)	NO	YES	YES	(not observed)
	Does Site have Data Type D?**	(not observed)	(not observed)	(not observed)	YES	NO	YES	(not observed)
	Can Hypotheses be Addressed?	unknown	unknown	unknown	NO	YES	YES	unknown
	Site Significance	Not Significant	Not Significant	Not Significant	Not Significant	Significant	Significant	Significant
FINAL MANAGEMENT RECOMMENDATION		No Further Management	No Further Management	No Further Management	No Further Management	Avoid, Protect & Preserve - or - Mitigate	Avoid, protect & Preserve - or - Mitigate	Avoid, Protect & Preserve - or - Mitigate

* "Essential" data for hypothesis ** "Useful" data *** Not tested

site #4 not only does not disclose data set C, it also does not disclose A or B. However, testing at site #4 does disclose useful data set D, but data set D cannot be used to test any research hypotheses. Site #4 is lacking essential data and is ultimately assessed as not significant, requiring no further management. Testing at site #5 also does not disclose evidence for data sets A or B, but because it does disclose C, it is capable of addressing research hypotheses. Given this capacity, site #5 is evaluated as significant and requiring avoidance, preservation, and protection.

Site #6 has no known essential data after inventory tactics have been applied, but there is reason to suspect that it might have some essential data that can be disclosed by testing tactics. Site #6 is therefore recommended for testing. Testing not only discloses data sets C and D, but also A. Site #6 has some of the needed data types, but probably not all. Site #6 therefore has the capacity to address research hypotheses, and is judged significant. Note that the disclosure of data type D at site #6 has no influence on the evaluation because type D data is merely useful; significance is judged from the presence of essential data.

6.2.2 A Significance Model for Fort Hood

This section applies the general model of significance developed above to the case study of Fort Hood. The very specific data needs outlined in Chapter 5 are integrated with the landscape and adverse impacts discussed in Chapter 3, and are then filtered through the data limitations of section 6.1. Two types of natural context fatal flaws are proposed: deposits which have lost informational integrity through extensive post-depositional disturbances, and deposits which have no potential for segregation of temporally-distinct cultural assemblages.

As is represented schematically in Figure 6.2, not every locus of cultural material is treated as a site. If the locus does *not* qualify as a site (i. e., it does not meet the explicit site definition criteria in the Fort Hood Standard Operating Procedures), then it is recorded as an isolate (or "non-site") and no further management is warranted. If a cultural locus is designated as a site, then it is formally recorded and assessed for significance. Importantly, if inventory tactics define the site as overlapping different natural context zones (e.g., a stable Pleistocene surface and an alluvial Holocene terrace), then each subarea of the site should be *separately* assessed for fatal flaws in both context, and then, content. These stipulate conditions under which a site (or subarea) has (or lacks) the potential to satisfactorily address the research hypotheses.

Question #1: *Does the site (or subarea) have the potential to contain intact and undisturbed assemblages of artifacts and/or features?*

Assessing integrity of cultural deposits requires observations on the types and degrees of disturbances the site has suffered. Some disturbances are natural events such as bioturbation, range fires, sedimentation, or erosion (e.g., gullying, sheetwash). Usually more serious at Fort Hood are the artificial (man-made) impacts. As has been discussed more fully in section 5.4, these include historic farm and ranch related modifications of the landscape (e.g., irrigation ditches, roads, rock walls); more recent military modifications (e.g., tank tracking on the surface, foxholes, tank "hulldowns"); as well as intentional site vandalism (e.g., "potholes," surface collection). If the site survives this fatal flaw, it is then matched against question #2.

Question #2: *Does the site (or subarea) have the potential to contain chronological indicators?*

Assessing chronological potential requires observations on the types and probable frequencies of chronometrically-dateable samples and/or temporally-diagnostic artifacts. Samples which can be chronometrically assayed using currently available techniques include organics (wood, bone, shell, charcoal, soil humates) for radiocarbon analysis, obsidian artifacts for hydration analysis, and *in situ* burned rock or fired clay for archaeomagnetic dating.

Temporally-diagnostic artifacts at Fort Hood include lithic tools (e.g., projectile points and some types of scrapers), and ceramics.

These first two questions define fatal flaws because intact deposits and chronometric potential are both necessary under *every* research question. If the answer to either of these questions is no, then the site has a minimum potential to satisfactorily address any of the research design hypotheses. The sites' physical and locational attributes are recorded; it has no further information content and is judged not significant and no further management is warranted. If the site avoids these elimination criteria, questions #3 and #4 are asked.

Question #3: *Does the site (or subarea) have the potential for stratigraphically separated (i. e., buried) deposits in primary context?*

Note that this question targets the *potential* for buried deposits; because of the data limitations of inventory tactics, a clear determination of the actual *presence* of buried primary deposits must usually wait for testing tactics. This question is answered by closely observing the geomorphology and stratigraphy of the site. At one extreme, bedrock surfaces and ancient residual soils have no potential for buried deposits, and so shovel testing is not warranted.

However, if surface observations alone are not adequate to determine potential, then subsurface shovel tests are excavated in those portions of the site which may have some potential. If shovel testing determines that the site has the potential for buried primary deposits, then the types of artifacts and features observed on the site are matched against actual data needs as specified in the research design, and the process continues under question #6; questions #4 and #5 below are bypassed.

However, if the site contains only surficial (or very shallow) deposits and does *not* have the potential for primary and stratigraphically separated deposits, it *may*, under certain conditions, still contain important data. To determine this, the question is asked:

Question #4: *Does the surface assemblage have evidence of primary lithic procurement and/or lithic reduction activities?*

This question is addressed by closely observing the natural site context in conjunction with the surface assemblage. If the site is in the vicinity of natural chert resources and if the assemblage is distinguished by artifacts characteristic of lithic procurement and reduction (e.g., cores, tested cobbles, core flakes), then the site is considered to be a "lithic resource procurement area" (LRPA). Sites in this contingency branch which do not have evidence of lithic procurement or reduction have minimum potential to satisfactorily address any of the research design hypotheses. Their physical and locational attributes are recorded, but the site has no further information content and is judged not significant; no further management is warranted (note that sites *with* buried deposits have bypassed this criterion, see Figure 6.2).

At this point, the conditional branching has defined the current set of sites as being undisturbed (or largely so), with some chronological potential (e.g., with projectile points), but without buried deposits and with an assemblage and natural context suggestive of primary lithic procurement or reduction. At Fort Hood, these sites are characterized by palimpsest surface occupations of geologically stable Pleistocene land surfaces. Multiple chronologically-distinct occupations are possible on such sites, but their assemblages overlap to unknown degrees on the site surface. For these sites then, the question remains whether the palimpsest occupations can be peeled back and separately analyzed:

Question #5: *Do currently available technical procedures allow temporal separation of unstratified palimpsest assemblages?*

No technology is currently (1993) available which reliably allows such an assemblage to be temporally distinguished. Ongoing research into the utility of chert patination as a chronometric indicator is suggestive but as yet inconclusive. If the palimpsest assemblage can *not* be sorted out temporally, then the site has a minimum potential to satisfactorily address any of the research design hypotheses. Physical and locational attributes are recorded, but the site has no further information content and is judged not significant; no further management is warranted.

If however, a temporally-sensitive technique can be applied to the assemblage, then the surface nature of the assemblage is *not* a fatal flaw and the process continues under question #6: the artifacts and features on the site are matched against the essential data needs as specified in the research design.

For example, given the very poorly developed state of current knowledge of Central Texas subsistence, ethnobotanical evidence of edible resources can be dated by AMS radiometric techniques. Thus, for the purposes of initial subsistence model building, these resources are potentially significant because even weak subsistence data (if temporally controlled) are essential at this stage of research because such data represent a significant advance over the current state of knowledge. This data base may actually become redundant if ongoing research in Central Texas succeeds in modeling subsistence. Such an improvement in the regional data base would serve to downgrade the ethnobotanical materials in palimpsest middens from essential data to merely useful data.

Finally, sites which have survived the fatal flaws of context and content are matched against the key data needs of the research design.

Question #6. *Does the site meet key (essential) data needs?*

Under the current Fort Hood research design, essential data needs can be summarized into the following:

A. Economic indicators such as faunal specimens (e.g., animal or human bone, riverine shell); macrobotanical specimens (e.g., seeds, wood charcoal); microbotanical remains (e.g., pollen, phytoliths); processing features (e.g., storage pits, burned rock middens);

B. Technological indicators such as tools (e.g., utilized flakes, projectile points, ceramics) and analytically diverse lithic assemblages;

C. Indicators of regional exchange and interaction such as exotic artifact types (e.g., incised ceramics); non-local artifact materials (e.g., obsidian); non-local faunal or botanical remains (e.g., marine shell, parrots); specialized production assemblages (e.g., caches of tool blanks);

D. Indicators of intra-site spatial organization, such as multiple features; and

E. Temporal indicators such as diagnostic artifacts (e.g., projectile points); chronometric samples (e.g., charcoal, baked feature substrate); or clear stratigraphic separation.

While these data needs are not separately identified in Figure 6.2, each of these essential data needs can be individually addressed. For example:

Question 6A: *Does the site contain prehistoric bone or shell specimens which can be identified and/or dated?*

Question 6B: *Does the site contain prehistoric macrobotanical specimens which can be identified and/or dated?*

Question 6C: *Does the site contain features which may contain economic and/or chronometric samples or which may imply economic activities?*

Question 6D: *Does the site contain multiple and spatially separated features?*

Question 6E: *Does the site contain burned rock features including middens or mounds?*

Question 6F: *Does the site contain unique, unusual, and/or non-local artifact types, artifact materials, concentrations of artifacts, feature types, or constellations of these?*

If a site meets all of these essential data needs, then it has been found to have artifacts and/or features which bear directly on multiple research design issues *and* the potential for undisturbed cultural deposits, and *either* the potential for buried primary deposits, *or* a surface lithic assemblage which can be segregated into discrete temporal components. Such sites have important research potential and they must be assessed as significant and recommended for avoidance and protection, even on the basis of baseline inventory data. However, in many cases, such sites also should be recommended for testing in order to determine as much as possible the range of relevant data sets represented at the site.

If none of the essential data sets can be unambiguously demonstrated during the inventory phase, but the site still has the suspected *potential* to meet these essential data needs, then it is assessed as being of unknown significance and is recommended for testing procedures. If none of the essential data sets are found during inventory and there is no reason to suspect that they exist, the site does not have significant research potential and should be evaluated as not significant.

6.2.3 Implementing the Significance Model at Fort Hood

Because of earlier management decisions at Fort Hood concerning the goals of inventory and the kinds of field observations which were made (see section 2.3), the process of significance assessment at Fort Hood has proceeded in three more or less distinct phases.

Phase 1: Surface Inventory

The first phase, largely conducted prior to 1992, achieved a nearly 95 percent inventory of the 339 m^2 at Fort Hood. The inventory used rigorous site definitions and survey tactics to locate sites on the Fort Hood landscape, assess each of these for integrity, and document the diversity of surface assemblages. However, the inventory did *not* involve observations of geomorphic context and did *not* include subsurface shovel testing. As a result, the initial phase of baseline data collection could not adequately evaluate the majority of sites for the potential of stratigraphically separated deposits in primary context. As a result, a remedial, or supplementary, phase of baseline inventory was necessary.

Phase 2: Site Evaluations

The second phase of inventory, conducted since 1992, has not involved pedestrian resurvey of the Fort Hood landscape in order to find new sites. Rather, this phase has involved revisiting known sites and rigorously, replicably, and explicitly evaluating their data potential. (During this phase however, a number of new sites were indeed discovered and evaluated.) Revisited sites are assessed for geomorphic context, and those with the potential for intact deposits are shovel tested.

All known prehistoric sites within a given training area are first visited by a team consisting of a Holocene geomorphologist and archeologist. During this reconnaissance, sites are evaluated both qualitatively *and quantitatively* in terms of the archaeological materials and features present, the integrity of deposits, their apparent age, and the geomorphic potential for intact buried deposits. Importantly, if the site boundaries (as previously defined) overlap different natural context zones (for example, a stable Pleistocene surface and a Holocene alluvial terrace), then each portion of the site is separately assessed as if it were an individual site.

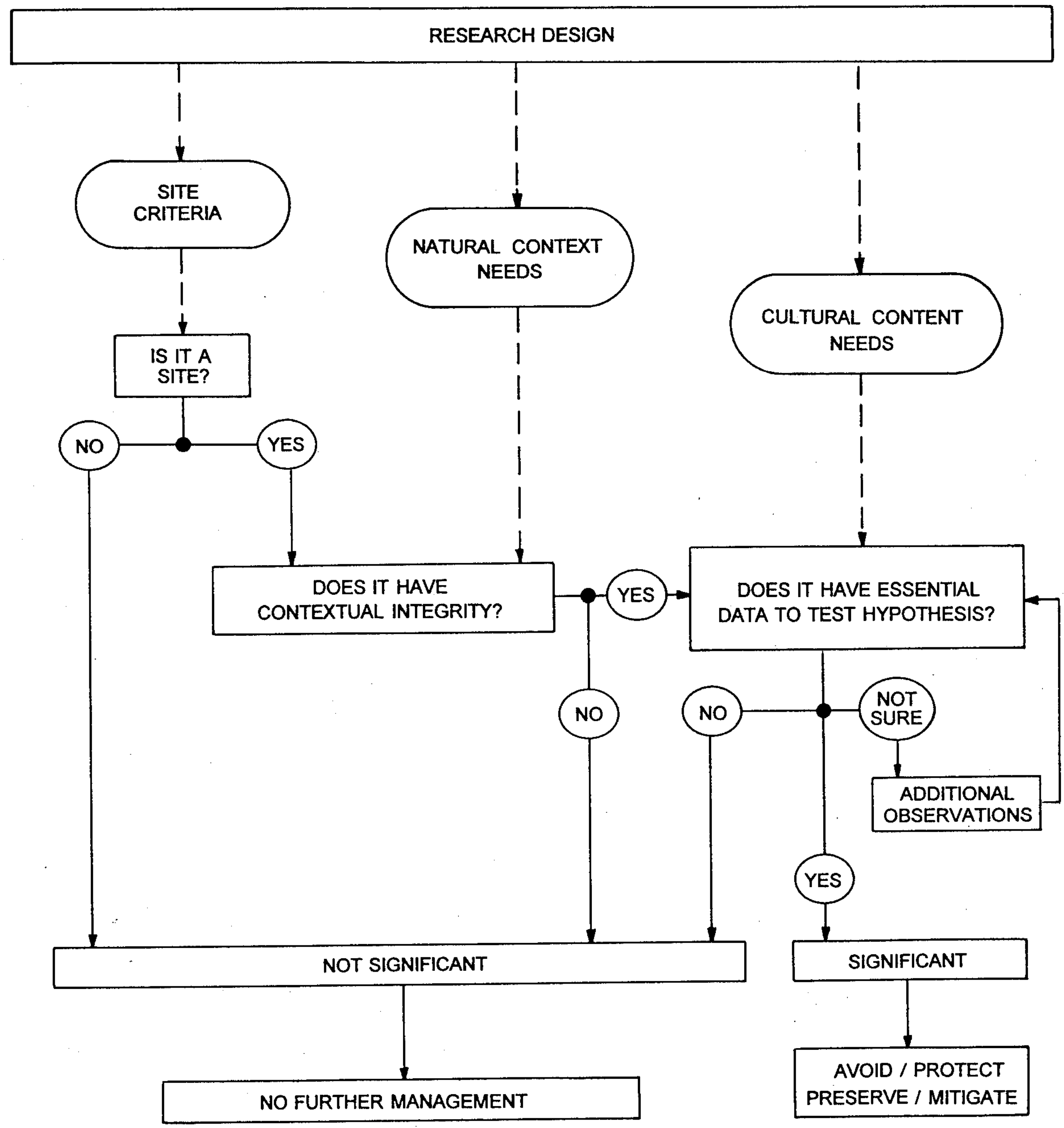


Figure 6.2 Model for Assessing Site Significance at Fort Hood.

Descriptive observations are recorded for archaeological content and for geomorphological context using data recording sheets custom designed for the project (see Appendix A, forms 3 and 5). These record, in free-form text format, observations pertaining to specific topics. For example, the archaeological evaluation calls for observations on features, dateable items, cultural materials present, and other key archaeological topics. The geomorphological evaluation calls for observations on exposures, sediment profiles, disturbances, and other geomorphic topics.

Similarly, custom data recording sheets are used to quantitatively score multiple criteria of archaeological content and geomorphological context along ordinal scales. Examples are shown in Appendix A (forms 4 and 6). For example, the archaeological evaluation assigns numeric scores to *potentially dateable material* ("1" for few to "4" for abundant), *nature of occupation* ("1" for unsealed secondary context to "6" for sealed primary context), and other archaeological criteria. The geomorphic evaluation assigns numeric scores to *surface type* ("1" for flat upland surface to "5" for a rockshelter with clear deposition), *age of geomorphic surface* ("1" for older than 15,000 years to "2" for less than 2,000 years); *erosion* ("1" for greater than 50% to 3 for less than 20%), and other geomorphological context criteria.

The scores for each criterion are summed to obtain a total archaeological score and, separately, a total geomorphological score. High geomorphology scores indicate sites (or subareas) with a natural context that is conducive to the preservation and/or segregation of cultural components; low geomorphology scores suggest a natural context that is unlikely to preserve or segregate components. Similarly, high archaeological scores indicate observed data sets which bear on multiple research design issues; low archaeological scores suggest that the site (or subarea) has data which can be brought to bear on few or no research design issues.

Importantly, the total scores do *not* indicate an interval (i. e., calibrated unit) scale of research value because they are the sum of ordinal rankings of arbitrary value. However, they do reflect relative position along a continuum of research potential. Cross plotting the geomorphological and archaeological scores yields a useful heuristic framework for discerning overall research potential (Figure 6.3) within any subset of sites.

On the basis of the reconnaissance scoring, sites (or subareas) with the lowest research potential are assessed as not significant and are recommended for no further management unless there is some unscored evidence that the low overall potential is offset by a capacity to address an important research issue. Sites (or subareas) with high and intermediate scores are then shovel tested to assess the presence, density, and vertical and horizontal distribution of subsurface cultural materials.

The number and distribution of shovel tests on any given subarea depends on its size and geomorphic setting. In general, shovel tests are placed at 30-m grid intervals across the entire surface of any subarea with the potential for deposits, *and* also in features on upland surfaces. Shovel testing in upland settings focuses on the fairly restricted areas where eolian, minor alluvial, or slight colluvial deposits are suspected, except where plowing, sheet erosion, or vehicle impacts are excessive. By contrast, the alluvial deposits along river and major tributaries have the potential for intact cultural remains at depths much greater than allowed by shovel testing. The goal of shovel testing in these settings is to document and assess the potential for occupational structure and integrity in the shallow portions of the terrace which are apt to be severely impacted by training maneuvers using tracked and wheeled vehicles. Shovel tests in minor lateral tributaries are placed to search for shallow intact cultural deposits along the alluvial sediments and the base of toe slopes. Shovel tests in rockshelters and associated talus slopes are placed in the least disturbed area having the greatest depth potential. In some rockshelters and other types of small features, 1 m^2 or 0.25 m^2 tests are determined to be more productive (and less destructive) than the standard 35-cm diameter shovel tests.

HIGH	Site located on an alluvial terrace with few cultural remains visiable on the surface *(uncertain research potential)*	Site located on an alluvial terrace with abundant remains visible in stratified context *(high research potential)*
LOW	Site located on ancient land surface with palimpsest assemblage and no intact features *(low research potential)*	Site with possibly intact features located on an ancient land surface *(uncertain research potential)*
	LOW	**HIGH**
	ARCHEOLOGICAL SCORE--->	

Figure 6.3 Examples of Sites with High and Low Geomorphic and Archeological Reconnaissance Scores.

Following shovel testing, the excavated materials are quick sorted to provide data on three variables: the relative *frequency* of artifacts on the site (abundant to sparse); the relative *ubiquity* of cultural material (artifacts from most, many, few, or no shovel tests); and the relative horizontal and vertical *distribution* of artifacts (single or multiple groupings and strata). These three variables are then rank-order scored for each subarea, both for feature contexts and for non-feature contexts.

Based on this supplementary analysis, overall research potential is reassessed as one of three possibilities: (1) none to limited; (2) uncertain or indeterminate; or (3) very high demonstrated research potential.

Shovel tested sites with none or limited research potential are assessed as not significant and are recommended for no further management. Shovel tested sites with very high demonstrated research potential are assessed as significant and are recommended for preservation and protection, or mitigation if protection is not possible. In fact, few sites can be unquestionably demonstrated to be significant on the basis of shovel testing alone. At Fort Hood, these have almost without exception proved to be undisturbed rockshelters with subsurface evidence of features or human burials. The shovel tested sites which still have uncertain or indeterminate research potential are recommended for formal testing.

Phase 3: Test Excavations

The third phase of significance evaluation at Fort Hood began in 1993 and involves formal testing of those sites with uncertain or indeterminate research potential. This step is very succinctly represented in Figure 6.1 as the "additional observations" box (leading back to evaluation of essential data sets), and in Figure 6.2 as the "test for significance" box (not further diagramed).

Field tactics call for mechanically excavated trenches on sites with potential deposits deeper than the maximum depth of shovel tests, and manually excavated 1 m^2 test units with carefully controlled vertical proveniencing. Laboratory tactics call for thorough documentation of assemblages as well as processing and analysis of economic and chronometric samples from feature contexts. In addition, depending on the results of current investigations into the utility chert patina as a chronometric indicator, tactics may also involve field and laboratory documentation of surface assemblages.

Depending on the management recommendations of this phase, data recovery excavations may be necessary on significant sites which can not be preserved and protected.

7 REFERENCES CITED

Advisory Council on Historic Preservation
1980 *Treatment of Archaeological Properties: A Handbook.* United States Government Printing Office, Washington, D. C.

Ahler, Stanley A.
1972 Mass Analysis of Flaking Debris. Paper presented at the 30th Annual Plains Anthropological Conference, Lincoln, Nebraska.

1986 *The Knife River Flint Quarries: Excavations at Site 31DU508.* State Historical Society of North Dakota, Bismarck.

Allred, B. W., and Homer C. Mitchell
1955 Major Plant Types of Arkansas, Louisiana, Oklahoma and Texas and Their Relation to Climate. *Texas Journal of Science* 7:7-19.

Altschul, Jeffrey H.
1990 Red Flag Models: The Use of Modeling in Management Contexts. In *Interpreting Space: GIS and Archaeology,* edited by K. M. Allen, S. W. Green, and E. B. W. Zubrow, pp. 226-238. Taylor & Francis, London.

Anderson, James N.
1973 Ecological Anthropology and Anthropological Ecology. In *Handbook of Social and Cultural Anthropology,* edited by J. J. Honigmann, pp. 179-239. Rand McNally, Chicago.

Aynesworth, K. H.
1936 Biographic Studies of 21 Skulls of the Central Texas Indians. *Bulletin of the Central Texas Archeological Society* 2:30-35.

Bamforth, Douglas B.
1986 Technological Efficiency and Tool Curation. *American Antiquity* 51:38-50.

Banks, Larry D.
1990 *From Mountain Peaks to Alligator Stomachs: A Review of Lithic Resources in the Trans-Mississippi South, the Southern Plains and Adjacent Southwest.* Oklahoma Anthropological Society, Memoir 4, Oklahoma City.

Barnes, Virgil E.
1970 *Geologic Atlas of Texas, Waco Sheet.* Bureau of Economic Geology, University of Texas at Austin.

Barrett, Richard A.
1987 *Culture and Conduct: An Excursion in Anthropology.* Wadsworth, Belmont, California.

Bateson, Gregory
1972 *Steps to an Ecology of Mind.* Ballantine, New York.

Beardsley, R. K., P. Holder, A. Krieger, B. Meggers, J. Rinaldo, and P. Kutsche
1956 Functional and Evolutionary Implications of Community patterning. In *Seminars in Archaeology: 1955,* edited by R. Wauchope, pp. 129-157. Memoirs of the Society for American Archaeology 11, Salt Lake City.

Bement, Leland C.
1989 Lower Pecos Canyonlands. In *From the Gulf to the Rio Grande: Human Adaptation in Central, South, and Lower Pecos Texas,* by T. R. Hester, S. L. Black, D. G. Steele, B. W. Olive, A. A. Fox, K. J. Reinhard, and L. C. Bement, pp. 63-76. Arkansas Archaeological Survey Research Series Number 33. Center for Archaeological Research, University of Texas at San Antonio, Texas A&M University, and Arkansas Archaeological Survey, Fayetteville, Arkansas.

Bennett, J. W.
1967 Comments on the Cultural Ecology of India's Sacred Cattle. *Current Anthropology* 3:251-252.

Binford, Lewis R.
1977 *Olorgesailie* Deserves More Than the Usual Book Review. *Journal of Anthropological Research* 33:493-502.

1978a *Nunamiut Ethnoarchaeology.* Academic Press, New York.

1978b Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. *American Antiquity* 43:330-361.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255-273.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4-20.

1981a *Bones: Ancient Men and Modern Myths.* Academic Press, New York.

1981b Long-Term Land-Use Patterning: Some Implications for Archaeology. Paper presented at the 46th Annual Meeting of the Society for American Archaeology, San Diego, California. Published 1983 in *Working at Archaeology,* edited by L. R. Binford, pp. 379-386. Academic Press, New York.

1981c Behavioral Archaeology and the Pompeii Premise. *Journal of Anthropological Research* 37(3):195-208.

1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1(1):5-31.

1983a *In Pursuit of the Past: Decoding the Archaeological Record.* Thames and Hudson, New York.

1983b *Working at Archaeology.* Academic Press, New York.

Binford, Lewis R., and Jeremy A. Sabloff
1982 Paradigms, Systematics, and Archaeology. *Journal of Anthropological Research* 38(2):137-153.

Birdsell, Joseph B.
1968 Some Predictions for the Pleistocene System Among Recent Hunters and Gatherers. In *Man the Hunter,* edited by R. Lee and I. DeVore, pp. 229-240. Aldine, Chicago.

Birkeland, Peter W.
1984 *Soils and Geomorphology.* Oxford University Press, New York.

Black, Stephen L.
1989 Central Texas Plateau Prairie. In *From the Gulf to the Rio Grande: Human Adaptation in Central, South, and Lower Pecos Texas,* by T. R. Hester, S. L. Black, D. G. Steele, B. W. Olive, A. A. Fox, K. J. Reinhard, and L. C. Bement, pp. 17-38. Arkansas Archaeological Survey Research Series Number 33. Center for Archaeological Research, University of Texas at San Antonio, Texas A&M University, and Arkansas Archaeological Survey, Fayetteville, Arkansas.

Black, S. L., J. Guy-Motriuk, L. W. Ellis, D. G. Creel, L. Douglass, K. Miller, and C. Ward
1992 *The Five Burned Rock Midden Sites Project: Progress Report and Research Plan.* Texas Archeological Research Laboratory, University of Texas at Austin.

Black, Stephen L., and A. Joachim McGraw
1985 *The Panther Springs Creek Site: Cultural Change and Continuity Within the Upper Salado Creek Watershed, South-central Texas.* Archaeological Survey Report Number 100. Center for Archaeological Research, University of Texas at San Antonio.

Blair, W. Frank
1950 The Biotic Provinces of Texas. *Texas Journal of Science* 2(1):93-117.

Blum, Michael D., James T. Abbot, and Salvatore Valastro, Jr.
1992 Evolution of Landscapes on the Double Mountain Fork of the Brazos River, West Texas: Implications for Preservation and Visibility of the Archaeological Record. *Geoarchaeology* 7:339-370.

Blurton Jones, Nicholas, and Melvin J. Konner
1976 !Kung Knowledge of Animal Behavior (or: The Proper Study of Mankind Is Animals). In *Kalahari Hunter-Gatherers: Studies of the !Kung San and Their Neighbors,* edited by R. B. Lee and I. DeVore, pp. 325-348. Harvard University Press, Cambridge, Massachusetts.

Bousman, C. Britt
1974 *Archeological Assessment of Alibates National Monument.* Archeology Research Program, Southern Methodist University, Dallas.

1990 Paleoenvironments and Human Diets. In *Prehistoric Archeology and Paleoenvironments in Hidalgo and Willacy Counties, South Texas: Results of the Phase II Excavations,* by C. B. Bousman, S. A. Tomka, and G. L. Bailey, pp. 91-103. Reports of Investigations Number 76. Prewitt and Associates, Austin.

Bousman, C. B., S. A. Tomka, and G. L. Bailey
1990 *Prehistoric Archeology and Paleoenvironments in Hidalgo and Willacy Counties, South Texas: Results of the Phase II Excavations.* Reports of Investigations Number 76. Prewitt and Associates, Austin.

Bradley, R. S.
1985 *Quaternary Paleoclimatology: Methods of Paleoclimatic Reconstruction.* Allen and Unwin, Boston.

Brady, Nyle C.
1990 *The Nature and Properties of Soils.* 10th ed. Macmillan, New York.

Briuer, Frederick L., and George B. Thomas
1986 *Standard Operating Procedure for Field Surveys.* Research Report Number 13. United States Army, Fort Hood Archaeological Resource Management Series.

Bronitsky, Gordon
1986 The Use of Materials-Science Techniques in the Study of Pottery Construction and Use. In *Advances in Archaeological Method and Theory,* volume 9, edited by M. B. Schiffer, pp. 209-276. Academic Press, Orlando, Florida.

Brune, Gunnar
1981 *Springs of Texas, Volume I.* Branch-Smith, Fort Worth.

Bryant, Vaughn M.
1974 The Role of Coprolite Analysis in Archeology. *Bulletin of the Texas Archeological Society* 45:1-28.

Bryant, Vaughn M., and Richard G. Holloway
1985 A Late-Quaternary Paleoenvironmental Record of Texas: An Overview of the Pollen Evidence. In *Pollen Records of the Late Quaternary North American Sediments,* edited by V.M. Bryant and R.G. Holloway, pp. 39-70. American Association of Stratigraphic Palynologists Foundation, Dallas.

Bryant, Vaughn M., and Harry J. Shafer
1977 Late Quaternary Paleoenvironment of Texas: A Model for Archaeologists. *Bulletin of the Texas Archeological Society* 48:1-26.

Butzer, Karl W.
1971 Environment and Arcaheology: An Ecological Approach to Prehistory. Aldine-Atherton Press, Inc. Chicago.

1982 *Archaeology as Human Ecology: Method and Theory for a Contextual Approach.* Cambridge University Press, Cambridge.

Califano, L., P. Dohrn, G. Montalenti, and H. S. Purvi (editors)
1964 *Ostracods as Ecological and Paleoecological Indicators.* Publication of the Naples Zoological Station Volume 33, Supplement. Stazione Zoologica di Napoli, Naples, Italy.

Campbell, D. T.
1965 Variation and Selective Retention in Sociocultural Evolution. In *Social Change in Underdeveloped Areas: A Reinterpretation of Evolutionary Theory,* edited by R. W. Mack, G. I. Blankstein, and H. R. Barringer, pp. 19-48. Schenkman, Cambridge.

Carlson, David L. (editor)
1992 *Archaeological Investigations in Bull Branch: Results of the 1990 Summer Archaeological Field School.* Archaeological Management Series Research Report Number 19. United States Army, Fort Hood, Texas. Draft submitted for review.

Carlson, David L.
1992 Conclusions and Recommendations. In *Archaeological Investigations in Bull Branch: Results of the 1990 Summer Archaeological Field School,* edited by D. L. Carlson, pp.161-163. Archaeological Management Series Research Report Number 19. United States Army, Fort Hood, Texas. Draft submitted for review.

Carlson, David L., and Frederick L. Briuer
1986 *Analysis of Military Training Impacts on Protected Archaeological Sites at West Fort Hood, Texas.* Archaeological Management Series Research Report Number 9. United States Army, Fort Hood, Texas.

Carlson, S. B., H. B. Ensor, D. L. Carlson, E. A. Miller, and D. E. Young
1987 *Archaeological Survey at Fort Hood, Texas, Fiscal Year 1984.* Archaeological Management Series Research Report Number 14. United States Army, Fort Hood, Texas.

Carlson, S. B., D. L. Carlson, H. B. Ensor, E. A. Miller, and D. E. Young
1988 *Archaeological Survey at Fort Hood, Texas, Fiscal Year 1985, the Northwestern Training Area.* Archaeological Management Series Research Report Number 15. United States Army, Fort Hood, Texas.

Cerling, T. E., J. Quade, Y. Wang, and J. R. Bowman
1989 Carbon Isotopes in Soils and Paleosols as Ecology and Paleoecology Indicators. *Nature* 341:138-139.

Clark, J. G. D.
1975 *The Earlier Stone Age Settlement of Scandinavia.* Cambridge University Press, Cambridge.

Cleland, Charles E.
1976 The Focal-Diffuse Model: An Evolutionary Perspective on the Prehistoric Cultural Adaptations of the Eastern United States. *Midcontinent Journal of Archaeology* 1(1):59-76.

Cohen, Gerald A.
1978 *Karl Marx's Theory of History: A Defence.* Princeton University Press, Princeton, New Jersey.

Collins, Michael B.
1973 The Devil's Hollow Site, A Stratified Archaic Campsite in Central Texas. *Bulletin of the Texas Archeological Society* 43:77-100.

1991 Thoughts on Future Investigations of Burned Rock Middens. In *The Burned Rock Middens of Texas: An Archeological Symposium,* edited by T. R. Hester, pp. 1-24. Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

Collins, Michael B., Bruce Ellis, and Cathy Dodt-Ellis
1990 *Excavations at the Camp Pearl Wheat Site (41KR243): An Early Archaic Campsite on Town Creek, Kerr County, Texas.* Studies in Archeology Number 6. Texas Archeological Research Laboratory, University of Texas at Austin.

Cordell, Linda S.
1984 *Prehistory of the Southwest.* Academic Press, New York.

Cotterell, Brian, and Johan Kamminga
1987 The Formation of Flakes. *American Antiquity* 52:675-708.

Courty, M. A., P. Goldberg, and R. MacPhail
1989 *Soils and Micromorphology in Archaeology.* Cambridge University Press, Cambridge.

Crabtree, Don E.
1972 *An Introduction to Flintworking.* Occasional Papers of the Idaho State Museum Number 28. Pocatello

Creel, Darrell G.
1986 *Assessing the Importance of Acorns in Archaic Subsistence: The Distribution of Burned Rock Middens in West Central Texas.* Unpublished Ph.D. dissertation, Department of Anthropology, University of Arizona.

1991 Assessing the Relationship Between Burned Rock Midden Distribution and Archaic Subsistence in West-Central Texas. In *The Burned Rock Middens of Texas: An Archeological Symposium,* edited by T. R. Hester, pp. 33-43. Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

Crumley, Carole L., and William H. Marquardt
1990 Landscape: A Unifying Concept in Regional Analysis. In *Interpreting Space: GIS and Archaeology,* edited by K. M. S. Allen, S. W. Green, and E. B. W. Zubrow, pp. 73-79. Taylor and Francis, London.

Dean, Jeffrey S.
1978 Independent Dating in Archaeological Analysis. In *Advances in Archaeological Method and Theory,* volume 1, edited by M. B. Schiffer, pp. 223-255. Academic Press, New York.

Delorme, L. Denis
1989 Methods in Quaternary Ecology #7. Freshwater Ostracodes. *Geoscience Canada* 16(2):85-90.

DeNiro, Michael J.
1985 Postmortem Preservation and Alteration of *In Vivo* Bone Collagen Isotope Ratios in Relation to Paleodietary Reconstruction. *Nature* 317:806-809.

Dennell, R.
1983 *European Economic Prehistory: A New Approach.* Academic Press, New York.

Department of the Army
1984 Historic Preservation. Army Regulation 420-40.

Dibble, David S., and Frederick L. Briuer
1989 *Archaeological Survey at Fort Hood, Texas.* Fort Hood Archaeological Resource Management Series, Reserach Report Number 3. United States Army, Fort Hood, Texas.

Dickens, William A.
1992 In *Archaeological Investigations in Bull Branch: Results of the 1990 Summer Archaeological Field School,* edited by D. L. Carlson, pp.107-159. Archaeological Management Series Research Report Number 19. United States Army, Fort Hood, Texas. Draft submitted for review.

Dillehay, Tom D.
1974 Late Quaternary Bison Population Changes on the Southern Plains. *Plains Anthropologist* 19:180-196.

Dunnell, Robert C.
1971 *Systematics in Prehistory.* Free Press, New York.

Elias, Scott A., and Laurence J. Toolin
1990 Accelerator Dating of a Mixed Assemblage of Late Pleistocene Insect Fossils from the Lamb Spring Site, Colorado. *Quaternary Research* 33:122-126.

Elias, Scott A., and Thomas R. Van Devender
1990 Fossil Insect Evidence for Late Quaternary Climatic Change in the Big Bend Region, Chihuahuan Desert, Texas. *Quaternary Research* 34:249-261.

Ellis, Linda W.
1992 *Technological Style in Upper Texas Coastal Ceramics: A Case Study from 41HR616, Harris County, Texas.* Unpublished Masters thesis, Department of Anthropology, University of Texas at San Antonio.

Ensor, H. Blaine
1991 *Archaeological Survey at Fort Hood, Texas, Fiscal Year 1987, the MCA Range Construction, Pidcoke Land Exchange, and Phantom Range Projects.* Archaeological Management Series Research Report Number 23. United States Army, Fort Hood, Texas.

Ensor, H. Blaine, and Erwin Roemer, Jr.
1989 Comments on Sullivan and Rozen's Debitage Analysis and Archaeological Interpretation. *American Antiquity* 54:175-178

Ericson, Jonathon E.
1977 Egalitarian Exchange Systems in California: A Preliminary View. In *Exchange Systems in Prehistory,* edited by T. K. Earle and J. E. Ericson, pp. 109-126. Academic Press, New York.

Espey Huston and Associates
1979 Ecological Baseline Report, Fort Hood Texas. Environmental Impact Statement, Overall Mission, Fort Hood Texas. Submitted to Department of Army Headquarter Forces Command by Espey Huston and Associates, Austin.

Fenneman, Nevin M.
1931 *Physiography of the Western United States.* McGraw Hill, New York.

1938 *Physiography of the Eastern United States.* McGraw Hill, New York.

Ferring, Reid C.
1986 Rates of Fluvial Sedimentation: Implications for Archaeological Variability. *Geoarchaeology* 1:259-274.

Feyerabend, Paul
1975 *Against Method.* Verso, London.

Flannery, Kent V.
1973 The Origins of Agriculture. *Annual Review of Anthropology* 2:271-310.

Flannery, Kent V. (editor)
1986 *Guilá Naquitz: Archaic Foraging and Early Agriculture in Oaxaca, Mexico.* Academic Press, New York.

Ford, Richard I.
1988 Commentary: Little Things Mean a Lot--Quantification and Qualification in Paleoethnobotany. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains,* edited by C. A. Hastorf and V. S. Popper, pp. 215-222. University of Chicago Press, Chicago.

Franke, Richard, and Barbara Chasin
1980 *Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel.* Allanheld, Osmun and Co., Montclair, New Jersey.

Futato, Eugene M.
1977 Toward a Formal Account of Projectile Point Morphology. In *The Belfonte Site, 1J300,* by E. M. Futato, pp. 36-62. Research Series 2. Office of Archaeological Research, University of Alabama.

1983 Appendix A. A Beginning Artifact Geometry. In *Archaeological Investigation in the Cedar Creek and Upper Bear Creek Reservoirs,* by E. M. Futato, pp. 467-486. Reports of Investigation Number 29. Office of Archaeological Research, University of Alabama.

Goode, Glen T.
1991 Late Prehistoric Burned Rock Middens in Central Texas. In *The Burned Rock Middens of Texas: An Archeological Symposium,* edited by T. R. Hester, pp. 71-93. Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

Goodfriend, Glenn A.
1992 The Use of Land Snail Shells in Paleoenvironmental Reconstruction. *Quaternary Science Reviews* 11:665-685.

Gore, Albert
1992 *Earth in the Balance: Ecology and the Human Spirit.* Houghton Mifflin, New York.

Gould, F. W.
1975 *Texas Plants--A Checklist and Ecological Summary.* Report MP-585/Revised. Texas Agricultural Experimental Station, Texas A & M University, College Station.

Gould, Richard A., and Sherry Saggers
1985 Lithic Procurement in Central Australia: A Closer Look at Binford's Idea of Embeddedness in Archaeology. *American Antiquity* 50:117-136.

Gould, Stephen J.
1989 *Wonderful Life: The Burgess Shale and the Nature of History.* W. W. Norton and Company, New York.

Gould, S. J., and R. C. Lewontin
1979 The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme. *Proceedings of the Royal Society* 205:581-598.

Greer, John W.
1965 A Typology of Midden Circles and Mescal Pits. *Southwestern Lore* 31(3):41-45.

Greiser, Sally T., and Payson D. Sheets
1979 Raw Materials as a Functional Variable in Use-Wear Studies. In *Lithic Use-Wear Analysis,* edited by B. Hayden, pp. 289-296. Academic Press, New York.

Guccione, M. J., R. H. Lafferty III, and L. S. Cummings
1988 Environmental Constraints of Human Settlement in an Evolving Holocene Alluvial System, the Lower Mississippi Valley. *Geoarchaeology* 3:65-84.

Guderjan, Thomas H., George B. Thomas, and Howard R. Cramer
1980 *Final Report: Existing Data Inventory of Cultural Resource and Paleontological Information, Fort Hood, Texas.* Soil Systems, Marietta, Georgia.

Gunn, Joel
n.d. Mobility Patterns in Central Texas. Manuscript in author's files.

Gunn, Joel, and Royce Mahula
1977 *Hop Hill: Culture and Climatic Change in Central Texas.* Special Report Number 5. Center for Archaeological Research, University of Texas at San Antonio.

Guy, Janice A.
1990 Previous Archeological Investigations. In *The Archeology and Bioarcheology of the Gulf Coastal Plain: Volume 1,* by D. A. Story, J. A. Guy, B. A. Burnett, M. D. Freeman, J. C. Rose, D. G. Steele, B. W. Olive, and K. J. Reinhard, pp. 26-130. Arkansas Archaeological Survey Research Series Number 38. Arkansas Archaeological Survey, Fayetteville, Arkansas.

Haas, H., V. T. Holliday, and R. Stuckenrath
1986 Dating of Holocene Stratigraphy with Soluble and Insoluble Organic Fractions at the Lubbock Lake Archaeological Site: An Ideal Case Study. *Radiocarbon* 28:473-485.

Hagstrum, Melissa B., and John A. Hildebrand
1990 The Two-Curvature Method for Reconstructing Ceramic Morphology. *American Antiquity* 55:388-403.

Hall, Grant D.
1981 *Allens Creek: A Study in the Cultural Prehistory of the Lower Brazos Valley.* Research Report Number 51. Texas Archeological Survey, University of Texas at Austin.

Hall, Stephen A.
1988 Environment and Archaeology of the Central Osage Plains. *Plains Anthropologist* 33(120):203-218.

Hally, David J.
1983 Use Alteration of Pottery Vessel Surfaces: An Important Source of Evidence for the Identification of Vessel Function. *North American Archaeologist* 4(1):3-26.

Harris, Marvin
1966 The Cultural Ecology of India's Sacred Cattle. *Current Anthropology* 7:51-59.

1968 *The Rise of Anthropological Theory.* T. Y. Crowell, New York.

1979 *Cultural Materialism: The Struggle for a Science of Culture.* Vintage, New York.

Hassan, Fekri A.
1981 *Demographic Archaeology.* Academic Press, New York

Hastorf, Christine A., and Virginia S. Popper
1988 *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains.* University of Chicago Press, Chicago.

Hayden, Brian (editor)
1979 *Lithic Use-Wear Analysis.* Academic Press, New York.

Hays, T. R. (compiler and editor)
1982 *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas.* 3 volumes. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

Hays, T. R., and Olin McCormick

1982 Archaeological Background. In *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas,* volume 1, compiled and edited by T. R. Hays, pp. 4-1-4-6. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

Helm, June

1962 The Ecological Approach in Anthropology. *American Journal of Sociology* 67:630-639.

Henry, D. O., F. E. Kirby, A. B. Justen, and T. R. Hays

1980 *The Prehistory of Hog Creek: An Archaeological Investigation of Bosque and Coryell Counties, Texas.* 3 volumes. Laboratory of Archaeology, Department of Anthropology, University of Tulsa.

Hester, Thomas R. (editor)

1991 *The Burned Rock Middens of Texas: An Archeological Symposium.* Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

Hester, Thomas R.

1970 Burned Rock Middens on the Southwestern Edge of the Edwards Plateau, Texas. *Plains Anthropologist* 15(1):237-249.

1971 Archeological Investigations at the La Jita Site, Uvalde County, Texas. *Bulletin of the Texas Archeological Society* 42:51-148.

1973 The Formation of a Burned Rock Midden: A California Example. *The Record* 30(1):4. Dallas Archeological Society, Dallas.

Higgs, E. S., and C. Vita-Finzi

1972 Prehistoric Economies: A Territorial Approach. In *Papers in Economic Prehistory,* edited by E. S. Higgs, pp. 27-36. Cambridge University Press, Cambridge.

Hill, R. T.

1900 *Physical Geography of the Texas Region, Topographic Atlas of the United States.* Folio 3, U.S. Geological Survey.

Hodder, Ian

1986 *Reading the Past: Current Approaches to Interpretation in Archaeology.* Cambridge University Press, Cambridge.

1991 Interpretive Archaeology and Its Role. *American Antiquity* 56:7-18.

Hofman, Jack L.

1989 Prehistoric Culture History--Hunters and Gatherers in the Southern Great Plains. In *From Clovis to Comanchero: Archaeological Overview of the Southern Great Plains,* by J. L. Hofman, R. L. Brooks, J. S. Hays, D. W. Owsley, R. L. Jantz, M. K. Marks, and M. H. Manhein, pp. 25-60. Arkansas Archaeological Survey Research Series Number 35. Oklahoma Archeological Survey of the University of Oklahoma, Louisiana State University, and Arkansas Archaeological Survey, Fayetteville, Arkansas.

Hoganson, John W., and Allan C. Ashworth
1992 Fossil Beetle Evidence for Climatic Change 18,000-10,000 Years B. P. in South-Central Chile. *Quaternary Research* 37:101-116.

Hole, Frank, and Robert F. Heizer
1973 *An Introduction to Prehistoric Archaeology.* 3rd ed. Holt, Reinhart and Winston, New York.

Holliday, Vance T.
1985 Holocene Soil-Geomorphological Relations in a Semi-Arid Environment: The Southern High Plains of Texas. In *Soils and Quaternary Landscape Evolution*, edited by J. Boardman, pp. 325-357. John Wiley and Sons, New York.

Holliday, V. T., E. Johnson, H. Hass, and R. Stuckenrath
1983 Radiocarbon Ages from the Lubbock Lake site, 1950-1980: Framework for Cultural and Ecological Change on the Southern High Plains. *Plains Anthropologist* 28:165-182.

Howard, Margaret A.
1991 Burned Rock Midden Excavations, Hearths and Botanical Remains. In *The Burned Rock Middens of Texas: An Archeological Symposium,* edited by T. R. Hester, pp. 45-69. Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

Huckabee, John W., David Thompson, Jim Wyrick, and E. G. Pavlat
1977 *Soil Survey of Bell County, Texas.* Soil Conservation Service, United States Department of Agriculture. Government Printing Office, Washington, D.C.

Huebner, Jeffrey A.
1991 Cactus for Dinner Again! An Isotopic Analysis of Late Archaic Diet in the Lower Pecos Region of Texas. In *Papers on Lower Pecos Prehistory,* edited by S. A. Turpin, pp. 175-190. Studies in Archeology Number 8. Texas Archeological Research Laboratory, University of Texas at Austin.

Huskey, Vane
1935 An Archeological Survey of the Nueces Canyon of Texas. *Bulletin of the Texas Archeological and Paleontological Society* 7:104-114.

Jackson, Jack M.
1993 Cultural Resource Management. Army Environmental Manager's Handbook Series. Manuscript in author's files, Directorate of Engineering and Housing, Fort Hood, Texas.

Jackson, Jack and Frederick Briuer (editors)
1989 *Historical Research and Remote Sensing: Applications for Archaeological Resource Management at Fort Hood, Texas Fiscal Year 1981.* United States Army, Fort Hood, Texas, Archaeological Resource Management Series, Research Report 5, 6 and 7.

Jelks, Edward B.
1951 *Relationships Between Foci of the Edwards Plateau Aspect: A Distributional Analysis of Diagnostic Projectile Point Types from Archaeological Sites in the Marshall Ford Dam Reservoir, Travis County, Texas.* Unpublished Masters thesis, Department of Anthropology, University of Texas at Austin.

1962 *The Kyle Site: A Stratified Central Texas Aspect Site in Hill County, Texas.* Archaeology Series Number 5. Department of Anthropology, University of Texas at Austin.

1978 The Diablo Range. In *Chronologies in New World Archeology,* edited by R. E. Taylor and C. W. Meighan, pp. 71-111. Academic Press, New York.

Jochim, Michael A.
1976 *Hunter-Gatherer Subsistence and Settlement: A Predictive Model.* Academic Press, New York.

Johnson, LeRoy, Jr.
1962 *Survey and Apparaisal of the Archeological Resources of Stillhouse Hollow Reservoir on the Lampasas River, Bell County, Texas.* Texas Archeological Salvage Project, University of Texas at Austin.

1967 *Towards a Statistical Overview of the Archaic Cultures of Central and Southwestern Texas.* Texas Memorial Museum Bulletin 12, Austin.

1987 A Plague of Phases: Recent Sociocultural Taxonomy in Texas Archaeology. *Bulletin of the Texas Archeological Society* 57:1-26.

1989 Classification of Stone Projectile Points by a Small Texan Folk Community: A Case Study. *Texas Journal of Science* 41(2):193-203.

1990 *The Life and Times of Toyah-Culture Folk as Seen from the Buckhollow Encampment, Site 41KM16, Kimball County, Texas.* 4 volumes. Draft submitted to Texas State Department of Highways and Public Transportation, Highway Design Division, Texas Antiquities Permit Number 35, Austin.

1991 *Early Archaic Life at the Sleeper Archaeological Site, 41BC65, of the Texas Hill Country, Blanco County Texas.* Publications in Archaeology Report Number 9. Texas State Department of Highways and Public Transportation, Highway Design Division, Austin.

Johnson, L., Jr., D. A. Suhm, and C. D. Tunnell
1962 *Salvage Archeology of Canyon Reservoir: The Wunderlich, Footbridge, and Oblate Sites.* Bulletin Number 5. The Memorial Museum, University of Texas at Austin.

Kant, Immanuel
1787 [1965] *Critique of Pure Reason.* Translated and edited by N. Kemp Smith. Saint Martin's, New York.

Kelley, J. Charles
1940 Report on Excavations in Travis County, Site 52C1-5(412) Work Project 15311. Unpublished manuscript on file. Texas Archeological Research Laboratory, University of Texas at Austin.

1947a The Lehmann Rock Shelter: A Stratified Site of the Toyah, Uvalde, and Round Rock Foci. *Bulletin of the Texas Archaeological and Paleontological Society* 18:115-128.

1947b The Cultural Affiliations and Chronological Position of the Clear Fork Focus. *American Antiquity* 13(2):97-109.

Kelley, J. Charles, and Thomas N. Campbell
1942 What Are the Burned Rock Mounds of Texas? *American Antiquity* 7:319-322.

Kelly, E. F., R. G. Amundson, B. D. Marino, and M. J. DeNiro
1991 Stable Isotope Ratios of Carbon in Phytoliths as a Quantitative Method of Monitoring Vegetation and Climate Change. *Quaternary Research* 35:222-233.

Kennedy, Stephen K, and Wei-Hsiung Lin
1988 A Fractal Techniques for the Classification of Projectile Point Shapes. *Geoarchaeology* 3:297-301.

Kornicker, Louis S.
1964 A Seasonal Study of Living Ostracoda in a Texas Bay (Redfish Bay) Adjoining the Gulf of Mexico. In *Ostracods as Ecological and Paleoecological Indicators,* edited by L. Califano, P. Dohrn, G. Montalenti, and H. S. Purvi, Pp. 45-60. Publication of the Naples Zoological Station Volume 33, Supplement. Stazione Zoologica di Napoli, Naples, Italy.

Kosso, Peter
1991 Method in Archaeology: Middle-Range Theory as Hermeneutics. *American Antiquity* 56:621-627.

Krieger, Alex D.
1946 *Culture Complexes and Chronology in Northern Texas*. The University of Texas Publication, Number 4640. Austin.

1953 New World Culture History: Anglo-America. In *Anthropology Today,* edited by A. L. Kroeber, pp. 238-264. University of Chicago, Chicago.

Krueger, H. W., and C. H. Sullivan
1984 Models for Carbon Isotope Fractionation Between Diet and Bone. In *Stable Isotopes and Nutrition,* edited by J. R. Turnland and P. E. Johnson, pp. 205-220. ACS Symposium Series Number 258. American Chemical Society.

Kuchler, A. W.
1964 *Potential Natural Vegetation of the Coterminous United States.* Special Publication 36. American Geographical Society, New York.

Kuhn, Thomas S.
1970 *The Structure of Scientific Revolutions.* 2nd ed., enlarged. University of Chicago Press, Chicago.

Lakatos, Imre

1978a History of Science and Its Rational Reconstructions. In *The Methodology of Scientific Research Programs.* Philosophical Papers, volume 1, edited by J. Worall and G. Currie, pp. 102-138. Cambridge University Press, London.

1978b Falsification and the Methodology of Scientific Research Programs. In *The Methodology of Scientific Research Programs.* Philosophical Papers, volume 1, edited by J. Worall and G. Currie, pp. 8-101. Cambridge University Press, London.

1978c Changes in the Problem of Inductive Logic. In *Mathematics, Science and Epistemology.* Philosophical Papers, volume 2, edited by J. Worall and G. Currie, pp. 128-200. Cambridge University Press, London.

Lamb, H. H.

1977 *Climatic History and the Future.* Princeton University Press, Princeton, New Jersey.

Larson, Richard E., and Foster E. Kirby

1976 *Test Excavations at the L. E. Robertson Shelter and the Stone Rockshelter.* Research Report Number 87. Archaeological Research Program, Southern Methodist University, Dallas.

Latham, T. S., P. A. Sutton, and K. L. Verosub

1992 Non-Destructive XRF Characterization of Basaltic Artifacts from Truckee, California. *Geoarchaeology* 7:81-101.

Lawrence, T. G., Jr., and Albert J. Redder

1985 Frank. H. Watt, the Central Texas Archeologist. *Central Texas Archeologist* 10(Spring):7-10.

Lechtman, Heather

1977 Style in Technology--Some Early Thoughts. In *Material Culture: Styles, Organization, and Dynamics of Technology,* edited by H. Lechtman and R. S. Merrill, pp. 3-20. West Publishing, New York.

Lee, Richard, and Irven DeVore

1968 *Man the Hunter.* Aldine, Chicago.

Lintz, Christopher

1989 Experimental Thermal Discoloration and Heat Conductivity Studies of Caliche from Eastern New Mexico. *Geoarchaeology* 4:319-346.

Löffler, Heinz

1986 Ostracod Analysis. In *Handbook of Holocene Palaeoecology and Palaeohydrology,* edited by B. E. Berglund, pp. 693-702. John Wiley and Sons, New York.

Lukowski, P.

1987 *Archaeological Investigations at 41BX1, Bexar County, Texas.* Archaeological Survey Report 135. Center for Archaeological Research, University of Texas at San Antonio.

Malmer, Nils, and Gösta Regnéll
1986 Mapping Present and Past Vegetation. In *Handbook of Holocene Palaeoecology and Palaeohydrology,* edited by B. E. Berglund, pp. 203-218. John Wiley and Sons, New York.

Maruyama, Magoroh
1963 The Second Cybernetics: Deviation Amplifying Mutual Causal Processes. *American Scientist* 51:164-179.

Marchbanks, Michael L.
1989 *Lipid Analysis in Archaeology: An Initial Study of Ceramics and Subsistence at the George C. Davis Site.* Unpublished Masters thesis, Department of Anthropology, University of Texas at Austin.

Marx, Karl, and Frederick Engels
1846 *The German Ideology.* In *Collected Works of Marx and Engels,* volume 5, pp. 19-92. International Publishers, New York.

Matthews, J. A.
1985 Radiocarbon Dating of Surface and Buried Soils: Principles, Problems, and Prospects. In *Geomorphology and Soils,* edited by K. S. Richards, R. R. Arnett, and S. Ellis, pp. 269-288. Allen and Unwin, London.

McCullough, Samuel D., Jr.
1986 *An Assessment of the Environment and Resources of Central Texas in Terms of Prehistioric Adaptations.* Unpublished Masters thesis, Department of Anthropology, University of Texas at Austin.

McGimsey, Charles R., III, and Hester A. Davis
1977 *The Management of Archaeological Resources: The Airlie House Report.* Special Publication of the Society for American Archaeology.

McKern, W. C.
1939 The Midwestern Taxonomic Method as an Aid to Archaeological Culture Study. *American Antiquity* 4:301-313.

Mill, John Stuart
1859 [1978] *On Liberty.* Edited by E. Rapaport. Hackett, Indianapolis.

1863 [1979] *Utilitarianism.* Edited by G. Sher. Hackett, Indianapolis.

Miller, E. O., and E. B. Jelks
1952 Archaeological Excavations at the Belton Reservoir, Coryell County, Texas. *Bulletin of the Texas Archeological and Paleontological Society* 23:168-217.

Minnis, Paul E.
1985 *Social Adaptation to Food Stress: A Prehistoric Southwestern Example.* University of Chicago.

Moncure, Henry
1989 Impacts Research. In *Archaeological Survey at Fort Hood, Texas Fiscal Year 1980 (Spring).* David Dibble and Frederick Briuer, editors. United States Army, Fort Hood, Texas, Archaeological Resource Management Series, Research Report 3 (not paginated).

Moore, James A.
1981 The Effects of Information Networks in Hunter-Gatherer Societies. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archeological Analyses,* edited by B. Winterhalder and E. A. Smith, pp. 194-217. University of Chicago Press, Chicago.

Mueller-Wille, C. S., and David L. Carlson
1990 *Archaeological Survey at Fort Hood, Texas Fiscal Year 1986 Other Training Areas.* United States Army, Fort Hood, Texas, Archaeological Resource Management Series, Research Report 21.

Nanda, Serena
1991 *Cultural Anthropology.* 4th ed. Wadsworth, Belmont, Califronia.

Nordt, Lee C.
1992 *Archaeological Geology of the Fort Hood Military Reservation, Fort Hood, Texas.* Archaeological Resource Management Series, Research Report Number 25. United States Army, Fort Hood, Texas.

Olive, Ben
1992 Botanical Analyses. In *Archaeological Investigations in Bull Branch: Results of the 1990 Summer Archaeological Field School,* edited by D. L. Carlson, pp. 81-89. Archaeological Management Series Research Report Number 19. United States Army, Fort Hood, Texas. Draft submitted for review.

Pearce, J. E.
1919 Indian Mounds and Other Relics of Indian Life in Texas. *American Anthropologist* 21(3):223-234.

1932 The Present Status of Texas Archaeology. *Bulletin of the Texas Archeological and Paleontological Society* 4:44-54.

Peter, Duane E.
1982 Alternative Perspectives on Burned Rock Middens. In *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas,* volume 2, compiled and edited by T. R. Hays, pp. 20-1-20-15. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

Peter, Duane E., and T. R. Hays
1982 Models of Prehistoric Adaptation in the San Gabriel River Valley. In *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas,* volume 2, compiled and edited by T. R. Hays, pp. 19-3-19-10. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

Peter, Duane E., T. R. Hays, and Marie-Anne Demuynck
1982 An Evaluation of the "Phase" Concept. In *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas,* volume 2, compiled and edited by T. R. Hays, pp. 21-1-21-18. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

Phillips, Phillip
1970 *Archaeological Survey in the Lower Yazoo Basin, Mississippi, 1949-1955.* Papers of the Peabody Museum of Archaeology and Ethnology Number 60. Cambridge, Massachusetts.

Prewitt, Elton R.
1974 *Archeological Investigations at the Loeve-Fox Site, Williamson County, Texas.* Texas Archeological Survey, Research Report Number 49. University of Texas, Austin.

1981 Culture Chronology in Central Texas. *Bulletin of the Texas Archeological Society* 52:65-89.

1982 *Archeological Investigations at the Loeve-Fox, Loeve and Tombstone Bluff Sites in the Granger Lake District of Central Texas.* Volume 4, *Archaeological Investigations at the San Gabriel Reservoir Districts, Central Texas,* compiled and edited by T. R. Hays. Archaeology Program, Institute of Applied Sciences, North Texas State University, Denton.

1985 From Circleville to Toyah: Comments on Central Texas Chronology. *Bulletin of the Texas Archaeological Society* 54: 201-238.

1991 Burned Rock Middens: A Summary of Previous Investigations and Interpretations. In *The Burned Rock Middens of Texas: An Archeological Symposium,* edited by T. R. Hester, pp. 25-32. Studies in Archeology Number 13. Texas Archeological Research Laboratory, University of Texas at Austin.

n.d. The Rogers Springs Site: 1974 Investigations. Unpublished manuscript on file. Texas Archeological Research Laboratory, University of Texas at Austin.

Prikryl, Daniel.J.
1987 *A Synthesis of the Prehistory of the Lower Elm Fork of the Trinity River.* Unpublished Masters thesis, Department of Anthropology, University of Texas at Austin.

Putnam, Hilary
1975 Brains and Behavior. In *Mind, Language and Reality,* Philosophical Papers, volume 2, by H. Putnam, pp. 325-341. Cambridge University Press, Cambridge.

1983 Why There Isn't a Ready-Made World. In *Realism and Reason,* Philosophical Papers, volume 3, by H. Putnam, pp. 205-228. Cambridge University Press, Cambridge.

Quine, W. V.
1953 Two Dogmas of Empiricism. In *From a Logical Point of View,* by W. V. Quine, pp. 20-46. Harvard University Press, Cambridge, Massachusetts.

Quine, W. V., and J. S. Ullian
1970 *The Web of Belief.* 2nd ed. Random House, New York.

Rafferty, Janet E.

1985 The Archaeological Record on Sedentariness: Recognition, Development and Implications. In *Advances in Archaeological Method and Theory,* volume 8, edited by Michael Schiffer, pp. 113-156. Academic Press, New York.

Ray, Cyrus N.

1929 A Differentiation of the Prehistoric Cultures of the Abilene Region. *Bulletin of the Texas Archeological and Paleontological Society* 1:7-22.

Ray, Cyrus, and E. B. Sayles

1941 An Agreement on Abilene Region Terminology. *Bulletin of the Texas Archeological and Paleontological Society* 13:175-176.

Redder, Albert J.

1985 Bibliography of Frank H. Watt. *Central Texas Archeologist* 10(Spring):12-20.

Reina, Ruben E., and Robert M. Hill, Jr.

1978 *The Traditional Pottery of Guatemala.* University of Texas Press, Austin.

Renfrew, Colin

1977 Alternative Models of Exchange and Spatial Distribution. In *Exchange Systems in Prehistory,* edited by T. K. Earle and J. E. Ericson, pp. 71-90. Academic Press, New York.

Rice, Prudence

1987 *Pottery Analysis: A Source Book.* University of Chicago Press, Chicago.

Ricklis, Robert A.

1992 The Spread of a Late Prehistoric Bison Hunting Complex: Evidence from the South-Central Coastal Prairie of Texas. *Plains Anthropologist* 37:261-273.

Rindos, David

1984 *The Origins of Agriculture: An Evolutionary Perspective.* Academic Press, New York.

Ritter, Dale F.

1986 *Process Geomorphology.* 2nd ed. Wm. C. Brown, Dubuque, Iowa.

Rosenberg, Alexander

1988 *Philosophy of Social Science.* Westview, Boulder, Colorado.

Rovner, Irwin

1988 Macro- and Micro-Ecological Reconstruction Using Plant Opal Phytolith Data from Archaeological Sediments. *Geoarchaeology* 3:155-163.

Rye, Owen

1981 *Pottery Technology: Principles and Reconstruction.* Taraxcum, Washington, D.C.

Sackett, James R.
1986 Style, Function, and Assemblage Variation: A Reply to Binford. *American Antiquity* 51:628-634.

Salmon, Merrilee H.
1982 *Philosophy and Archaeology.* Academic Press, New York.

Sanchez, Julia L., and Brian S. Shaffer
1992 Faunal Analysis. In *Archaeological Investigations in Bull Branch: Results of the 1990 Summer Archaeological Field School,* edited by D. L. Carlson, pp. 59-79. Archaeological Management Series Research Report Number 19. United States Army, Fort Hood, Texas. Draft submitted for review.

Savage, Stephen. H.
1990 Modelling the Late Archaic Social Landscape. In *Interpreting Space: GIS and Archaeology,* edited by K. M. S. Allen, S. W. Green, and E. B. W. Zubrow, pp. 73-79. Taylor and Francis, London.

Schiffer, Michael B.
1976 *Behavioral Archaeology.* Academic Press, New York.

1986 Radiocarbon Dates and the "Old Wood" Problem: The Case of the Hohokam Chronology. *Journal of Archaeological Science* 13:13-30.

1987 *Formation Processes of the Archaeological Record.* University of New Mexico Press, Albuquerque.

Schiffer, Michael B., and James Skibo
1987 Theory and Experiment in the Study of Technological Change. *Current Anthropology* 28:595-622.

Schultz, Jack M.
1992 The Use-Wear Generated by Processing Bison Hides. *Plains Anthropologist* 37:333-351.

Schultz, Theodore W.
1974 *Transforming Traditional Agriculture.* Yale University Press, New Haven, Connecticut.

Schuum, Stanley A.
1977 *The Fluvial System.* John Wiley and Sons, New York.

Schwarcz, Henry P., and Nicholas Eyles
1991 Laurentide Ice Sheet Extent Inferred from Stable Isotopic Composition (O, C) of Ostracodes at Toronto, Canada. *Quaternary Research* 35:305-320.

Sedlak, Michael A., and Sammy Brown
1992 *Maneuver Activity Damage Assessment Model Applications to Predicting the Effects of the Restationing of the 5th Infantry Division (Mech) to Fort Hood, Texas.* Texas A&M Research Foundation, College Station, Texas.

Shafer, Harry J.

1963 Test Excavations at the Youngsport Site, a Stratified Site in Bell County. *Bulletin of the Texas Archeological Society* 34:57-81.

1986 The Future of Texas Archeology. *Texas Archeology* 30(2):1-6.

Shafer, Harry J., and Thomas R. Hester

1983 Ancient Maya Workshops in Northern Belize, Central America. *American Antiquity* 48:519-543.

Shafer, H. J., D. A. Suhm, and J. D. Scurlock

1964 *An Investigation and Appraisal of the Archeological Resources of Belton Reservoir, Bell and Coryell Counties, Texas: 1962.* Miscellaneous Papers Number 1. Texas Archeological Salvage Project, University of Texas at Austin.

Siegenthaler, Ulrich, and Ulrich Eicher

1986 Stable Oxygen and Carbon Isotope Analyses. In *Handbook of Holocene Palaeoecology and Palaeohydrology,* edited by B. E. Berglund, pp. 407-422. John Wiley and Sons, New York.

Sillen, A., J. C. Sealy, and N. J. van der Merwe

1989 Chemistry and Paleodietary Research: No More Easy Answers. *American Antiquity* 54:504-512.

Skinner, B. F.

1953 *Science and Human Behavior.* Macmillan, New York.

Skinner, S. Alan

1971 Prehistoric Settlement of the DeCordova Bend Reservoir, Central Texas. *Bulletin of the Texas Archeological Society* 42:149-269.

1974 *Prehistoric Settlement of a "Natural Area."* Unpublished Ph.D. dissertation, Department of Anthropology Southern Methodist University.

Skinner, S. A., F. L. Briuer, G. Thomas, and I. Shaw

1981 *Initial Archaeological Survey at Fort Hood, Texas, FY78.* Archaeological Resource Management Series, Research Report Number 1. United States Army, Fort Hood, Texas.

Skinner, S. A., F. L. Briuer, W. A. Meiszner, and I. Show

1984 *Archaeological Survey at Fort Hood, Texas, Fiscal Year 1979.* Archaeological Resource Management Series, Research Report Number 2. United States Army, Fort Hood, Texas.

Smith, Ralph A.

1962 Apache "Ranching" Below the Gila. *Arizoniana* 3(4):1-17.

Smith, Robert L.

1977 *Elements of Ecology and Field Biology.* Harper and Row, New York.

Sollberger, J. B., and Thomas R. Hester
1972 The Strohacker Site: A Review of the Archaic Manifestations in Texas. *Plains Anthropologist* 17:327-344.

Sorrow, William
1969 *Archeological Investigations at the John Ischy Site: A Burnt Rock Midden in Williamson County.* Papers of the Texas Archeological Salvage Project Number 18. University of Texas at Austin.

Sorrow, William, Harry J. Shafer, and Richard Ross
1967 Excavations at Stillhouse Hollow Reservoir. *Papers of the Texas Archaeological Salvage Project* 11. University of Texas at Austin.

Speth, John D.
1983 *Bison Kills and Bone Counts: Decision Making by Ancient Hunters.* University of Chicago Press, Chicago.

Stephenson, Robert L.
1985 Frank H. Watt: A Tribute. *Central Texas Archeologist* 10(Spring):1-6.

Steward, Julian
1973 *Theory of Culture Change: The Methodology of Multilinear Evolution.* University of Illinois, Urbana.

Stine, Roy S., and T. Drew Decker
1990 Archaeology Data Integration and GIS. In *Interpreting Space: GIS and Archaeology,* edited by K. M. Allen, S. W. Green, and E. B. W. Zubrow, pp. 134-140. Taylor & Francis, London.

Story, Dee Ann
1990 Cultural History of the Native Americans. In *The Archeology and Bioarcheology of the Gulf Coastal Plain: Volume 1,* by D. A. Story, J. A. Guy, B. A. Burnett, M. D. Freeman, J. C. Rose, D. G. Steele, B. W. Olive, and K. J. Reinhard, pp. 161-366. Arkansas Archaeological Survey Research Series Number 38. Arkansas Archaeological Survey, Fayetteville, Arkansas.

Suhm, Dee Ann
1960 A Review of Central Texas Archeology. *Bulletin of the Texas Archeological Society* 29:63-107.

Suhm, Dee Ann, Alex D. Krieger, and Edward Jelks
1954 An Introductory Handbook of Texas Archaeology. *Bulletin of the Texas Archeological Society* 25:1-582.

Sullivan, Alan P., III, and Keneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50:755-779.

Syms, E. Leigh
1977 Cultural Ecology and Ecological Dynamics of the Ceramic Period in Southwestern Manitoba. Memoir 12, *Plains Anthropologist* 22(76), Part 2.

Taylor, Walter W.
1964 Tethered Nomadism and Water Territoriality: An Hypothesis. In *Acts of the 35th International Congress of Americanists,* pp.34-38. Mexico City.

Testart, Alain
1982 The Significance of Food Storage Among Hunters-Gatherers: Residence Patterns, Population Densities, and Social Inequalities. *Current Anthropology* 23:523-537.

Thomas, George B.
1978 A Survey and Assessment of the Archeological Resources of Fort Hood, Texas. *Bulletin of the Texas Archeological Society* 49:193-240.

Thoms, Alston V.
1989 *The Northern Roots of Hunter-Gatherer Intensification: Camas and the Pacific Northwest.* Unpublished Ph.D. dissertation, Department of Anthropology, Washington State University, Pullman.

Todd, Larry
1992 Rethinking Context: A Descriptive or an Analytical Concept? Paper presented at the 50th Plains Anthropological Conference, Lincoln.

Torrance, Robin
1983 Time Budgeting and Hunter-Gatherer Technology. In *Pleistocene Hunters and Gatherers in Europe,* edited by G. Bailey, pp. 11-22. Cambridge University Press, Cambridge.

Toynbee, Arnold
1976 *Mankind and Mother Earth.* Oxford University Press, New York.

Treece, Abby
1992 *A Study of Five Annular Burned Rock Middens from the O. H. Ivie Reservoir, West Central Texas.* Unpublished Masters thesis, Department of Anthropology, University of Texas at Austin.

Trigger, Bruce G.
1978 *Time and Traditions: Essays in Archaeological Interpretation.* Columbia University Press, New York.

Tringham, R., G. Cooper, G. Odell, B. Voytek, and A. Whitman
1974 Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.

Troike, Rudolph C.
1955 Anthropological Theory and Plains Archeology. *Bulletin of the Texas Archeological Society* 26:113-143.

Turner, Ellen S.
1989 Exploring the Possibilities of Acorn Utilization in the Burned Rock Middens of Texas. *Bulletin of the Texas Archeological Society* 59:177-191.

Turner, Ellen S., and Thomas R. Hester
1985 *A Field Guide to Stone Artifacts of Texas Indians.* Texas Monthly Press, Austin.

Turner, William B., and Walter E. Klippel
1989 Hunter-Gatherers in the Nashville Basin: Archaeological and Geological Evidence for Variability in Prehistoric Land Use. *Geoarchaeology* 4:43-67.

Turpin, Solveig A.
1991 Time Out of Mind: The Radiocarbon Chronology of the Lower Pecos River Region. In *Papers on Lower Pecos Prehistory,* edited by S. A. Turpin, pp. 1-49. Studies in Archeology Number 8. Texas Archeological Research Laboratory, University of Texas at Austin.

United States Department of the Interior, National Park Service
1977 Recovery of Scientific, Prehistoric, Historic, and Archaeological Data: Methods, Standards and Reporting Requirements. *Federal Register* 42(19, 28 January 1977): 5374-5383.

1983 Archaeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines. *Federal Register* 48(190, 29 September 1983):44716-44742.

van der Leeuw, Sander E.
1981 Ceramic Exchange and Manufacture: A "Flow Structure" Approach. In *Production and Distribution: A Ceramic Viewpoint,* edited by H. Howard and E. L. Morris, pp. 361-386. British Archaeological Reports International Series 120. Oxford.

Vayda, Andrew P, and Roy A. Rappaport
1968 Ecology, Cultural and Noncultural. In *Introduction to Cultural Anthropology,* edited by James Clifton, pp. 447-496. Houghton Mifflin, New York.

Warren, Robert E.
1990 Predictive Modeling in Archaeology: A Primer. In *Interpreting Space: GIS and Archaeology,* edited by K. M. Allen, S. W. Green, and E. B. W. Zubrow, pp 90-111. Taylor & Francis, London.

Watt, Frank H. (editor)
1936 *Bulletin of the Central Texas Archeological Society No. 2.* Central Texas Archeological Society, Waco.

Watt, Frank H.
1938 The Waco Sinker. *Bulletin of the Central Texas Archeological Society* 4:21-70

Weir, Frank
1976 *The Central Texas Archaic.* Unpublished Ph.D. dissertation, Department of Anthropology, Washington State University, Pullman.

Wiessner, Polly
1985 Style or Isochrestic Variation? A Reply to Sackett. *American Antiquity* 50:160-166.

Willey, Gordon R., and Phillip Phillips
1958 *Method and Theory in American Archaeology.* University of Chicago Press.

Willey, Gordon R., and Jeremy A. Sabloff
1980 *A History of American Archaeology.* 2nd ed. W. H. Freeman, San Francisco.

Williams-Thorpe, O., R. S. Thorpe, C. Elliot, and C. Xenophontos
1991 Archaeology, Geochemistry, and Trade of Igneous Rock Millstones in Cyprus During the Late Bronze Age to Roman Periods. *Geoarchaeology* 6:27-60.

Wilmsen, Edwin N., and Frank H. H. Roberts, Jr.
1984 *Lindenmeier, 1934-1974: Concluding Report on Investigations.* Smithsonian Contributions to Anthropology Number 24. Smithsonian Institution, Washington.

Wilson, E. W.
1930 Burned Rock Mounds of Southwest Texas. *Bulletin of the Texas Archeological and Paleontological Society* 2:59-63.

Winner, Langdon
1977 *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought.* MIT Press, Cambridge, Massachusetts.

Winterhalder, Bruce, and Eric A. Smith (editors)
1981 *Hunter-Gatherer Foraging Strategies: Ethnographic and Archeological Analyses.* University of Chicago Press.

Wood, Raymond, and Donald Lee Johnson
1978 A Survey of Disturbance Processes in Archaeological Site Formation. In *Advances in Archaeological Method and Theory,* volume 1, edited by Michael B. Schiffer, pp. 315-381, Academic Press, New York.

Yellen, John E.
1976 Settlement Patterns of the !Kung: An Archaeological Perspective. In *Kalahari Hunter-Gatherers: Studies of the !Kung San and Their Neighbors,* edited by R. B. Lee and I. DeVore, pp. 47-72. Harvard University Press, Cambridge, Massachusetts.

Young, Diane
1988 An Osteological Analysis of the Paleoindian Double Burial from Horm Shelter, Number 2. *Central Texas Archeologist* 11(Spring):13-115.

Zubrow, Ezra B. W.
1990 The Fantasies of GIS Software. In *Interpreting Space: GIS and Archaeology,* edited by K. M. Allen, S. W. Green, and E. B. W. Zubrow, pp 184-193. Taylor & Francis, London.

APPENDIX A

FIELD FORMS

FORT HOOD SITE EVALUATIONS

Form 3: Descriptive Archaeological Assessment

SITE NO.: __________ Subsection(s): _____________ Training Area: ______

Recorder: ___________________ Date: ____________

Datable materials (diagnostics, bone, shell, perishables)

Features (for each: type, size, number, preservation, location, disturbance)

Cultural material (for each type: description, location [horizontal, vertical], abundance)

Nature of occupation (number of components, mixing, height of overhang)

Resources available (chert, springs, shelter)

Disturbance (types, locations, intensity)

Preservation of perishable goods (tufa, bog, wet/dry, dry)

version 2.2 (9/92)

FORT HOOD SITE EVALUATIONS

Form 4: Quantitative Archaeological Assessment

SITE NO.: ________ Subsection(s): __________ Training Area: ______

Recorder: ______________ Date: __________

For each, circle ordinal rank; sum rankings at bottom

Potentially Datable Material

1 = few **3** = unknown **4** = abundant
1 = one type **3** = two/three types **4** = four or more types

Area Function

1 = debitage only **3** = unknown **4** = tools & debitage **6** = features, tools, debitage

Archaeological In-Situ Material

1 = absent **3** = unknown **6** = present

Total Area: **1** = < 20m² **2** = 20-50m² **3** = 50-200m² **4** = 200-1000m² **5** = > 1000m²
Percent of Total Area: **1** = <10% **2** = 10-80% **3** = unknown **5** = 80-100%
Depth of Deposits: **1** = <20 cm **2** = 20-40 cm **3** = unknown **5** = > 40 cm
Features: **3** = intact features on disturbed surfaces

Ecofacts

1 = none **2** = snails **3** = clams **4** = bone **5** = multiple types

Nature of Cultural Occupation(s) <u>either</u> Unknown, Primary, <u>or</u> Secondary

Unknown **4** = unknown whether primary or secondary

Primary context (undisturbed)
2 = unsealed single or multiple (palimpsest) activity surface(s)
4 = multiple activity surfaces, partially or completely sealed
6 = sealed single or multiple activity surface(s)

Secondary context (transported)
1 = unsealed **2** = sealed

Artifact Assemblage Uniques (non-local lithics, unique tools)

1 = none **3** = unknown **6** = unique

TOTAL ARCHAEOLOGICAL SCORE: [ ]

version 2.2 (9/92)

FORT HOOD SITE EVALUATIONS

Form 5: Descriptive Geomorphic Assessment

SITE NO.: __________ Subsection(s): _____________ Training Area: ______

Recorder: __________________ Date: ____________

OBSERVATIONS

Exposures (for each: height, location, deposit type, cultural manifestations, features, and depth)

Geomorphic Surfaces (relief, relative height)

Soil or Sediment Profiles (for each: horizon sequence, parent material, age estimate, integrity)

Disturbance (form, extent, location)

Surface or Subsurface Visibility (vegetation type, density, location of visible surfaces, % visible)

Soil Probes (for each: location, depth, profile description, cultural material)

INTERPRETATIONS

Depositional Processes and Events (number, type of process, age)

SITE __________, Subsection(s) _____________

Erosional Events (number, type, extent, age)

Cultural Occupations/Horizons (number, type, extent, features, age)

RECOMMENDATIONS (sketch map and illustrate all locations on site map)

Subsurface Inspection (trenches, number and locations)

Qualitative Evaluation of Site Context (relative area of potential deposits, thickness, number of occupations)

In-situ Archaeological Deposits (present? are they restricted to features?)

COMMENTS

FORT HOOD SITE EVALUATIONS

Form 6: Quantitative Geomorphic Assessment

SITE NO.: _________ Subsection(s): ____________ Training Area: ______

Recorder: _________________ Date: ___________

CONTEXT

Surface Type (circle one)

1	flat to gently sloping upland surface					
2, 2, 1	water spreading slope:	low /	moderate /	steep		
3, 2 ,2	water gathering slope:	low /	moderate /	steep		
4	colluvial toe slope					
5	terrace; 1°	2°	3°	4°	5° order stream	
3	floodplain;	1°	2°	3°	4°	5° order stream
3, 5	rock shelter;	minimal deposits		obvious deposits		

Age of Geomorphic Surface (circle one)

1	ancient (>15,000 yrs; Bt, Bk, K)
2	moderate (15,000-2,000 yrs; Bw, weak Bt, no B)
2	young (<2,000 yrs; A-C, no soil development)
1.5	unknown. give reason:_____________________

Position and Context of Cultural Remains (circle one)

1, 5, 4, 3 surface / buried / buried & surficial / unknown

CONTEXT SUBTOTAL: _______

INTEGRITY

In-situ Deposits of Late Pleistocene/Holocene Age (circle one)

5, 1, 3 present / absent / unknown
discrete / continuous / unknown
thickness: ________. depth: _________

In-situ Cultural Deposits (circle one)

5, 3, 1, 3 present / potentially present / absent / unknown

Pedoturbation (circle one)

1, 2, 3, 1.5 extent: HI (>50%) / MED (20-50%) / LO (<20%) / unknown
Form: argillic / faunal / floral / vehicular / vandalism

Erosion (circle one)

1, 2, 3, 1.5 Extent: HI (>50%) / MED (20-50%) / LO (<20%) / unknown
Form: gully / sheet / road / cutbank
Currently active or remnant
Evidence: (type, extent, location) ________________________

INTEGRITY SUBTOTAL: ________

TOTAL GEOMORPHIC SCORE: [ ]

version 2.2 (9/92)

USACERL DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CECG
ATTN: CERD-M
ATTN: CECC-P
ATTN: CERD-L
ATTN: CECW-P
ATTN: CECW-PR
ATTN: CEMP-E
ATTN: CEMP-C
ATTN: CECW-O
ATTN: CECW
ATTN: CERM
ATTN: CEMP
ATTN: CERD-C
ATTN: CEMP-M
ATTN: CEMP-R
ATTN: CERD-ZA
ATTN: DAEN-ZC
ATTN: DAIM-FDP

CECPW 22310-3862
ATTN: CECPW-F
ATTN: CECPW-TT
ATTN: CECPW-ZC
ATTN: DET III 79906

US Army Engr District
ATTN: Library (40)

US Army Engr Division
ATTN: Library (12)

INSCOM
ATTN: IALOG-I 22060
ATTN: IAV-DPW 22186

USA TACOM 48397-5000
ATTN: AMSTA-XE

Defense Distribution Region East
ATTN: DDRE-WI 17070

HQ XVIII Airborne Corps 28307
ATTN: AFZA-DPW-EE

4th Infantry Div (MECH) 80913-5000
ATTN: AFZC-FE

US Army Materiel Command (AMC)
Alexandria, VA 22333-0001
ATTN: AMCEN-F
Installations: (19)

FORSCOM
Forts Gillem & McPherson 30330
ATTN: FCEN
Installations: (23)

6th Infantry Division (Light)
ATTN: APVR-DE 99505
ATTN: APVR-WF-DE 99703

TRADOC
Fort Monroe 23651
ATTN: ATBO-G
Installations: (20)

Fort Belvoir 22060
ATTN: CETEC-IM-T
ATTN: CECC-R 20314-1000
ATTN: Engr Strategic Studies Ctr
ATTN: Water Resources Support Ctr
ATTN: Australian Liaison Office

USA Natick RD&E Center 01760
ATTN: STRNC-DT
ATTN: DRDNA-F

US Army Materials Tech Lab
ATTN: SLCMT-DPW 02172

USARPAC 96858
ATTN: DPW
ATTN: APEN-A

SHAPE 09705
ATTN: Infrastructure Branch LANDA

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

HQ USEUCOM 09128
ATTN: ECJ4-LIE

AMMRC 02172
ATTN: DRXMR-AF
ATTN: DRXMR-WE

CEWES 39180
ATTN: Library

CECRL 03755
ATTN: Library

USA AMCOM
ATTN: Facilities Engr 21719
ATTN: AMSMC-EH 61299
ATTN: Facilities Engr (3) 85613

USAARMC 40121
ATTN: ATZIC-EHA

Military Traffic Mgmt Command
ATTN: MTEA-GB-EHP 07002
ATTN: MT-LOF 20315
ATTN: MTE-SU-FE 28461
ATTN: MTW-IE 94626

Fort Leonard Wood 65473
ATTN: ATSE-DAC-LB (3)
ATTN: ATZA-TE-SW
ATTN: ATSE-CFLO
ATTN: ATSE-DAC-FL

Military Dist of WASH
Fort McNair
ATTN: ANEN 20319

USA Engr Activity, Capital Area
ATTN: Library 22211

US Army ARDEC 07806
ATTN: SMCAR-ISE

Engr Societies Library
ATTN: Acquisitions 10017

Defense Nuclear Agency
ATTN: NADS 20305

Defense Logistics Agency
ATTN: DLA-WI 22304

Walter Reed Army Medical Ctr 20307

National Guard Bureau 20310
ATTN: NGB-ARI

US Military Academy 10996
ATTN: MAEN-A
ATTN: Facilities Engineer
ATTN: Geography & Envr Engrg

Naval Facilities Engr Command
ATTN: Facilities Engr Command (8)
ATTN: Division Offices (11)
ATTN: Public Works Center (8)
ATTN: Naval Constr Battalion Ctr 93043
ATTN: Naval Civil Engr Service Center 93043-4328

8th US Army Korea
ATTN: DPW (12)

USA Japan (USARJ)
ATTN: APAJ-EN-ES 96343
ATTN: HONSHU 96343
ATTN: DPW-Okinawa 96376

416th Engineer Command 60623
ATTN: Gibson USAR Ctr

US Army HSC
Fort Sam Houston 78234
ATTN: HSLO-F
Fitzsimons Army Medical Ctr
ATTN: HSHG-DPW 80045

Tyndall AFB 32403
ATTN: HQAFCESA Program Ofc
ATTN: Engrg & Srvc Lab

USA TSARCOM 63120
ATTN: STSAS-F

American Public Works Assoc. 64104-1806

US Army Envr Hygiene Agency
ATTN: HSHB-ME 21010

US Gov't Printing Office 20401
ATTN: Rec Sec/Deposit Sec (2)

Nat'l Institute of Standards & Tech
ATTN: Library 20899

Defense Tech Info Center 22304
ATTN: DTIC-FAB (2)

255
+75
8/94

This publication was reproduced on recycled paper.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1994—3510-S/00061

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES
CORPS OF ENGINEERS
PO BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

OFFICIAL BUSINESS