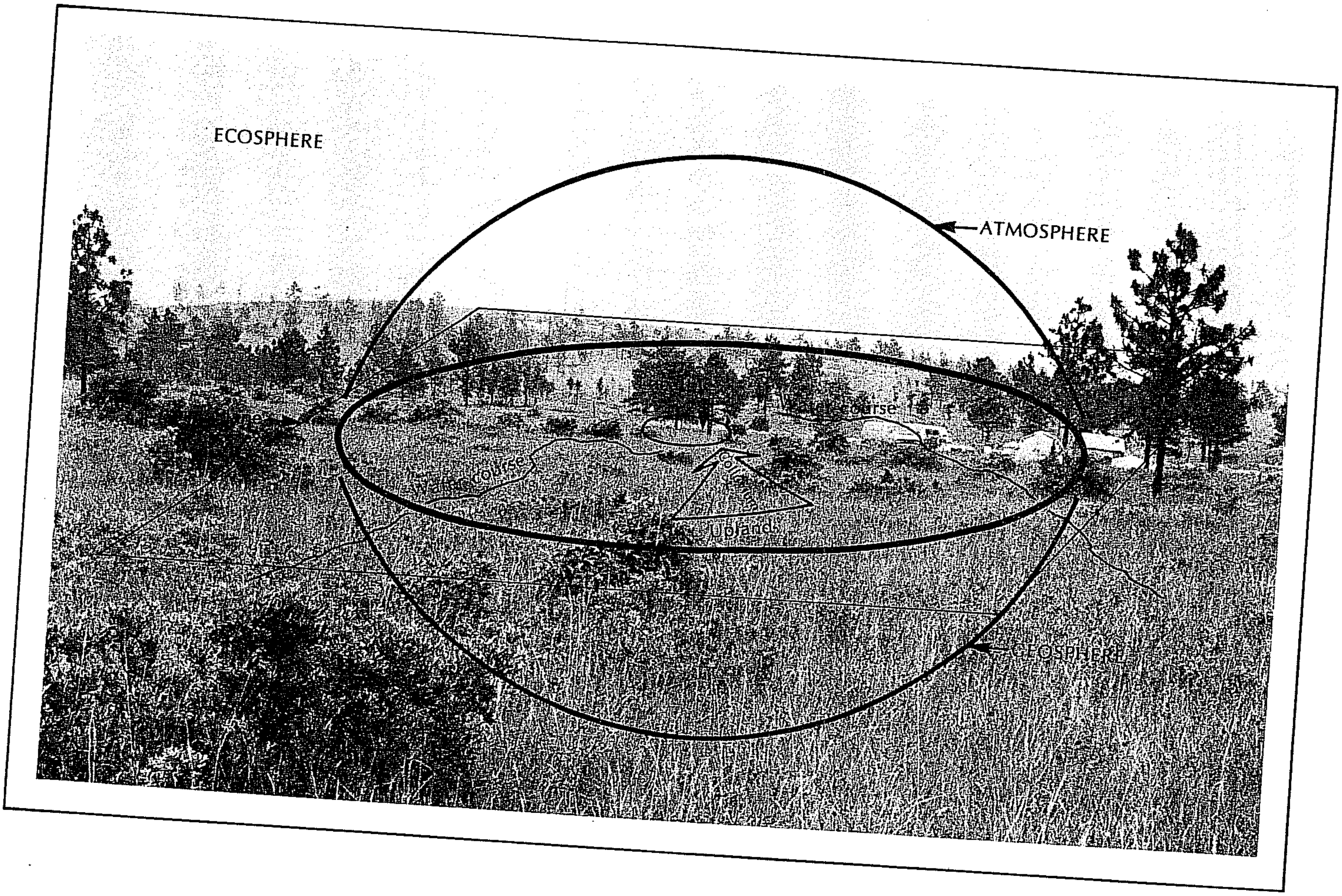
EAGLE HILL: A LATE QUATERNARY UPLAND SITE IN WESTERN LOUISIANA

JOEL GUNN and DAVID O. BROWN



in association with
Eric Gibson, Royce Mahula, Kevin Jolly,
Patricia Wallace, Edward Garner, Mark Sheehan,
Joan Sherwood, Margo Lopez, Donald R. Lewis,
Beverly Van Note, and Fred Nials

CENTER FOR ARCHAEOLOGICAL RESEARCH
THE UNIVERSITY OF TEXAS AT SAN ANTONIO
SPECIAL REPORT, NO. 12

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Thomas R. Hester, Director

SPECIAL REPORTS

Publications dealing with the archaeology of Texas and Mesoamerica.

No. 1 (1975) Some Aspects of Late Prehistoric and Protohistoric Archaeology in Southern Texas. By Thomas R. Hester and T. C. Hill, Jr. Photocopy reprints available $2.28 + .13 tax for Texas residents.

No. 2 (1976) The Texas Archaic: A Symposium. Edited by Thomas R. Hester. Photocopy reprints available. $6.00 + .33 tax for Texas residents.

No. 3 (1976) Papers on Paleo-Indian Archaeology in Texas. Papers by T. R. Hester and W. W. Birmingham. Photocopy reprints available. $2.16 + .12 tax for Texas residents.

No. 4 (1976) Maya Lithic Studies: Papers from the 1976 Belize Field Symposium. Edited by T. R. Hester and Norman Hammond. Reprinted 1979. $9.00 + .50 tax for Texas residents.

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No. 12 (1982) Eagle Hill: A Late Quaternary Upland Site in Western Louisiana. By Joel Gunn and David O. Brown. Write to the Center for information.

ABSTRACT

The Eagle Hill II site (16 SA 50) is located in a rolling upland area of western Louisiana known as Peason Ridge. Because of its location in a saddle, the locale accumulated colluvial sediments during certain intervals of the late Quaternary; in addition, it served as a habitation area for prehistoric groups. Sediments were preserved from the early and late Holocene, apparently reflecting the relatively cooler and moister conditions of those periods that were conducive to erosion-preventing vegetation.

The site was excavated in a manner to provide both vertical and horizontal information on site occupation at relatively high resolution. A sampling design was used to target critical occupation levels for careful excavation of occupational floors. Floors were stratified based on analysis of lithics from test excavations. On targeted occupation floors, artifacts were provenienced to the centimeter. A battery of information was collected on the sediments to allow definition of fire hearths, activity areas, etc.

The early Holocene levels (10,000-7000 B.P.) began with a Folsom-related occupation and ended with an Early Archaic technology. Analysis of lithic wear patterns, tool morphology, and fire-related attributes clearly defined activity areas. Similar success was achieved with the late Holocene (A.D. 6000-present) ceramic levels.

X-ray fluorescence and neutron activation were used to examine lithic source areas and mineral content of the soils in the occupation floors.

The rhythm of occupation at Eagle Hill II can be explained as a product of demographic fluctuations in the adjacent Sabine and Red River valleys, response of those populations to Holocene climatic change, and response of sediments and erosion to the same climatic variations.

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ACKNOWLEDGMENTS

A project as involved as the Eagle Hill II excavation leaves innumberable persons to be thanked. Those persons directly involved in the project are cited in the text either as authors or as contributers in other capacities.

Deserving of special thanks are the employees from The University of Texas at San Antonio administration who facilitated the project and from the employees of the Center for Archaeological Research. Mary Lou Ellis, Patricia Wallace, and Ann Young typed the manuscript, and Sharon Quirk was the editor.

Vic Carbone and Ed Hession of the former Interagency Archeological Services, Atlanta, deserve special recognition for their council relative to the design of the project. Dr. Stephanie Rodeffer of the National Park Service, Santa Fe, New Mexico, managed the later stages of the project because of an administrative reorganization and is to be thanked for her understanding.

Persons from other universities, Mark Sheehan of the University of Indiana, Ed Garner of The University of Texas at Austin, Fred Nials of Eastern New Mexico, the Nuclear Reactor Laboratories at Texas A&M, and many colleagues were most helpful and free with their council and advice.

Certainly the project would have been less productive and less possible had it not been for the support and assistance of Fort Polk personnel. Special thanks goes to Ron Tomas and James Grafton of the Environmental office and John Guy and his family of Annacoco, Louisiana. Also, the Air Force Personnel of the bomb targeting facility on top of Eagle Hill contributed immensely to the quality of life during the field work.

Finally, the many U.T. San Antonio and U.T. Austin students who devoted their hours to the project deserve special recognition and respect. They not only learned, but created knowledge. First among these was David Brown whose careful scholarship and ceaseless argumentation contributed materially to the design and final form of the project. Eric Gibson is also to be thanked for rushing to the rescue with appropriate lithic wear analysis techniques.

FOREWORD: OVERVIEW OF THE PROJECT AND CONCLUSIONS

Joel Gunn

Proof of assertions spelled out in such a manner that it can be observed by others is the substance of modern scientific method. Unfortunately, as important as it is, scientific evidence is often tedious reading even to the interested specialist and the bane of the casual reader. A remedy for the tedium is a middle ground of writing that attempts to interpret the works of science into a more generally readable format. The growing interest of the public in matters of science and growing desire on the part of scientists themselves to cross disciplinary bounds and see what is on the other side of the academic fences has led to the successful publication of several magazines in the last few years. While this foreword is unlikely to appear on the news-stands of airports, it is intended to serve as an extensive introduction to the report which follows. Those who are skeptical of the assertions made in the foreword are encouraged to examine the detailed reports that follow and which outline in great detail the supporting arguments, methods, and data.

Excavations at the Eagle Hill locality (Fig. 1) were suggested by a survey of the Peason Ridge area of Fort Polk, Louisiana, during 1976 by Frank Servello of Southwest Louisiana University. Subsurface testing of several sites indicated considerable evidence of prehistoric occupation during both the ceramic and pre-ceramic periods. One site designated in the Servello survey as Eagle Hill II (16 SA 50) appeared to have Paleo-Indian artifacts and was in danger of being eroded. It is this site to which this report pertains. The Eagle Hill site is located 500 m southwest of a peculiar topographic prominence of the same name.

A Request for Proposals to excavate the Eagle Hill locality was issued in 1979 by Interagency Archeological Services (IAS) in Atlanta. The proposals were examined during the early months of 1980 and the contract granted to the Center for Archaeological Research, The University of Texas at San Antonio (CAR-UTSA), in April 1980.

The excavation and analysis of artifacts progressed through six stages during the remainder of 1980 and the early half of 1981.

(1) Late in April 1980 the site was examined in a preliminary mapping and coring expedition. (2) In May preparation for the UTSA Summer Field School were made, the results of the coring expedition examined, and plans laid for extensive excavations. (3) Excavation began in mid-May with a small, seasoned crew that mastered the record-keeping procedure and carefully removed a one meter square of soil to the bottom of the site's approximately one meter depth. Nearly surgical excavation revealed occupation floors frequented by prehistoric inhabitants of the region. (4) The full crew consisting mainly of UTSA Archaeological Field School students arrived on the site the first of June. Excavation began on a large block in a manner designed to recover evidence of camp patterns as well as the usual pottery and stone artifact inventories. This intensive excavation process lasted through the summer until the first week in August. A 5 x 6 m block was excavated to the underlying, archaeo-logically sterile deposits. (5) Laboratory operations designed to gather interpretable data from the summer's excavated artifacts were conducted from August to December. Project staff and interested students measured, weighed,

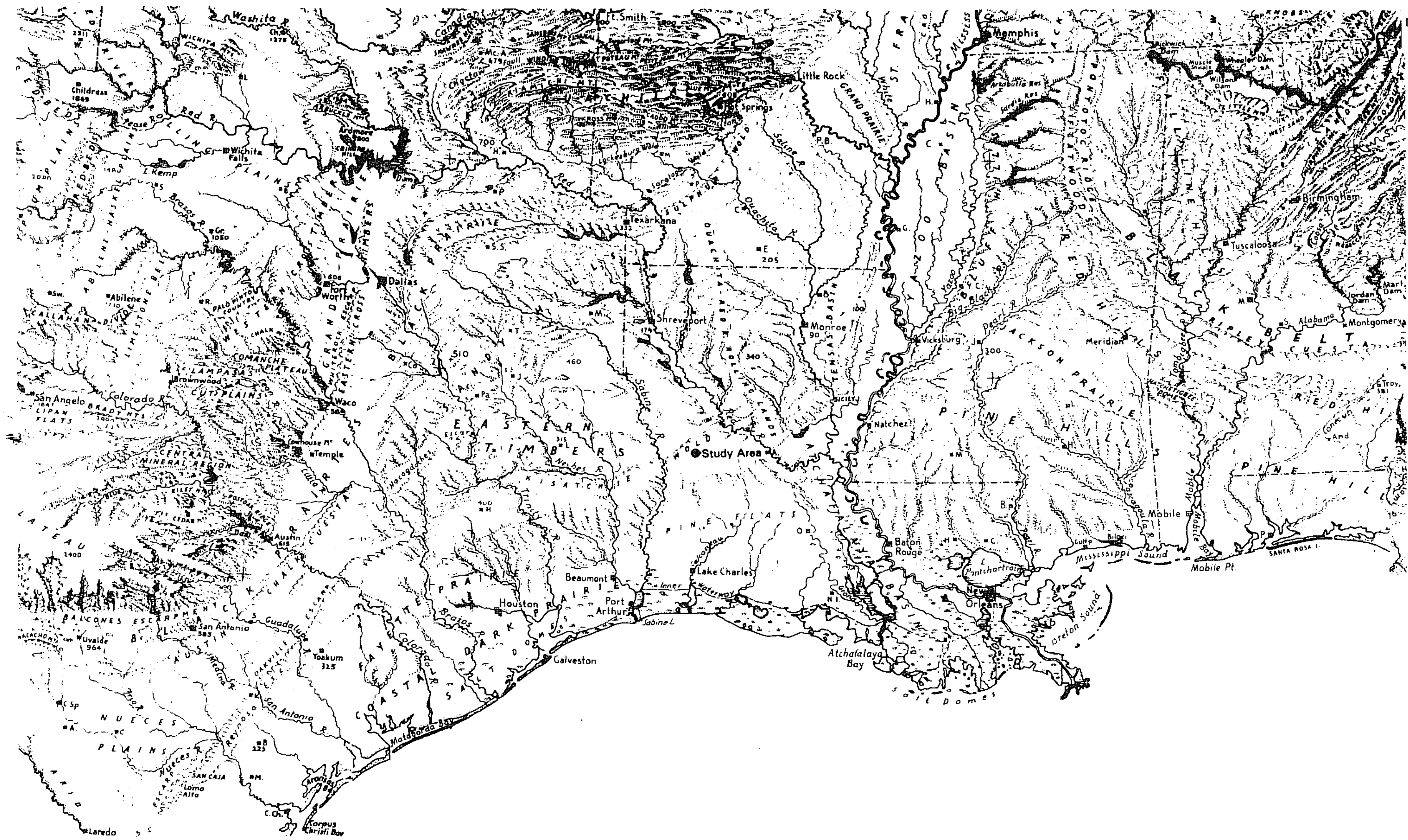


Figure 1. *Physiographic Map of Central and Western Southeastern United States with the Study Area.*

and coded thousands of pieces of relevant evidence and wrote preliminary reports. (6) The spring of 1981 was devoted to final analysis of the data, report writing, and production.

The first question addressed by the April expedition was why there should be a site of such great age on the top of a hill. Two geologists, Fred Nials and Ed Garner, examined the deposits on Peason Ridge and, thanks to their thorough knowledge of soils and the geologic past of the area, an answer soon emerged. Several million years ago the area, which is now on top of Peason Ridge, was on the bottom of a lake. The Gulf of Mexico was closer then, and the lake was probably somewhat like present-day Lake Pontchartrain near New Orleans, Louisiana.

The sediments deposited in the bottom of the lake contained a substantial amount of sand and herein lies the key to survival of Peason Ridge through millions of years of erosion. Ordinarily, sand is thought of as an easily moved and eroded sediment. However, if a sand deposit is deep enough to absorb all of the precipitation which falls on it, the sand will not move. The water simply seeps through the sand without disturbing the soil. Thus, the sand acts as a protective layer shielding Peason Ridge from erosion as long as precipitation is small.

An additional clue to the survival of the Eagle Hill site is that prehistoric inhabitants of the Ridge chose to locate in a saddle at the base of the two gentle slopes, one from the northeast and one from the southeast. They were probably attracted by running water at the base of the slope. When there was sufficient precipitation to move sediments down the hill, they piled up at the very location where prehistoric men lived. Thus, through time, alternating layers of sediment and artifacts built up over the site.

Close inspection of the deposits in the site showed that there were two separate periods of deposition at the site. The top zone was separated from the bottom by a period of erosion. We can therefore assume that for some reason the sands of Peason Ridge were not always the effective erosional shield they are now. The lower zone contained no ceramics. The upper zone revealed ceramics and considerable evidence of human occupation.

Having resolved some of the problem of the origin of the site, we turned next to its surroundings and their attraction to early man. Peason Ridge is about 120 m (400 feet) above sea level. These elevations are relatively recent developments according to geological time. Thirty million years ago Peason Ridge was at sea level. Since then, however, rivers such as the nearby Sabine and Red have dumped great quantities of sediment into the Gulf of Mexico. There have been two results. First, the shore of the Gulf has moved away to the south about 180 km (110 miles). Second, the weight of the sediments has forced areas off the coast downward. Surfaces inland from the coast have responded in a seesaw fashion by rising about 140 m (450 feet). Naturally, the movements have been so slow, that conditions have been much as they are now during the last few thousand years and during the time of human occupation in Louisiana.

An aerial photo survey of the area within a six kilometer radius of the site shows that the top of Peason Ridge has probably been relatively stable for some time, excepting the recent traumatization of the ridge top by logging and stumping operations in this century. The land is relatively flat, and the range of the habitats available for prehistoric people to exploit is consequently narrow. Flat, unbroken countryside suggests the hunting of larger animals.

A survey of the literature of the archaeology of the lower Mississippi Valley suggests that, there may have been periods during the last 10,000 years when people would have been more likely to explore and utilize upland locations such as Peason Ridge. Clovis hunters (11,500-10,500 years ago) may or may not have been interested in the Eagle Hill area. In the lower Mississippi Valley, they seem to have confined themselves to the river bottomlands. However, western Louisiana is near the Plains margin, which was inhabited by a more open-ground, herd-hunting people.

During the subsequent Dalton (10,500-9900 years ago; for dating of Dalton see Goodyear 1982) and Early Archaic (9900-8000 years ago) periods, there is considerable evidence that humans inhabited not only the river valleys, but also the uplands all over the southeastern United States. The reasons are not clearly understood. It may have been related to overpopulation. In any event, Peason Ridge was frequented during the time interval 10,500-8000 years ago. A Late Paleo-Indian point and a tool kit of scrapers, knives, and so forth were found in the lowest level.

The Middle Archaic is ill defined in the lower Mississippi Valley. It probably falls between 5000 and 8000 years ago. Sherwood Gagliano, who has a long-standing familiarity with the problem, thinks that upland cultures were probably stagnant during this time. River bottoms were accumulating sediment, which suggests that ridge tops were being eroded. Peason Ridge was probably a dry and unpleasant place during these times.

After 5000 years ago, populations began to grow in the alluvial floodplains of the Southeast. During the periods of Coles Creek (A.D. 900-1150) and Plaquemine (A.D. 1150-1250) interest in the uplands was rekindled, perhaps by overpopulation of the productive lowlands (Griffin 1978:56).

On a purely speculative basis, then, surges of activity on Peason Ridge might be expected relatively early and late in the human history of the Southeast with intervening episodes of disinterest or, at least, reduced human activity.

Additional search of the literature indicated that lithic tools should resemble those of the Paleo-Indians to the end of the Early Archaic with the exception of projectile points. After that time, we expected to find fewer formal tools, such as scrapers, and more use of less well-prepared tools, such as utilized flakes.

Naturally, when we turned our attention to the excavation and analysis of artifacts from Eagle Hill, we hoped that we would see clues as to what transpired there by studying cultural chronologies from surrounding areas. However, many nearby excavations have produced meaningful, through-time collections of archaeological materials. Our ambitions for this particular excavation went far beyond a collection of temporal or vertical indicators. We hoped, as well, to examine the horizontal evidence of primitive man's lifeways stored at the Eagle Hill site. By recovering remains of campfires and tools measured to their exact location on living floors, we hoped to treat the whole site as a big artifact of human camp activity.

The procedure adopted to achieve this goal also had to take into account the limited amount of time available to us. Our late May excavations showed that there were about 20 discernible levels of flakes in the 100 cm depth of the site. Excavating all 20 would have been impossible if we intended to excavate enough area to recover a meaningful segment of the camp space at each level. It was apparent that we would have to select the most important levels and excavate them with the greatest of care. Intervening levels would be removed in one meter squares by shovels. Seven levels were selected for excavation by trowel with all artifacts plotted on maps or provenienced by exact measurements. Measurements were recorded in such a way that they could be analyzed by computer. Figure 2 shows the numbering of the levels and their relative positions in the site.

In the laboratory, various types of material, such as baked clay, charcoal, and chert were analyzed first for vertical changes. Attention was then turned to five of the 6 x 5 m horizontal floors recovered during the summer.

There was a great deal of charcoal in the upper levels. Radiocarbon dates were run on charcoal from the upper four floors for two reasons. The obvious reason was to acquire dates meaningful to the time of occupation of the floors. In addition, we were not sure whether the increase of charcoal in the upper levels was due to increased occupation or just the burning of roots during the modern deforestation process. This was very important since charcoal was instrumental in defining fireplaces, the presumed center of camp activities.

Baked clay also increased substantially in the later floors. Clay potsherds appeared in the upper zone of occupation (Zone I). Another, somewhat mystifying series of clay objects consisted of small clay balls normally from one to three centimeters in diameter. They appeared in all levels, although much more frequently in the upper zone associated with pottery. We could only surmise that they came from humans building fires on the remains of crayfish castles. Crayfish castles are often high in clay, because they burrow down to the Miocene clays under the archaeological layers of the site.

Lithic pieces appear in great numbers throughout all levels of the site. A close examination of the types of material being brought into the site indicates that the greatest numbers of exotic materials, perhaps carried from very far away, were brought in during occupation of Occupation Plane (OP) 3.11. During this time, the trade and/or exchange of lithic materials seems to have been at a maximum. David Brown undertook the task of determining the source of both the lithic and ceramic materials. He used neutron activation to study trace elements in the materials and compared them to sources in Texas and Arkansas.

Examination of flakes for use on hard (bone and wood) or soft (meat, skins, and soft plants) materials shows that there was a marked increase of soft wear during the OP 2.13 ceramic period. This observation coupled with a notable increase in the amount of occupation debris suggests that Eagle Hill probably assumed a much more important status during this time than it did before or

Dates BP	C-14 BC-AD	Eagle Hill II Soil Zones	Eagle Hill II Cultural Strata		Southeastern U.S. Cultural Chronology
0	2000				
			1.13		Plaquemine
1000	1000	Zone I	2.13	Ceramic	Coles Creek
			3.11		Troyville
2000	0				Tchefuncte
3000	1000				Poverty Point
4000	2000	Hiatus			Late Archaic
5000	3000	Deflated			
6000	4000				Middle Archaic
7000	5000				
			4.12		
8000	6000			Preceramic	
9000	7000	Zone II	4.15		Early Archaic
			4.16		
10000	8000		4.17	Paleo-Indian	Dalton
11000	9000	Hiatus			Clovis
12000	10000				
		Zone III			

Figure 2. *Generalized Stratigraphic Sequence and Cultural Chronology.*

after. It may be that during OP 2.13 times, the site was visited by whole families. At other times, it was only occupied by men on hunting trips.

Close examination of the patterns of worked flakes around fireplaces indicates that some areas were used to work on hard materials, while others were devoted to soft substances. Interestingly enough, soft cutting is usually next to a fire, while hard cutting and scraping occurs both by the fire and in isolated areas away from fires. This may mark the use of flakes next to fires to cut soft, cooked foods, while some harder tasks, such as the manufacture or refurbishment of weapons, were relegated to more out-of-the-way spots.

When occupation at Peason Ridge is studied in the context of the climate of the greater southeastern United States, it seems likely that the ridge attracted human occupation during moderately cool and moist periods. It would have been during such intervals that water would have been available for a reasonably long period during the year. Also, the vegetation would have supported game and provided nuts and other vegetable foods in greatest abundance. The appearance of pine forests on high sandy ridges, known as the "pine barrens," during the last 500 years appears to have discouraged occupation as affectively as earlier, excessively dry intervals.

I. HISTORY OF THE EAGLE HILL ARCHAEOLOGICAL PROJECT (Gunn)

The Eagle Hill II site (Servello n.d.) is located at the top of a northeast-southwest trending sand ridge in west central Louisiana. As subsequent discussions will verify, the site is one of those points in the landscape that, thanks to its geomorphological situation, has preserved the remnants of sediments as old as 10,000 years. The site is an erosional remnant which at present appears as a one-meter deep mound. The deposits are approximately equally divided between an eroded late Pleistocene/early Holocene paleosol and a late Holocene cap. The cap is at least partly of aeolian origin.

Efforts to obtain the 16 SA 50 contract were begun by CAR personnel in the fall of 1979. The principal investigator, having had experience with such sites in other parts of North America and Europe, was attracted by the prospect of Pleistocene age deposits. Such a site would not only be of considerable scientific interest, but attract students to the field school in the summer of 1980 as well.

Early in April 1980, Joe Watkins notified the CAR of receipt of the 16 SA 50 contract. However, more specific notification was delayed until mid-April by a bid protest. Formal notification was forthcoming by telegram on April 14 and the contract received April 24.

A five-day field expedition was launched almost immediately upon receipt of the telegram. At midnight on April 15, the principal investigator and a crew of three left for Fort Polk to explore and auger the site and meet Fort Polk personnel. We arrived at midday on April 16, surprised at the length of the trip, but pleased to be met by Ron Tomas, James Grafton, John and Billie Guy, and others. We were soon apprised of the folk history of Peason Ridge. On the night of April 17, rain and wet roads forced a move to the site, where we stayed for the duration of the exercise. Fortunately, both weather and roads improved consistently over the next few days.

Our geomorphologist, Fred Nials, arrived on April 17; his efforts and those of the auger crew rapidly revealed the geomorphological and sedimentological nature and setting of the site. An incipient fragipan within the walls of Servello's (n.d.) test pits precluded the possibility that the site was disturbed by recent military traffic. A preliminary report was prepared in the field. Also, transit shots were taken to generate a contour map of the area (Fig. 3).

Upon our return to UTSA on April 21, chemical analyses of soils for pH and phosphates were initiated. During the last 10 days of the month, laboratory analyses proceeded in conjunction with administrative and material preparation for the field season.

A literature search of the archaeology of the Louisiana/east Texas/Arkansas area and of lithic tool kits in that and surrounding areas (the Plains and eastern United States) was launched. To give these researches a common underlying theme, we incorporated the development of a nonprojectile point tool typology into the more general background. Properly managed and quantified, such a typology would serve as a vehicle to test the tool kit hypothesis posed in our original proposal.

During the first 10 days of May, gathering supplies, chemical analysis of soils, and recruiting and organizing the field school occupied Gunn, Scruggs, and Sims. Colorimeter tests of phosphates were delayed by acquisition of chemicals and proved too slow for extensive use in the time remaining. However, they did provide a useful backdrop for the more extensively used spot test. Results showed that there were accumulative layers of phosphate in Area A, and that phosphate concentrations were generally higher in Area B. Our subsurface testing also showed that the areas with respectable deposits were substantially smaller than anticipated.

Thanks to the cooperation of the UTSA purchasing department and Mary Lou Ellis of the CAR, acquisition of supplies and organization of project personnel were almost completed by the tenth of the month. Supplies were purchased in San Antonio when possible, but most were purchased in the Florien/Many, Louisiana, area so that supplies would not have to be transported across 500 intervening miles. Field school and later excavation personnel came from several Texas educational institutions and England.

Gunn, Scruggs, and Sims loaded equipment on May 11 and journeyed to the site to set up camp and begin excavation. Brown and Sullivan arrived at the end of the week. Huber joined the crew after the beginning of the next week. It rained the first six days at the site, so we took advantage of this enforced leisure to examine the results of our chemical tests, auger soils data, and plan the excavation.

Complementing this effort was a visit by Victor Carbone, Edwin Hession, and Frank Servello. Through them we were able to broaden our knowledge of previous excavation at the site and clarify our understanding of the government's project expectations. Talks on May 15 and 16 led to an agreement to concentrate on questions raised by Carbone relative to geomorphology, soils, and cultural chronology of the site and to meet again at the site during the second week of June. This meeting would include Fred Nials and Ed Garner of our staff and a soils morphologist commissioned by the government. The goal was to resolve unanswered questions of geomorphic and pedogenic development at the site.

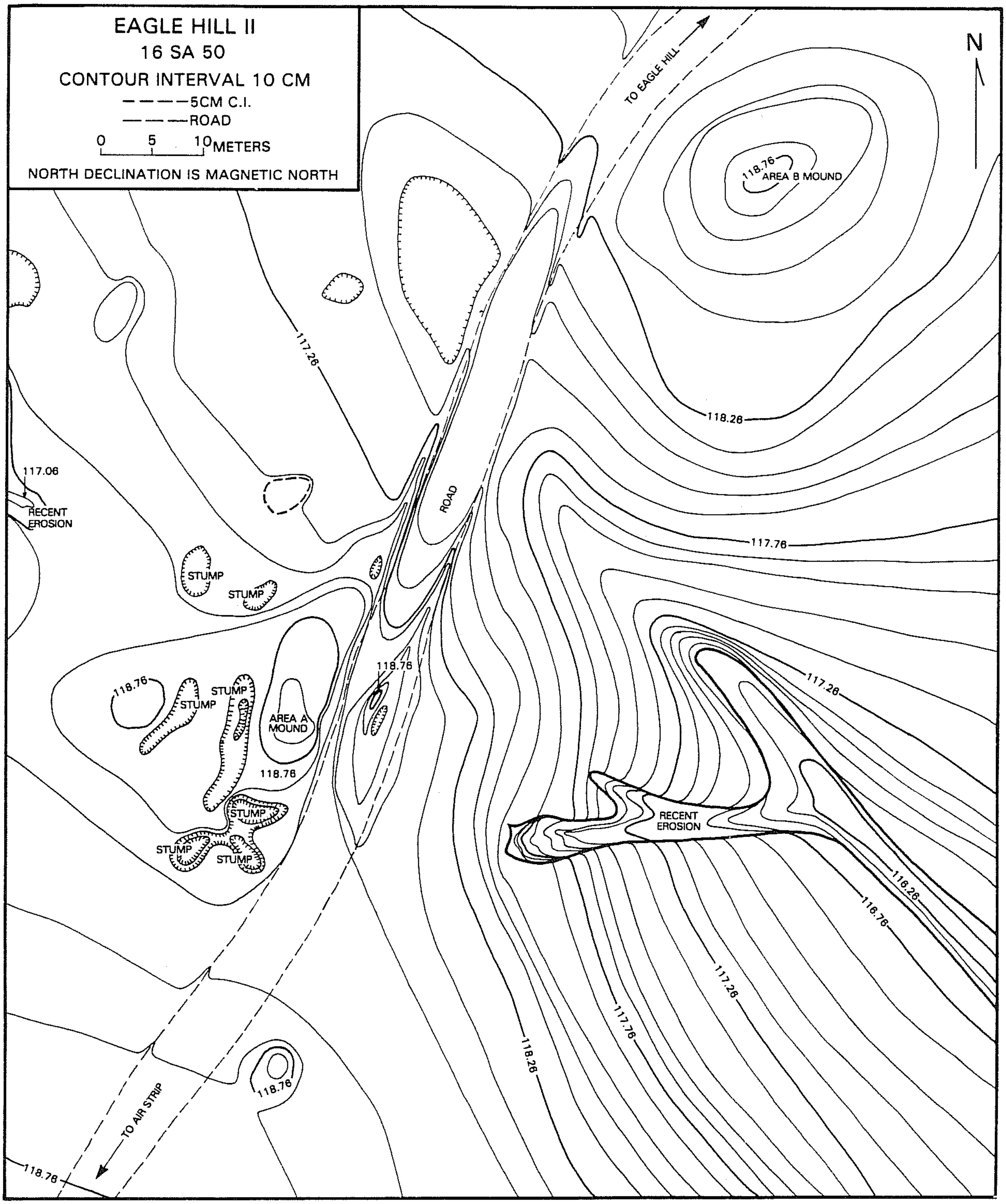


Figure 3. *Contour Map of Eagle Hill II, Areas A and B.*

As with the earlier field excursion, excavation began again by opening Servello's test pits. Since we were not equipped to work in the rain, this operation was hampered. Our most judicious move upon arrival was to leap out of our trucks into the rain and cover the site with polyethylene tarp to save it from excessive water. If this had not been done, the subsequent six days would have been most unproductive. Re-excavation was begun on May 13 and ended simultaneously with the beginnings of excavations on May 16. By then, we had learned to use our tarps to facilitate excavation during light rain. During the third week of May, we concentrated on excavating a 1-m^2 block of Servello's checkerboard pattern to clarify our stratigraphic problems and some of the cultural/chronological problems Carbone had raised. We also planned to define strata and substrata for reference during subsequent planar excavations and to develop our excavation, recording, screening, and other techniques. We found water screening to be quite efficient. The principal investigator returned to San Antonio on May 22. Excavation efforts continued at a more modest rate, while camp facilities were built.

Our excavation techniques were quite slow compared to the more customary approaches. We were, however, recovering substantial information on artifacts and cultural substrata. While each item of that battery of information provides some data on the cultural and stratigraphic situation, it may or may not be indispensible, depending upon the kind of information that is ultimately desired. Our approach was state-of-the-art relative to occupation floor data recovery. We did, on occasion, streamline those techniques, as long as they agreed with our research goals; the integrity of the data set was maintained so that it would be respectable and serviceable to future generations of archaeologists.

Pottery was recovered from Soil Horizon A2, and two Archaic points were recovered from the lower Soil Horizon A2 and the upper Soil Horizon IIB. The two points were in undisturbed context and contradicted Servello's position that there was a Clovis occupation in the sediments of the lower A2/upper IIB soil zones. While cleaning the test pits, we did recover flakes in the gray clay interface (lower IIB) that could be of Paleo-Indian workmanship.

During June, the UTSA Archaeological Field School participated in the Eagle Hill excavations. Good weather permitted us to excavate a 5-m^2 block of Area A from the surface to the IIB/IIIB interface. Early in the excavation it became apparent that we could not excavate an adequate area using the most precise excavation technology, so a vertical sampling scheme with a mixed excavation strategy was developed (this will be discussed in detail in a later section). Cultural strata judged to be more important were excavated with trowels. Other zones that appeared to be less important (disturbed or deflated) were removed with shovels.

Ed Hession, Victor Carbone, John Foss (a soil scientist consultant for Interagency Archeological Services--Atlanta), and Fred Nials and Ed Garner of our staff visited the site to clarify the pedological and geomorphic situation. The consensus was that, the site was as intact as an open site could be expected, and that excavation should continue.

Aside from the Area A controlled excavation, all other activities were initiated in June. With a mind to further excavation, a control column was opened in

Area B to determine the nature of the occupation floors. With student help, the laboratory analyses at UTSA continued throughout June, primarily directed toward analysis of artifacts from the Area A control column.

During July, crew morale sagged as excavators confronted the hard realities of the lower levels and the daily routine of professional archaeology. From the laboratory came our first detailed view of the materials; from kind neighbors on Peason Ridge came some insight into the probable prehistoric hydrology of the area--a picture which suggests a much more favorable situation than can be observed today. Finally, our thoughts turned to profiling, backfilling, and calling in some second opinions for what we had found in the field and were likely to find in the laboratory.

August saw the end of the field season and the beginning of the laboratory season. Due to complications of IAS reorganization, a visit to the site by IAS personnel did not materialize. However, consultant Albert C. Goodyear did visit the site and provided insights from a pan-southeast perspective. By the end of the month, the bulk of curation was completed, as well as keypunching of the summer's data store. In September, data generation and analyses reached a detailed planning stage. Laboratory analyses of Eagle Hill materials was begun:

Lithic Analysis--Quantities and types of material were coded at one-meter and one-centimeter precision levels.

Wear Analysis--Eric Gibson, who had attended one of Lawrence Keeley's workshops on lithic use-wear analysis, developed a coding scheme for the provenienced artifacts from the five targeted occupation planes. Since there were over 1500 such artifacts, it was necessary to devise a rapid coding format. We identified the general types of material on which artifacts were used, i.e., hard or soft substances, and the type of technological activity indicated in a square.

Material Analysis--David Brown proceeded with plans to perform neutron activation analysis on ceramic and lithic materials.

Clay Artifacts--David Brown also organized the ceramics. Joan Sherwood, a graduate student at UTSA, worked on the clay balls.

Literature Search--Royce Mahula was assigned to unravel the literature search problem. The lack of formal tools recovered during excavation forced us to develop a new scheme--bracketing Louisiana with materials from surrounding states in the context of presumed ecotonal shifts across the region.

Granules and Pebbles--Margo Lopez, an undergraduate student at UTSA, undertook analysis of granules and pebbles.

Charcoal--Pat Wallace, a graduate student of UTSA, analyzed the carbonized plant macrofossils, in addition to her duties as data manager. The materials were weighed and mapped in preparation for selecting radiocarbon samples. We received a post-1950 date on the carbon from the soil profile 100 m north of the site and assumed that its colluvial/fluvial sediments were in large part a product of stumping activity of the 1950s.

Geomorphology/Pedology--Both Ed Garner and Fred Nials continued work on their individual contributions.

During October, most of the laboratory effort was directed at collection of data on lithics, clay balls, charcoal, pebbles, and flake concentrations. A wear analysis was performed on 1500 flakes from five targeted occupation floors and preliminary analyses conducted.

Neutron activation studies proceeded in a most encouraging manner. Brown pre-checked clay and lithic specimens through X-ray fluorescence to avoid unnecessary expense. In addition, when he visited Texas A&M University, the staff of the Nuclear Research Laboratory provided several thousand dollars in matching funds.

Pollen samples were sent to Mark Sheehan for analysis. Careful examination of carbon samples for radiocarbon dates revealed that some of the carbon was the result of burned roots.

In November, the Eagle Hill Project moved from the data collection stage to the preliminary data analysis stage. The bulk of the data was coded, key-punched, and proofed. Students and staff were busy analyzing their data, primarily for statistical patterns in the vertical aspect of the site.

Analysis of the horizontal aspect of the site also commenced. Maps of occupation planes were prepared showing various types of material. Additionally, analysis of wear pattern data and plotting the distribution of 300 flakes, which showed evidence of use, was completed.

Various specialized tests continued to yield data into January. Among these was neutron activation of cherts and clays from Louisiana, Texas, and Arkansas. Charcoal had been sent to the Center for Applied Isotope Studies at the University of Georgia at Athens for radiocarbon assay. Seven constant volume samples (CVS) were sent to Jerry Hoffer at The University of Texas at El Paso for a series of X-ray fluorescence tests. These samples were taken from the High Resolution Environmental Column (HREC) from levels targeted for analysis. Principal components analysis suggested a great deal of free silicon in the samples; this provided us no useful information. We were more interested in clay particles, etc., that might bind trace elements concentrated by human activity. Therefore, we instituted a procedure to settle particles larger than fine silt. A most encouraging letter from Sheehan indicated that there was pollen in the HREC with reasonable botanical assemblages. This seemed almost too good to be true; Sheehan tried a new technique that concentrates pollen grains to increase frequencies and variety of species, but the results were disappointing.

In December, a preliminary report was issued that suggested that the remaining minimal horizontal deposits could add to existing horizontal information. However, a more than adequate vertical sample was recovered, and it seemed likely that the primary archaeological value of the site had been recovered.

January through March 1981 were devoted to data analyses and report preparation. Some analytical activities were continued in student papers. Radiocarbon assays arrived, and lack of dates for the IIB soil zone encouraged an attempt to date fire-burned lithics through thermoluminescence (TL). The results of TL dating provided a chronological context for the lower soil zone.

A. PRELIMINARY INVESTIGATIONS

Preliminary Field Examination of the Site

The preliminary field excursion was made between April 16 and 21, 1980. After spending the afternoon looking over the site, we returned to John Guy's home for the night and received a substantial introduction to the local archaeological lore. Throughout the remainder of the field program, John Guy was a consistent supporter of our efforts, as well as Environmental Office personnel.

During the week before our arrival at Fort Polk, it rained in Louisiana and promised more. Given the difficult status of the roads and the brevity of our planned stay, we stocked up on food and moved to the site for the duration of the period. This was done to avoid spending time extracting our vehicle and its trailer from forbidding mud holes, which were all too frequently encountered on the northern reaches of the Fort Polk Reservation. During the first two days of grid setting and augering, we had to retreat rapidly to the vehicle more than once to avoid sudden showers. However, the weather improved steadily thereafter, and the last days were most pleasant.

Trapped as we were, we were not distracted from our tasks and logged a substantial list of accomplishments in those four working days. The crew consisted of Joel Gunn, principal investigator; David Brown, field supervisor; Lang Scruggs, data and logistics manager; and Darrell Sims, aspirant archaeology student. Fred Nials, geomorphology consultant, arrived Thursday, April 17.

The Fort Polk Connection--The Environmental Office at Fort Polk provided us with much needed maps of the area, introductions to area residents, and guidance in finding our way about, which saved immense amounts of our shortest commodity--time.

The Community Connection--We were able to locate relevant roads, grocery stores, lumber yards, service stations, cafes, and motels necessary for the successful maintenance of an archaeological crew.

History of the Site--Jim Grafton provided us with an oral history of the site, which included the location of Frank Servello's test pits and explanations for the devastated appearance of Peason Ridge. Thanks to his efforts, we learned that the holes that pockmarked the ridge were left by the bulldozing of tree stumps. We could very well have wasted time and effort testing and puzzling over their genesis.

Condition of the Site--The rapidity of the headward erosion of the two gullies encroaching upon the site was apparent, as were the efforts of the army to prevent or at least slow the destructive effects. The most threatening erosion from the north was already flanking the culture-bearing deposits on the west and eroding rapidly into the bedrock clay.

The present site is a remnant of a larger site that existed before deforestation. As will be discussed later, Area B is probably equivalent to the upper soil zone of Area A; this suggests that Areas A and B, intermediate zones, and adjacent zones were once a contiguous site.

Gridding the Site--A grid, aligned with magnetic north, was established over the site (Fig. 4); pin flags were placed at 10-m intervals and other permanent data established. Grid point E3020 N1000 was located at the highest point on the Area A mound. It was also conformant with a yellow stake in the grid system established by Servello. Our grid system was 12.5° out of alignment with Servello's grid. Over 200 transit shots were taken. These included elevations of all bore holes, Servello's test pits, and prominent topographic features.

Geomorphology and Geology of the Site--Environs were geomorphically analyzed, and a preliminary report prepared. To check the correspondence between our observations and Servello's, we reopened his test pits in Area A and mapped the profiles. Nials' observations disagree with those of Servello. One notable exception was an incipient fragipan in Stratum IIB2. Such a soil structure insures that the site was not disturbed by the recent military traffic, since it takes hundreds or thousands of years for a fragipan to develop. Area A is also marked by less rilling and gullying than reported by Servello, and we observed no vertical "tongues" as Servello had indicated. There was heavy mottling in the levels as he had indicated, but mottling develops with the aging of the soil and implies no disturbance.

Groundwater--Upon our arrival, we were able to observe the groundwater at the site, thanks to their sodden conditions. The groundwater might have hampered excavation, but our excavation efforts in Servello's test pits lowered the water table in the adjacent bore holes.

Crayfish Problem--Thanks to the assistance of an amenable crayfish, we gained some insight into the hazards of the site. No doubt, wet-season crayfish activity accounts for some disruption of the soil, but there is no reason to believe that the problem is any more acute at Eagle Hill than similar rodent and crustacean problems elsewhere.

Paleosol--In a gully north of the site, we observed what we thought to be a paleosol. A radiocarbon assay of charcoal in this horizon proved to be younger than 1950 (UGa-2531) and reflects the extent of the damage perpetrated by the 1950s stumping operations.

Site Location Hypothesis--During our stay on Peason Ridge, a preliminary site-location hypothesis was developed (see Settlement Pattern section, page 140).

Where To Excavate: Bore Hole Analysis (Gunn)

One always approaches the testing of a Pleistocene age site with mixed feelings--for fear of spoiling some rare trophy or pattern. Normally, such sites are excavated in repeated seasons over long periods of time. F. Bordes has been returning to his favorite sites since 1948. For decades, each season has revealed a part of the structure of the site, and no part of the site is sacrificed as a means of understanding other parts of the site.

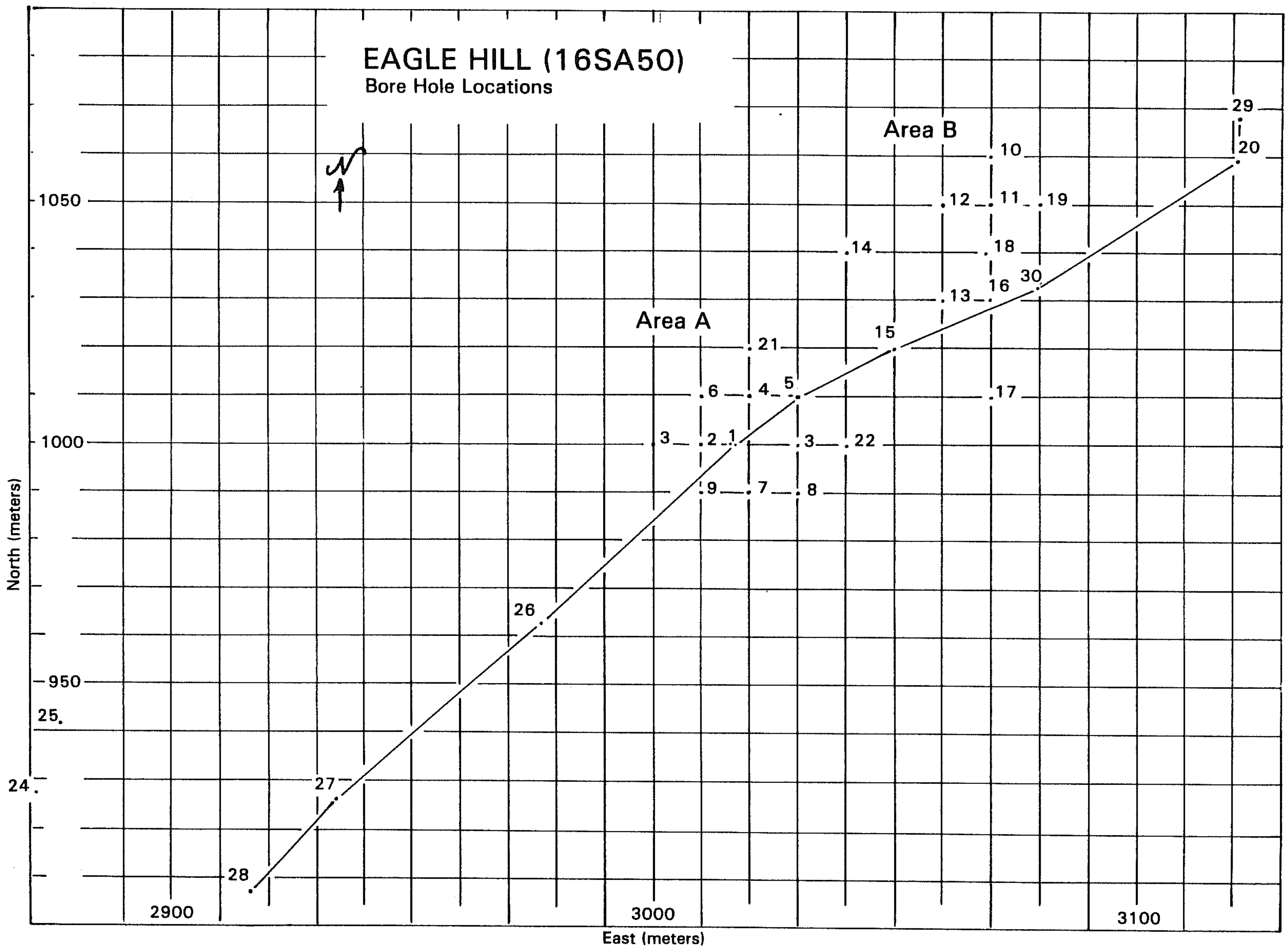


Figure 4. *Locations of Bore Holes with Clay Surface.*

Time limitations at Eagle Hill, however precluded such a time-consuming and laborious process. It was necessary to know what to expect and how to manage excavation problems expeditiously. Fortunately, coring has proven to be a minimally destructive mode of data recovery. We located core holes precisely and proceeded to auger in approximately 5-cm increments to the underlying Miocene clay (Fig. 4). The depth-to-bottom of each increment was measured. Thus, a 3-inch auger hole provided exact provenience on any artifact recovered, so that if the area was excavated, the artifacts could be mapped onto occupation floors with nearly accurate precision. Servello also found that 5-cm increments were sufficiently refined to define multiple occupation levels. The only real damage posed by augering is edge damage. Since it is unlikely that the whole edge of an important artifact could be reworked by the auger, we felt that the risk was acceptable.

Chemical analysis of soils and inspection of the site served to locate the best area for excavation. Figure 5 is an isopac map of the site. Contours show the depths of the soils above the bedrock clay. Augering showed that the area within which deposits of appreciable depth remain was relatively small. In Area A, for instance, the deposits are about 90 cm deep at the top of the mound. Because of a road through the site and the surrounding erosion, the area from which we could retrieve the full temporal spectrum represented at the site was small in comparison to the overall size of the site mounds.

Core Series

Three core series were taken: inside occupation areas, around occupation areas, and a transect of occupation areas and the surrounding terrain. In all, 30 cores were recovered. The first (Fig. 4; bore holes 1-15) consisted of 15 cores taken at 10-m intervals within areas of known prehistoric habitation and at 20-m intervals within areas of unknown potential. Twenty auger holes were originally scheduled for this. However, we found that the space between Areas A and B was eroded into the Miocene clay bedrock. Except for two bore holes augered within the gully bed, cores were confined to the erosional remnants in Areas A and B.

The spacing of holes was based on the density necessary to detect family occupation space (Yellen 1977). Yellen's examination of camping patterns among the Bushmen of the Kalihari was used as a model. The camping patterns of the Bushmen indicated that family units usually occupied circles 5 to 10 m in diameter. Since he studied nuclear familes, we can expect a 10-m sampling interval to detect family-sized occupation and work areas. Within Areas A and B, tests were located approximately 10 m apart. Nine cores were placed in Area A and four in Area B. The numbers are commensurate with a reasonable coverage of each area on the "10-m" principle. Seven augers were placed in the intermediate area at approximately 20-m intervals. Twenty meters generally correspond to minimal social units; i.e., the band.

Mode of Operation

The mode of operation of an auger team is important to its results and to the transition to the second core hole series. In addition to the person who turns the auger, at least two other persons are necessary to observe the soils and

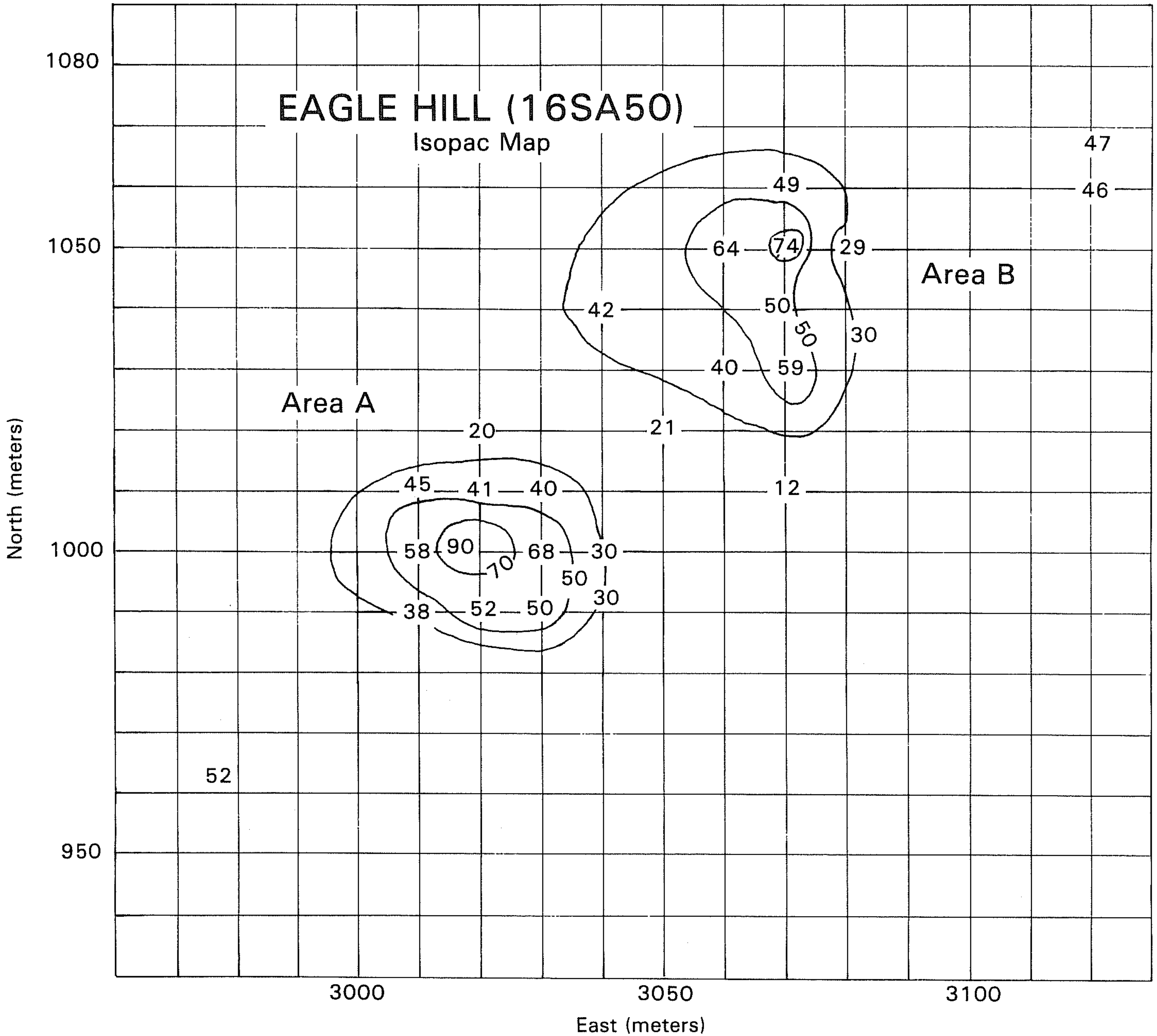


Figure 5. *Isopac Map Showing 10-Meter Grid and Depth of Deposits in Areas A and B.*

keep records. The observer determines the grain size, texture, and color of the soil and decides when interfaces between lithological units are crossed. The recorder enters information on computerized data-coding forms and written notes. Samples are bagged in ziplock plastic bags.

Synthesis of information is very important. Through conversation, a team consciousness of the subsurface characteristics of the area being tested is developed. During the augering exercise, the team offers comments on what is being encountered in terms of discontinuities, soil color, etc., and their observations are duly entered in the log by the recorder. As the work progresses, a mental picture develops in the minds of the auger team members as to the subsurface trends in frequency of artifacts, and at what depths. In most cases, these trends lead to further questions that can only be answered with judgmentally placed auger holes. For instance, the team may have noticed that the concentration of flakes is thinning to the west and, judging by the rate of the decreasing frequencies which they have kept in mind, suspect that the margin of a lithic workshop area in the second stratum down is near point X, so many meters to the west. If this hypothesis and test sequence work out, an important boundary has been established. In the bore hole sequence, units 16-25 are such judgmentally placed holes.

To determine the depth of the bedrock clay, the final series (Fig. 4; bore holes 26-30) was placed on a transect parallel to Peason Ridge, 150 m southwest of Area A and 100 m northeast of Area B.

Analysis of Core Samples

Upon returning to UTSA, the coding of a number of criteria proven useful in previous analyses (Muto and Gunn 1982), such as color, texture, and the presence of artifacts and charcoal, was immediately ready for analysis following completion of data entry. These observations allowed us to map artifact concentrations and lithologic characteristics at various levels and thus, define cultural areas. Increment depths, sediment texture, and artifact locations are shown for downhill transects of Areas A and B in Figures 6-9.

We were very much interested in the extent of human activity in the locality. For some time, phosphate and pH have been regarded as indicators of human activity and may define to some extent the nature of that activity. Yellen (1977), for instance, found that hide scraping was done in the area marginal to the camp's hut complex. One might expect phosphate residues to be associated with hide processing. Accumulated and decayed plant remains associated with bedding, huts, etc., would leave a higher pH.

To retrieve this information, samples were processed for pH and phosphate and the information added to the data set. Samples from all cores from all soil zones were analyzed for chemical constituency. On the Tombigbee River, phosphate was found to be prone to downward migration in the soil (Muto and Gunn 1982), while pH seemed to stay in place. By examining the phosphate concentrations at the bottom of the section, we expected to locate areas where humans had chemically altered the soil. In those areas, we proceeded to analyze up the column to locate the relevant strata, presumably with pH anomalies that should pinpoint appropriate levels.

AREA A; TRANSECT WEST TO EAST, PO4 SPOT READINGS ON VERTICAL SCALE

WEST ---------- ELEVATION 100.000 ---------- EAST

FN 10001
100.084 (SURFACE ELEVATION)
--0

(PO_4) 2 - 5 (DEPTH)

FN 10002
99.937
--0

1 - 6
1 -10
2 -15
2 -19
1 -23
1 -26
1 -31
1 -36
1 -40
2 -46
1 -51
1 -56
2 -63
1 -69

FN 10001:

2 -11
2 -16
2 -20
1 -25
1 -30
1 -34
1 -40
2 -47
2 -52
1 -58
1 -64
1 -69
1 -74
1 -79
1 -84
1 -90
2 -94
1 -99
1 -103
1 -107
2 -112
1 -116

VERTICAL SCALE (EXAGGERATED)
--0
--5cm
--10cm
HORIZONTAL SCALE (METERS)
0 ______ 10

FN 10003
99.725
--0

2 - 5
2 -11
1 -16
1 -19
1 -23
2 -28
1 -34
1 -40
1 -49
1 -56
1 -63
1 -68
1 -73

PO_4 Spot Readings
1 = None
2 = Some

Figure 6. *Phosphate Spot Tests for Area A Transect.*

AREA A; TRANSECT WEST TO EAST SHOWING SUBSURFACE SOIL HORIZONS

---------- ELEVATION: 100.000 ---------- EAST

FN 10023
100.007 (SURFACE ELEVATION)
--0

+· - 5
+· -10
+· -15
x
+· -20
+· -24
+· -28
+· -30
+· -33
·+ -36
*+ -42
*+ -47
·*+-52
·*+-56
·* -62
·* -66
·* -73
·* -79
·* -84
·* -88

FN 10002
99.937
--0

+· - 5
+· -10
+· -15
+· -19
x
+· -23
+· -26
x
·+ -31
·+ -36
·+ -40
x
·+ -46
·+ -51
·+ -56
·* -63
* -69

FN 10001
100.084
--0

+· - 5
+· -11
+· -16
+· -20
+· -25
+· -30
+· -34
+· -40
+· -47
·+ -52
·+ -58
·*+-64
·*+-69
·*+-74
·*+-79
x
*+ -84
·* -90
·* -94
* -99
·* -103
·* -107
·* -112
·* -116

FN 10003
99.725
--0

+· - 5
+· -11
+· -16
+· -19
+· -23
+· -28
+· -34
+· -40
·+ -49
·*+-56
·*+-63
·* -68
* -73

VERTICAL SCALE (EXAGGERATED)
--0
--5cm
--10cm
HORIZONTAL SCALE (METERS)
0 ______ 10

· = SAND
* = CLAY
+ = LOAM
x = FLAKE

FN 10022
99.327
--0

*· - 8
+· -14
+· -19
+· -24
·*+-30
* -37
* -44
* -49
* -56

Figure 7. *Soil Texture Observations for Area A Transects.*

AREA B; TRANSECT SOUTH TO NORTH, PO_4 SPOT READINGS ON VERTICAL COLUMNS

SOUTH ---------- /ELEVATION 100.000 ---------- NORTH

VERTICAL SCALE (EXAGGERATED)
--0
--5cm
--10cm

HORIZONTAL SCALE (METERS)
0 ________ 10

FN 10013 99.642 (SURFACE ELEVATION) --0	FN 10011 99.866 --0	FN 10010 99.812 --0
2 - 5	(PO_4) 1 - 5 (DEPTH)	1 - 6
2 -10	2 -11	2 -11
2 -15	2 -16	2 -15
2 -19	2 -22	1 -19
2 -25	2 -27	1 -24
2 -33	1 -31	2 -30
1 -40	2 -38	1 -40
1 -45	2 -44	1 -46
	2 -51	1 -49
	1 -60	1 -55
	1 -70	
	1 -74	

PO_4 Spot Readings
1 = None
2 = Some

Figure 8. *Phosphate Spot Tests for Area B Transect.*

AREA B; TRANSECT NORTH TO SOUTH SHOWING SUBSURFACE SOIL HORIZONS

NORTH ---------- /ELEVATION 100.000 ---------- SOUTH

VERTICAL SCALE
--0 (EXAGGERATED)
--5cm
--10cm

HORIZONTAL SCALE (METERS)
0 ________ 10

+ = LOAM
· = SAND
* = CLAY
x = FLAKE

FN 10010 99.812 --0	FN 10011 99.866 (ELEVATION) --0	FN 10018 99.64 --0	FN 10016 99.511 --0
+· - 6	+· - 5	+· - 7	+· - 8
+· -11	+· -11 x	+· -11	+· -13
+· -15	+· -16 x	+· -16	+· -18
+· -19	+· -22	+· -19	+· -23
+· -24	+· -27	+· -24	+· -29
+· -30	+· -31	+· -29	+· -35
+· -40	+· -38	+· -36	+ -42
+· -46	+· -44	+· -42	*+ -51
·+ -49	·+ -51	·*+-50	*+ -59
* -55	·+ -60	* -52	* -67
	·*+-70		* -73
	·*+-74		* -81

Figure 9. *Soil Texture Observations for Area B Transect.*

Without knowing the nature of the geochemical system of the sites, the exact nature of anomalies or signatures is hard to define. All constituents of that system (which is dependent upon the environment) must be in equilibrium. For instance, phosphate levels are dependent upon the acidity of the soils. If the soils are very acid, a minute trace of phosphate might be very important. To assist in this analysis, the chemical nature of offsite soils was examined. Also, the last two millenia have seen a great deal of climatic variation, and it is likely that Soil Horizon A2 is a reasonable estimate of the surface soils of the past. In a sense, we would like to subtract the effect of time on the lower horizons by examining the difference between Soil Horizons A2 and IIB.

Selected results of the chemical tests are illustrated for discussion. Figure 10 shows the results of the bottom of hole pH tests. Figures 6 and 8 are downhill transects of phosphate determinations. The methods used for these determinations are discussed in Appendix A.

Phosphate Ion Distribution in Soils (Gunn, Lewis)

As is often the case, anticipated and actual results diverge and suggest reformulations of plans and models. Surface sediments in the Eagle Hill locality were much more porous than we had envisioned in our planning and the bedrock much more impermeable. This situation led to a re-examination of our soil chemistry research design. Because of the pH and porosity of these surface sediments, we came to expect significant downward migration of the phosphates. However, there was some chance that the phosphates would be bound in place (either by iron or by the clays at the bottom of the section) and therefore not migrate laterally, once they had descended from the surface sediments.

The prospect and character of phosphate binding is discussed in the literature. Other researchers have found that the native phosphate distribution in soil profiles depends upon the degree of development and the composition of the soil (Smeck 1973; Sjoberg, Smeck, and Runge 1971). The extent and rate of phosphate elevation depends upon the pH (soil acidity) and the Eh (oxidation-reduction potential) of the soil (Patrick and Khalid 1974). In systems containing iron, aluminum, and calcium, phosphate ions are most soluble at pH 7. For archaeological studies, the pH must be greater than 5.5 (Sjoberg 1976). For anaerobic, low Eh conditions, phosphate will be mobile at somewhat lower pH values.

The formation of an alluvial phosphate concentration at the soil C-horizon (equivalent to our clay bedrock contact) is commonly observed. Whether or not this is modified, when associated with anthrosols (such as occur in archaeological sites), has not been established. The relative rates of phosphate dissolution from various soils have been studied by Olsen (1975). The interaction of clay minerals with phosphate in soils and sediments has been studied by Nriagu (1976) and Viellard, Tardy, and Nahon (1979).

The basic questions at Eagle Hill relate to the rate of movement of phosphate in soil in the time frame of the anthropogenic modification of soil phosphates. Eidt (1977) was able to show that phosphate concentrations in the upper 50 cm of soil, which reflected anthropogenic activities to 700 B.C., were preserved.

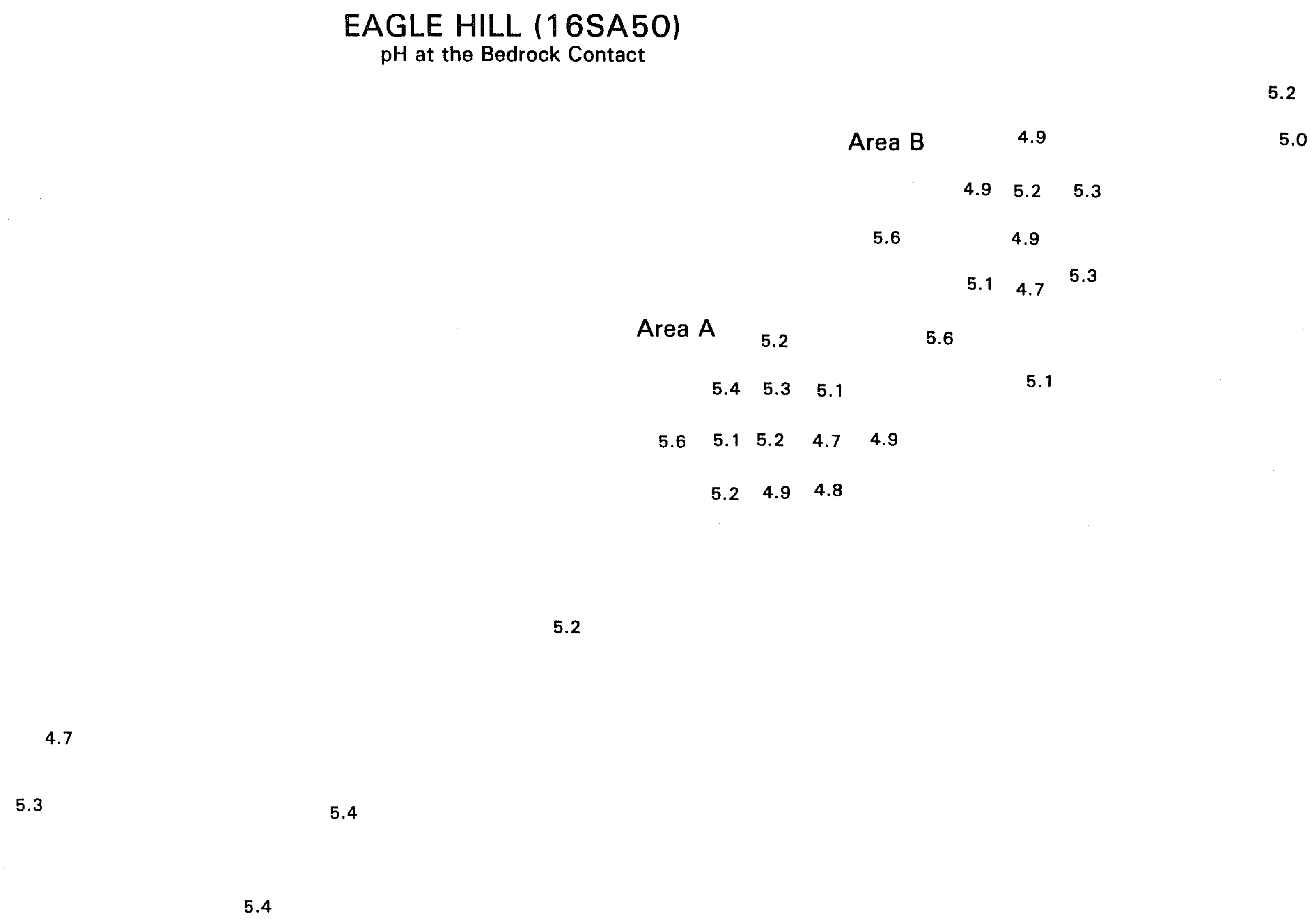


Figure 10. *pH Read with Test Strips at the Clay Bedrock Contact.*

The evidence from this work strongly suggests that man's influence will be most evident in the near-surface soils or in those now buried that were directly affected by man's activities. Cultivation of plants can reduce the phosphate concentration; burials, human and animal wastes, and food processing can increase the phosphate concentration.

To incorporate this information into the research design, the highly migratory properties of phosphate suggested first analyzing the bottoms of bore samples. Where high phosphate concentrations are found, we might readily expect significant sites above the bore hole bottom.

Given the probable seasonality and brief span of camps on top of Peason Ridge, the sandiness of the soil suggested that pH would not be a particularly useful indicator. On the other hand, pH was expected to provide us with some interesting information on phosphates. Phosphate is most soluble at pHs of 5.5 and 6.5. If the pH was in this range, we could expect phosphate to migrate down the section. If the soil was more alkaline, perhaps greater than 6.7, then the phosphate could be locked in the section and indicate the levels in which occupation would be found. As Figure 7 shows, pH in most parts of the site falls within the range at which phosphate is highly soluble. There appears to be no significant lateral differences in the distribution of pH.

Since the pH indications seemed to be rather indeterminate with respect to the research design, we undertook phosphate tests in several columns that seemed to be most critical. As Figure 6 shows, there are concentrations of phosphate in the Area A section. An expectable concentration occurs in the undisturbed humic zone on top of the mound. To the west in the stump hole, this zone is understandably truncated. A comparison of Figures 6 and 7 indicates a concentration of phosphates near the bottom of the sandy loam. This horizon eventually proved to be our densest occupation at the site. It is also about 1000 years old, apparently within the staying duration of the phosphates.

Figures 8 and 9 show a similar set of data for Area B. Phosphate readings were generally higher in Area B as compared to Area A. Interestingly enough, the high readings are toward the surface with no concentration at the bottom. As in Area A, the high readings are associated with the upper layer of sandy loam. We take this to support the geomorphologist's belief that Area B is a very recent development and equivalent to the sandy loam on top of the Area A mound.

The two bore holes (to the left in Fig. 10) suggest a concentration of phosphates at the contact between the colluvium and the Miocene lake sediments. This is the horizon from which the Paleo-Indian occupation was excavated. Whether the phosphates are there because of the Paleo-Indians or because of downward migration of phosphates is unclear. Using phosphate fractionation, a more detailed study, might determine the source.

The highest point of the mound is located over the deepest part of an apparent basin in the Miocene lake sediments/Pleistocene weathered Soil Horizon IIIB. Taken together with the impermeability of the lower sediments, the basin may have formed a tiny aquifer that fostered surface vegetation and accounted for the existence of the Eagle Hill II mound.

Conclusions

The bore hole operation familiarized us with the subsurface sediments of Eagle Hill. It showed that there were concentrations of phosphates, which eventually proved to contain important occupation horizons. Peason Ridge had been eroded to the Pleistocene soils and pockmarked by erosional remnants, some of which contained cultural material. These were Areas A and B of Eagle Hill II.

B. TESTING

In the original proposal an extensive testing program was scheduled for the end of the summer. However, our augering operation revealed that most of the area on the ridge between erosional remnants was eroded to the Miocene clay and therefore devoid of cultural material. We augered some of the erosional remnants in the vicinity of the site to determine their character. The soil was generally very sandy and bright yellow, in contrast to the darker colors of the soil horizon in the site. This, coupled with their less advantageous positions relative to the southward flowing gully, which reportedly carries water from seasonal springs, suggested that occupation in the more distant erosional remnants was unlikely.

Additionally, the 50-cm test pits that Servello used for his subsurface survey were found on virtually every prominence on the ridge for miles around. It seemed that the resources of the project could be better spent excavating the Area A mound rather than duplicating Servello's testing operation. IAS officials agreed.

Given this situation, testing was limited to Area A and the environs of Area B. The excavation of 4 m^2 in Area B amounted to little more than a test. Area B was determined to be geomorphically equivalent in age to the upper soil horizon in Area A. A control column similar to the one in Area A was excavated (see Project Methodology). Its artifacts were examined, but none were diagnostic and the occurrence of flakes low. Three more 1-m^2 units were excavated in arbitrary levels. No more spectacular materials appeared in this control column, and the effort was abandoned with IAS approval. The information to be obtained from the Area A mound was again judged more valuable.

C. OBSERVATIONS ON SITE LOCATION ON PEASON RIDGE (Gunn, Brown)

Our efforts were concentrated on exploring the Eagle Hill II site. However, living and working in the area through the summer provoked some thoughts on the location and preservation of sites on Peason Ridge. The model is not very sophisticated and certainly not very well tested. However, given the availability of literature concerning the region, it seemed advisable to make these observations a matter of record so that they stand as testable hypotheses. We will deal with five basic concepts ranging from specific locational phenomena to general site patterning on Peason Ridge. These concepts constitute the beginnings of a site-location model that explains the locations of sites and the reason for their existence by means of geomorphic and/or cultural causes. This model is elaborated in the section on site catchment.

Erosion is a key element in locating sites. Several aspects of erosion are pertinent. As discussed in the section on geomorphology and soils, natural erosive forces were well under way before the advent of Europeans. However, deforestation during this century appears to have accounted for the bulk of the erosion now evident. In combination, natural and man-made erosion accounts for the destruction of most of the colluvial land surfaces that once probably contained evidence of human occupation. The result is a relatively unbroken underlying Miocene clay surface upon which rest erosional remnants of colluvium, some located in culturally favored areas and some not.

The confinement of archaeological remains to prominent erosional remnants appears to be quite concise. For instance, because surface sediments have eroded into the Miocene clays, the zone between Area A and Area B in the Eagle Hill locality is devoid of artifactual material. In areas not marked by erosional remnants, most of our tests showed only a thin veneer of recent sands over the Miocene clay.

In addition to normal erosional processes, Peason Ridge was, and still is, plagued by a peculiar variety of soil disturbances generated by the removal of large tree stumps. According to J. Grafton, the virgin pine forests were logged during the early part of this century. After World War II, the stumps left by these earlier logging operations were bulldozed to recover gums, resins, etc. These operations left gaping holes in the landscape that are still being healed by the movement of nearby sediments into the voids. Such scars exist within the perimeter of Areas A and B and contribute to the diminished size of the sites.

Given that Peason Ridge is dotted with erosional remnants, there appear to be areas favored for occupation and others not. The proximity of the Eagle Hill locality to a possible seep spring is of interest. We tested a few of the mounds proximate to the known archaeological sites and found no archaeological materials. Servello (n.d.) appears to have followed a similar procedure with 50-cm test pits. When his data become available, it will be interesting to see if a similar lack of occupation is found in the mounds adjacent to the site. Our auger test also showed that there were no buried soils or soil structures in the extraneous mounds, and that these sands were a bright yellow color not found in the remnants evidencing human occupation.

While augering various mounds, we noticed that water stood in the bottom of the auger holes placed in erosional remnants, but not in holes adjacent to mounds. Several possible explanations can be made: (1) capillary action in the mounds draws water up to a higher level in the remnants; (2) the Miocene clay is sandier and more porous under the spots where the mounds are located; or (3) the mounds are located in basins in the Miocene clay. Whatever the reason, it seems quite likely that the erosional remnants can be accounted for, at least in part, by favorable conditions for erosion-preventing vegetation. There appears to be some support for the latter two arguments, because of the enhanced status of vegetation on remnants. In any event, the possibility exists that the location of archaeological sites on erosional remnants is independent of the existence of the remnants, and it is only by good fortune that prehistoric remains appear in occasional remnants. In other words, the remnants are not occupation mounds, but mounds which happen to contain pieces of once continuous living surfaces.

Given the elevation of sites, it seems likely that the force controlling the location of archaeological remains in this milieu is the presence of water. Sites should, therefore, be located in erosional remnants near existing or relict streams or springs.

D. PROJECT METHODOLOGY

Paleo-Indian Site Excavation Design and Method in the Eastern United States (Brown)

Introduction

In the fall of 1979, it was decided to pursue the matter of selecting a Paleo-Indian site for excavation during the 1980 UTSA Archaeological Summer Field School. Our intentions were to be as innovative as possible in our excavation methodology. However, we were also interested in the compatibility of data. A study of previous methods of excavation was undertaken. Twenty Paleo-Indian and Early Archaic excavations (Table 1) spanning the last four decades and more than two thousand miles from eastern Texas to central Nova Scotia were examined from a technical point of view to ask the question "Is there a better way?"

TABLE 1. SITE REPORTS EXAMINED IN THIS REPORT

Rodgers Shelter, Missouri	(McMillan 1976)
Rose Island, Tennessee	(Chapman 1975)
Thunderbird, Virginia	(Gardner 1974)
Brand, Arkansas	(Goodyear 1974)
Wells Creek, Tennessee	(Dragoo 1973)
John Pearce, Louisiana	(Webb, Shiner, and Roberts 1971)
St. Albans, West Virginia	(Broyles 1971)
Hatchery West, Illinois	(Binford 1970)
Habron, Virginia	(Rodgers 1968)
Debert, Nova Scotia	(MacDonald 1968)
Holcombe Beach, Michigan	(Fitting, DeVisscher, and Wahla 1966)
Hardaway, North Carolina	(Coe 1964)
Wolfshead, Texas	(Duffield 1963)
Eva, Tennessee	(Lewis and Lewis 1961)
Jake Martin, Texas	(Davis and Davis 1960)
Quad, Alabama	(Cambron and Hulse 1960)
Silver Springs, Florida	(Neill 1958)
Brohm, Ontario	(MacNeish 1952)
Starved Rock Archaic, Illinois	(Mayer-Oakes 1951)
Parrish Village, Kentucky	(Webb 1951)

For many years, American archaeology has nurtured the association between the early Paleo-Indian hunters and the western United States. Two principal factors have supported this association. The first is simply the early and dramatic discoveries of the first recognized Paleo-Indian remains on the fringes of the High Plains. This first and oldest mystique has penetrated the literature to the degree that it has returned in a kind of circular defense for western Paleo-Indian origins. The Paleo-Indian pattern of life is more than a few spear points and dead elephants. It is a projection of these cultural associations into the kind of environment where we have found them, the High Plains. Yet Gordon Willey (1966:480) argues for a High Plains origin for Clovis peoples because their ". . . pattern of life seemed best adapted to the kind of environment which has been reconstructed for the High Plains in the Late Pleistocene . . . ."

The second important factor is the correlation between the earliest well-documented Amerindian remains and their supposed route of migration. This makes a very nice theoretical picture, but the correlation is not strong and may be even less significant. Not only is the concept of an ice-free corridor questioned (Fladmark 1979), but there are an increasing number of claims for pre-Clovis sites (Stalker 1977; Adovasio *et al.* 1978; MacNeish 1973; Reagan *et al.* 1978).

The presence of Paleo-Indian artifacts in the eastern United States has long been recognized (Roberts 1938), not just as occasional occurrences, but in quantities that far outnumber finds of western specimens (Willey 1966:48). One eastern archaeologist has gone so far as to postulate an eastern origin for the Clovis tradition (Dragoo 1976). Whether one accepts such a speculative hypothesis or not, it is clear that interest in the eastern Paleo-Indian tradition is growing (Newman and Salwen 1977).

The growing interest in the eastern Paleo-Indian is paralleled by a growing interest in eastern Paleo-Indian sites and the special problems they present. Some of the more perplexing problems include the vast majority of projectile points as surface finds, very few radiocarbon dates associated with these finds, almost no faunal evidence (many of these sites are shallow and not all of the excavated artifacts from good subsurface contexts), a greater degree of variability in eastern fluted point styles, and fluted point styles persisting longer in the East, perhaps into the Archaic. Clearly, these problems are not unique to eastern Paleo-Indian sites; they plague archaeologists working everywhere in every period. Ultimately, practical solutions that arise from Paleo-Indian research will find a much wider application.

Research Design

When dealing with the eastern Paleo-Indian question, the serious need for relevant data is generally justification enough for excavation of the sites reviewed below. To excavate a site "because it is there" may be a somewhat questionable methodological approach in later and better known periods, but there is at least some support for this approach to rare and rapidly vanishing Paleo-Indian sites. On the other hand, the lack of a clear picture of what kind of data is needed or desired from a particular site may result in the inefficient and even possibly inordinately destructive collection of data.

This is perhaps a harsh judgment and one certainly biased toward more recent excavations where explicit research design and problem orientation is becoming standard. It is tempting to state that this is a problem in excavation techniques rather than research design, and that more careful techniques are requisite, so that no data are lost. Certainly the more careful the excavation the better, but perfection is impossible. A number of constraints are present, such as time and money, as well as excavator experience and popular excavation methodology. In the recovery of certain selected or preferred data, it is invariably the case that other data are lost or destroyed.

Extreme examples of selected data recovery are not terribly uncommon. At the St. Albans site (a deep, stratified site in West Virginia), Broyles (1971:11) implicitly commits herself to the relatively common "deeper is better" research orientation when she bulldozes 30,000 cubic feet of Middle Archaic deposits in order to begin the third season of excavation closer to the Paleo-Indian paydirt. No justification is offered, although the site is being gradually destroyed by erosion from the dammed Kanawha River.

These violent examples are the tip of the iceberg of selective data recovery. Almost every archaeological recovery technique involves a trade-off of some sort. Such common practices as the use of 1/4-inch screen instead of 1/8-inch or window screen or perhaps just the use of dry screen techniques in place of water screening can greatly influence the amount and kind of data recovered. It is clear that within such limitations, every excavation is guided by at least an implicit interest in the collection of certain kinds of data before other kinds. This implicit interest can be derived from an analysis of the excavation procedures, but the careful statement of an explicit research design often makes this derivation unnecessary.

Hypothesis Testing

It would be most inappropriate for any discussion of archaeological research design to skip over hypothesis testing and the new archaeology. If, over the past two decades, the concept of research design and the new archaeology have become almost synonymous in the minds of a few archaeologists, the technique of formal hypothesis testing is even more so. At no Paleo-Indian site in the East is this concept more closely approximated than in the report of excavations at the Brand site in Poinsett County, northeastern Arkansas (Goodyear 1974).

In his research design, Goodyear (1974:6) states that he intends to go beyond the usual approach to Dalton tools as indicators of the temporally and spatially bounded Dalton culture. Following the excellent discussion of prior research related to the Dalton culture and the problems therewith, Goodyear (*ibid.*) details his intentions at the Brand site:

> The immediate problem to be investigated at the Brand site was an exploration into Dalton lithic technology designed to pursue not only customary form and style of stone tools, but also to reconstruct manufacturing systems and the specific functions of Dalton tools. It was assumed that by regarding lithic technology as a sub-member of a larger energy-extracting system other

> aspects of prehistoric behavior would also be illuminated. At a more hypothetical level the field and laboratory research design was intended (1) to test certain hypotheses presented in the settlement model constructed by Morse (1971), which provided certain filed expectations to be verified, and (2) to generate other hypotheses that could be tested once certain formats of data were recovered, namely activity loci.

Goodyear's (1974:19-33) reconstruction of the manufacturing systems and specific functions of Dalton tools results in one of the most informative sections on lithic analysis in a group of papers that is heavily oriented to lithic analysis. The manufacturing strategy involved in producing *Dalton* points is examined in detail, and a theory proposed by Dan Morse outlining the steps produced by resharpening is analyzed statistically. His conclusion may be essentially correct, but his discussion is hampered by his awkward mathematical attempts to divide an approximately continuous set of points into three discrete categories, and then to statistically prove the existence of the categories. Although there is no proof that his categories are incorrect, it appears that what his analysis of variance has done is prove that the low ends of a normal distribution bell curve are statistically different from the center, rather than prove the existence of three separate groups, as he had wanted.

His attempts at defining the functional framework of the Dalton tool kit are nicely done. It is one of the best examples of Paleo-Indian stone tool wear analyses. The sole difficulty is the heavy reliance either on speculation of function or on Semenov's (1964) classic text, either directly or indirectly through Wilmsen (1970) and MacDonald (1968). This has to be overlooked, however, since Semenov's work was the only comprehensive treatise on wear analysis available at the time.

In regard to certain hypotheses formed from Morse's settlement model, one finds that only one prior settlement hypothesis was actually tested. This hypothesis states that the site was utilized exclusively as a temporary hunting-butchering station (Goodyear 1974:104-107). The hypotheses generated during the excavation were restricted to three competing explanations of the relationships between the living floors and activity areas excavated at the site. Emphasizing the central theme of the tested hypothesis, Goodyear and the new archaeology are able to give dramatic proof of site function (a temporary hunting camp) on the basis of functional classes of artifacts (scrapers and projectile points).

The latter point is a grossly unfair simplification and ignores the many strengths of the report, but it does point to one common flaw in the hypothesis-testing technique--a tendency toward oversimplification. This tendency is probably nowhere better illustrated than in the report of the first season of the Palmetto Bend Reservoir test excavations (McGuff 1978). For the central Texas coastal region, where ethnohistoric documentation and a relatively clear artifactual sequence indicate a long tradition of hunting and gathering, McGuff generates test expectations to prove that the precontact peoples were hunters and gatherers.

Limited Excavation Strategies

At the opposite end from the explicitly stated research design are various implicit research designs. The most common example is probably the limited excavation strategy in which the excavator clearly approaches the site with the intent of recovering only that subset of data which is of particular interest to him. More often than not this design is implicit (as in the case of Broyles's bulldozed Middle Archaic zone), but it can be more or less explicitly stated. Goodyear (1974), for example, states his particular interest in the subtitle of his report (*A Techno-Functional Study of a Dalton Site in Northeast Arkansas*), and that interest is maintained throughout. Despite the fact that Dalton materials are most numerous, there is some indication of a rather long sequence at the site, including at least 37 Late Archaic projectile points and a Late Woodland house floor. The space allotted to these later occupations is equivalent to one page in a 111-page report.

Goodyear's excavation strategy can best be described as horizontal. He was interested in intrasite patterning and clearly succeeded in obtaining exactly what he wanted--a plan view of a Dalton campsite. His intense concentration on the Dalton floor makes this an extreme example, but in any case, the shallow nature of deposits at the site (ca. 50 cm) might make a stratigraphic orientation impractical.

Impractical or not, the vertically oriented excavation of shallow sites is not uncommon. In many respects, the Wolfshead site in the McGee Bend Reservoir of Texas (Duffield 1963) is like the Brand site in northeastern Arkansas. Like the Brand site, the Wolfshead site is a shallow site overlying a basal clay soil. In both the upper third or more of the profile is a plow zone, and in both, some artifacts have worked down into the lower "sterile" clay stratum. The most important differences are the interval of eleven years and a wholly different approach to understanding the site.

The orientation of the excavations at the Wolfshead site is antithetical to the "new archaeology" approach used at the Brand site. Whereas Goodyear's primary concern was horizontal patterning, Duffield's was vertical patterning. Culture chronology and the projectile point sequence are the emphasis at the Wolfshead site. Given the inherent limitations of the depth (2-1/2 feet) and its plowed and sandy nature, this was certainly a valid, although difficult, goal. Not that Duffield ignores horizontal patterning. He is quick to point out the significant differences between two major areas of the site (Duffield 1963:9). His concern for the horizontal interpretation, however, is similar to Goodyear's concern for the upper zones of the Brand site. It is hard to say if the approach taken toward horizontal excavation of the Brand site would have been useful in the mixed strata of the Wolfshead site, but the similarities between the sites make for interesting speculation.

At the Wolfshead site, a lack of depth at the site and the definition of cultural zones with arbitrary strata account for the mixing of cultural materials. Where natural strata are nonexistent or difficult to follow, it may be necessary to devise other means. At the Late Archaic Berger Bluff site in Goliad

County, Texas, for example, the definition of cultural strata was assisted by the calculation of depths below a previously recorded set of surface elevations using a standard three-dimensional provenience (Brown 1983).

In certain cases, the definition of cultural strata might be carried to ridiculous extremes. At the Silver Springs site (a deep Paleo-Indian site in Marion County, Florida), the horizontal provenience of artifacts was recorded only by their respective 5 x 5 or 10 x 10 foot excavation unit, yet for every artifact and flint chip found, a depth from surface was recorded (Neill 1958: 36). Not surprisingly, the artifacts from the site form a series of discrete cultural strata.

Deep sites lend themselves beautifully to the eliciation of cultural strata and nicely drawn projectile point sequence charts. It would be impossible to ignore the potential for vertically oriented data recovery provided by such sites as St. Albans (Broyles 1971). In fact, for the St. Albans site, which has 40 feet of beautifully defined natural strata, there are two projectile point charts and an appendix of point types, which is a miniature version of the type descriptions in the *Handbook of Texas Archeology* (Suhm and Jelks 1962).

Horizontally and vertically oriented strategies are not mutually exclusive. Ideally, one should consider both in a thorough site analysis. Usually the data from most archaeological sites are presented in one or the other format. Deep sites are always presented as vertical records of cultural change through time; shallow sites are depicted as campsites of whatever phase or age found just as it had been left.

The break between these two types of sites occurs at about a meter's depth, although there are a few exceptions. One is the Wolfshead site, where Duffield (1963:5) searched for vertically oriented data in less than two feet of culture-bearing sediment. Undoubtedly, the most successful is the Hardaway site in North Carolina, where Coe (1964:59, 81-83) found four distinct Early Archaic or Late Paleo-Indian phases in 2-1/2 feet of sediment. More than 10 years before either author had puzzled over their tightly compacted vertical stratigraphic problems, the ultimate in shallow-site vertical orientation had been demonstrated. At the Parrish Village site in Kentucky, Webb (1951:24) found no culturally relevant stratigraphy and no significant differences between the artifact assemblages in his levels. Undaunted, he separated Archaic artifacts using his experience at other Archaic sites within the area and called the rest Paleo-Indian.

The two exceptions to the unidimensional excavation strategy include the Eva site in western Tennessee (Lewis and Lewis 1961) and the Thunderbird site in Virginia (Gardner 1974). The latter site, with just over a meter of cultural deposits (39 to 42 inches), falls predictably and heavily into the vertical category. Gardner (1974:13-17, 36-41) discussed eastern Paleo-Indian phases and the transition into the Early Archaic as they are reflected in the stratigraphy. Gardner (1974:20) also described and illustrated what he believed to be a Paleo-Indian structure, indicated by post molds and a quantity of typical Paleo-Indian jasper chipping debris. In a later article within the same volume, Gross (1974) discusses clusters of chipping debris found on apparent occupation floors. At the Eva site, with a maximum of approximately two meters of cultural deposits, the orientation is clearly vertical. Nevertheless, a plan map of each stratum with the location of burials, features, and concentrations of animal bone is also included (Lewis and Lewis 1961:6-14).

Multidisciplinary Approaches

Another approach to the problem of what to do with a site is the compendium of multidisciplinary studies. This approach is relatively recent and not yet common. In the present group of 20 studies, ranging in date of publication from 1951 to 1976, only four studies could be classified as truly multidisciplinary. All were published after 1965 and make up more than a third of the studies published during this latter half of the span.

The earliest multidisciplinary study of an eastern Paleo-Indian site was published in 1966 as a special issue of the journal *Quaternaria* and was devoted to the Debert site in Novia Scotia. In this volume, four different specialists present data on the Debert site from their particular perspective (Byers 1966). This attempt is unique in that the actual site report was published two years later in a monograph series by a single author (MacDonald 1968). Because of this approach, MacDonald does not have to synthesize contrasting views or edit cumbersome multiauthored volumes for consistency.

Other multidisciplinary approaches included those employed at the St. Albans site (Broyles 1971), the Thunderbird site (Gardner 1974), and the Rodgers Shelter-Pomme de Terre site (Wood and McMillan 1976). The latter is by far the finest, presenting a well-organized series of distinct studies that generally follow a logical order and are synthesized at different levels of analysis. The other two suffer from problems of presentation and synthesis.

Broyles's (1971) own report takes up half of the volume in the St. Albans report. It is balanced by five appendices, one of which (another one-fourth of the volume) is her own. Although there is some confusion resulting from discussion of changes in methodology (discussed below), there is a relatively coherent and detailed description of how the site was dug. Gardner's (1974) report leaves much of this to the imagination. In addition, his synthesis takes up one-third of the edited volume, yet does not adequately describe the work that has been attempted. A critical difference between the reports is that Broyles summarizes the lithic tools herself, while in Gardner's report, the summary is spread among four different authors with four different approaches and no real synthesis.

The Thunderbird site report exhibits one important aspect that is not a part of the other multidisciplinary studies reviewed here. The data on this important early site are presented in a small-scale regional framework. Included in the report are data on the excavations of two other sites, as well as a consideration of local jasper sources and regional environmental records. Although this attempt is perhaps a bit too ambitious for the single Flint Run volume, the importance of putting a site in its proper cultural-geographical context should not be minimized. One other nonmultidisciplinary study takes a similar approach. In the same volume with a report on the Hardaway site, Coe (1964) integrates a multisite excavation design into a description of regional culture change.

Excavation Methodology

Whatever approach to excavation planning and design or incorporation of external studies one adopts, actual excavation eventually becomes a reality. At this point, the significant difference between studies with a carefully stated research design and those without is a set of explicit guidelines that assure that the data collected will be applicable to a particular set of research problems. The use of any prior design does not, however, guarantee excavation quality. This must be judged independently.

Unit Location

The first, and perhaps the most important, question in the excavation of an eastern Paleo-Indian site (as in any site) is where to dig. This is, of course, not much of a problem in a total excavation. Realistically, however, even moderate-sized sites must be sampled. Although locating this sample has involved everything from random numbers tables to psychic advice, the most common method has been, and still is, the visual examination of the site surface. Excavation units can be located on the basis of highest artifact density, as at the Brohm site in the Thunder Bay District of Ontario (MacNeish 1952), or on the basis of surface topographic features, as at the Brand site (Goodyear 1974:15), where the initial units were located on the highest point of the small hillock that contained the site.

Both of these can work well for shallow sites. Artifact density estimation can be adapted to a quantitative measure of density which satisfies even the most statistically minded of new archaeologists. This technique has only recently been applied to eastern Paleo-Indian sites and is still not common. At the Wells Creek site in Steward County, Tennessee, Dragoo (1973) reports a systematic surface collection of all cultural material. As a result of this collection, he was able to isolate "hot spots," which he believed were foci of aboriginal habitation (Dragoo 1973:7). Systematic surface collections were also used at three sites reported in the volume on the archaeology of the Flint Run area: the Thunderbird site (Gardner 1974), the Fifty site (Carr 1974), and the Rudacil site (Walker 1974).

Although it does contain a preceramic (Archaic?) component, the Hatchery West site on the Kaskaskia River in Illinois is not a Paleo-Indian site (Binford 1970:72-73). It is included here because of the emphasis placed on the use of surface collection at the site. This site, which was situated in a cultivated field, was freshly plowed prior to collection. The site was then gridded into 6-m^2 units, and after a short period of exposure aided by rain, the artifacts in the gridded units were collected. After collection, the plow zone was stripped using a roadgrader and bulldozer; then excavation and recording of subsurface features began. Data from the surface collection and from the excavations showed excellent correlations. The surface collection proved to be not only a valuable indicator of subsurface features, but a valuable asset to the general picture of occupation type and density at the site.

In its application to shallow or wholly surficial components at eastern Paleo-Indian sites, controlled surface collection is considered to be of potentially major importance. It ties in closely with orientation of horizontal-versusvertical excavation. Although there is a clear bias in surface data toward showing the upper portion of a vertical section, the bias may be useful in delineating horizontally distinct artifact concentrations at shallow sites.

Controlled surface collection is the only means of obtaining quantitative delineation of components and activity areas at surficial sites such as the Shoop site in Pennsylvania, which is so thin that ". . . if it were any thinner it would not be a site" (Witthoft 1952:467); the Reagan site in Vermont (Ritchie 1953); or the Bull Brook site in Massachusetts (Byers 1954).

In the excavation of deep sites, surface collections may be limited and even misleading. Brown (1975) discusses some of the problems inherent in sampling deeply buried components. In the relatively rare, deep eastern Paleo-Indian and Early Archaic sites, the approach has been varied. At the Rose Island site in Monroe County, Tennessee, Chapman (1975:17-18) used a backhoe to trench and remove overburden (at least some of which must have contained Woodland materials) from his Early Archaic horizons. At the Rodgers Shelter in the western Ozark Highlands of Missouri, McMillan (1976) combined a large block excavation and a checkerboard pattern of smaller sondages in order to effectively sample this deep and rich alluvial site.

One of the more effective methods of dealing with the problems of deep site sampling has been used at one of the earliest and deepest Early Archaic (Late Paleo-Indian?) sites excavated in the East--core drilling. During the initial season of investigation at the St. Albans site, a geological core-drilling rig was used to take samples from the terraces of the Kanawha River in the vicinity of the site (Broyles 1971:3-6). Using data from these and subsequent cores, the geomorphology of the terraces has been partially reconstructed. This technique was so successful that it was possible to correlate the cultural zones in the excavation unit and the strata observed in core profiles.

Excavation

Despite similarites in orientation and the kind of data sought, there are few similarities in actual excavation technique. Simply put, there are many ways to dig a site. An estimate of the number of ways is the product of the number of archaeological sites multiplied by the number of archaeologists. Fortunately, there is not always a clearly right or wrong way, and many approaches are equally valid. Most of the sites examined have basically sound excavation techniques with only occasional minor problems. Most of these problems may ultimately be due to lack of time or money.

One of the most popular initial excavation strategies is the trench. At least nine of the 20 sites examined use some form of trenching as a prelude to major areal excavation or in its initial stages. Most of the remaining sites had no consistent initial strategy and depended on opening a number of small units or more larger units. Interestingly enough, although trenching is believed to be an old-fashioned means of attacking a site, the mean excavation date of those sites using trenching is 1965.5 or slightly greater than the 1965.25 mean excavation date of the whole population of sites under consideration here.

The Eva site in eastern Tennessee is an excellent example of the use of crossed trenches in large-scale excavations to delimit the area of concentrated occupation (Lewis and Lewis 1961). At two more recently excavated sites, the Rodgers Shelter (McMillan 1976) and the Rose Island site (Chapman 1975), trenches are used to initial advantage. At the Parrish Village site in Kentucky (Webb 1951), crossed parallel trenches were used to block out a number of units for excavation. The most unusual use of trenching was at the Wells Creek site in Tennessee (Dragoo 1973), where the last excavation unit was a 200-foot variable-width trench across the top of the hill on which this extremely shallow site was located.

An extremely important detail of excavation is the method of dividing up the site for excavation. Obviously one large unit would yield data radically different from data from many small ones. This is partially dependent upon the site and the topography. Thus, because of modern disturbances and the discrete nature of the units, it would have been impractical, if not impossible, to dig the Debert site (MacDonald 1968) as one large excavation unit.

There is a slight tendency for the sites that use only one or two large excavation blocks to show an early excavation date. The eight sites, which report this technique, have a mean excavation date of 1961. Two sites, Parrish Village (Webb 1951) and Eva (Lewis and Lewis 1961) use single large-scale excavation blocks. The publication data on the Eva site is misleading, since it, like the Parrish Village site, was a WPA excavation project dug in 1940 (MacDonald 1968:v). The trend away from the single large block is best shown by later sites: the Thunderbird site (Gardner 1974), the Rose Island site (Chapman 1975), and the Rodgers Shelter site (McMillan 1976). All use multiple area excavation strategies.

Although there seems to be a trend away from the use of a single large excavation block, it is recognized that the size and number of excavation units reflect a particular interest in more than just the amount of data collected. As pointed out above, large-scale, contiguous-area excavations yield a different type of data than does an equivalent amount of disjunct smaller units. With less than complete excavation, the smaller units can be successfully utilized to determine the extent of the site and the intrasite trends in spatial variability. The large-scale units uncover microareal patterning, as might be found in a family dwelling or a small-group campsite. An excellent example of the latter kind of microareal variability occurs at the Debert site (MacDonald 1968), where each of the 11 excavation units is believed to contain a spatially bounded cluster of artifacts. A similar situation occurs at the Brand site, where seven distinct artifact clusters are isolated (Goodyear 1974).

Data on these small activity area or campsite features do not always indicate an understanding of the entire site, as at the Brand site where there could be major differences between the defined clusters and unexcavated portions of the site. One solution is the excavation of the entire site or a large portion of it, as Binford (1970) did at the Hatchery West site in Illinois. His approach enabled him not only to define intrasite features, but their larger relationships as well. Another less expensive and less destructive approach is to coordinate large-scale excavations with smaller test units, as at Rodgers Shelter.

Stratigraphy

Perhaps the most important part of the success of an excavation depends upon the presence or absence and the use or abuse of stratigraphy. This is a complex subject and can only be touched upon here in a general way.

At the simplest level, this subject involves the choice between digging in arbitrary or natural levels. Most archaeologists would probably agree that, where possible, the use of natural stratigraphy for excavation control is preferred. This is, of course, not an unequivocal choice. The use of pedogenically derived soil strata, or those soil strata, which may have formed *in situ* after the deposition of the cultural material, may be quite misleading. As a rule, however, depositional strata can be used successfully in cultural-horizon separation.

Postoccupational pedogenic development is displayed in the formation of the Podzol (Spodosol) soil formed at the Debert site. Podzols typically have very distinct horizon separation between the bleached, white Soil Horizon A2 and the reddish brown Soil Horizon B2, yet the estimated time of formation (between 2000 and 4000 years) clearly postdates the 10,600-year-old date of occupation at the site (MacDonald 1968:11). The separation of the artifactual material by such criteria could result in erroneous separations concerning the occupation of the site.

Nine of the sites studied in this report used natural strata as the primary, or one of the more important, cultural-level markers in excavation. In most of the others, natural stratigraphy is recognized and used as an interpretive tool in understanding material from arbitrary levels. If soil stratigraphy is uninterpreted, the potential for error in the interpretation of cultural data increases. For this reason, it is critical to present as much data as possible on the nature and formation of strata when using natural stratigraphy in excavation.

Although sites with clear natural stratigraphy can occur in almost any kind of terrain and in almost any age soil deposit, the best stratified and most easily interpreted of all open sites are deep alluvial sites. As noted earlier, these sites are ideal for the elicitation of temporally or vertically patterned data. Eight of the sites studied in this paper have more than a meter of deposits; six of these are clearly alluvial. These are Rodgers Shelter, Rose Island, Thunderbird, St. Albans, Eva, and the Habron site in Virginia (Rodgers 1968). The nonalluvial deep sites are Silver Springs and the Starved Rock site in northern Illinois (Mayer-Oakes 1951).

The finest example of an alluvial site in the sample is the extremely important St. Albans site in West Virginia. In the main excavation block, a well-separated sequence of 41 alluvial strata containing 18 occupation zones has been delineated. Each occupation zone is separated by one or more strata of sterile clay or sand. A date of 9850 B.P. has been obtained on Zone 36 at a depth of about 16 feet below the surface. Core samples indicate that cultural deposits may extend to more than twice this depth (Broyles 1971:1).

Excavation at the St. Albans site has taken full advantage of this excellent natural stratigraphy. During the first season of major excavations a stratum block was isolated and excavated in natural levels. In subsequent seasons, the stratum block technique was abandoned, but excavation by natural levels was still maintained.

The lack of cultural stratigraphy is a common problem at shallow sites. Mixing by bioturbative processes can totally destroy whatever vertical separation might have existed between components. If separation does exist, it is often impossible to understand vertical relationships in terms of large arbitrary levels. The deposits at the Wolfshead site, for example, show only a vague stratigraphy of projectile points within the five 6-inch arbitrary levels (Duffield 1963:577). Yet these vaguely defined relationships, with Early Archaic *San Patrice* projectile points most common at the base of the sequence and Late Prehistoric arrow points common at the top, seem to be essentially correct.

Shallow sites can be stratified, however, although it may not always be obvious at first. The initial excavation units at the Brand site (Goodyear 1974:15) were placed in the highest and most disturbed portion of the hill where the site is located. Although some *Dalton* points were recovered, no stratigraphic relationships were recognized. Later, test units placed on the sides of the small hill were able to discern the natural stratigraphy used throughout the remainder of the excavations and were critical in separating the material identified as lying on the Dalton occupation floor.

At the John Pearce site in northwestern Louisiana, the decision to switch from arbitrary to natural vertical units was a simpler one. After only two small units had been excavated the natural stratigraphy was recognized, and natural levels were adopted (Webb, Shiner, and Roberts 1971:4). At other sites, this decision may not come so easily. After 23 five-foot-square levels failed to reveal any cultural stratigraphy at the Hardaway site in North Carolina, excavation was shifted to natural stratigraphy. Coe (1964:60) had concluded that ". . . any further excavation by arbitrary levels and in single isolated units was a waste of time and a destruction of potential data."

Reporting

The most important and most ignored aspect of excavation methodology is accurate reporting of the actual methods and techniques used. Without some data on the techniques of excavation, it is often impossible to assess the validity of cultural interpretations at a given site. This seems especially true in the case of the eastern Paleo-Indian sites where there are still large gaps in our understanding of the cultural relationships. Rather than being tested against a coherent, previously formulated cultural model (which is implicit in many excavations), eastern Paleo-Indian studies appear to be only now falling into a unified pattern. Most of the reports considered were involved in the formulation of that model in their particular region, and thus, our knowledge of the eastern Paleo-Indian is almost totally dependent upon the quality of excavation techniques utilized in these particular excavations.

This is not a consoling thought, because if there is any problem which is common to these diverse sites, it is the inadequate or only barely adequate reporting of excavation methodology. Few reports fail to expound on their particular theory of the origins and developments of eastern Paleo-Indian culture, but fortunately, almost all provide some information on the actual excavations. Few actually provide the data necessary for judging their interpretations.

There are several important variables that influence the quality of reporting. Perhaps the most important is the organ of publication. Invariably, reports published as monographs are of higher quality than those in journals. This is largely because of severe space limitations placed on journal articles, compounded by the fact that more detailed excavations are rarely published as journal articles (at least not in primary site report format). Four of the six journal articles reviewed here were authored by amateurs.

This latter distinction is not a universal rule, however. The John Pearce site in Caddo Parish, Louisiana, is a fine exception to the amateur authorship. This report, authored by two amateur archaeologists and one professional, was published in the annual *Bulletin of the Texas Archeological Society*, and, offers an adequate, if somewhat condensed, description of procedures (Webb, Shiner, and Roberts 1971:4-6). When comparing between the professional and amateur journal articles reviewed here, it is apparent that perhaps the worst of the lot, the Wells Creek site excavation, is authored by a well-known professional (Dragoo 1973).

Dragoo's article runs counter to another major trend in reporting excavation details. It seems that, in general, the more recent articles are more conscientious about reporting the fine details on excavation and are more likely to provide supporting physical data, such as soils and geomorphology. The Wells Creek article does contain a very interesting section on the geology of the Wells Creek crater area. The site is located near the center of a hypothesized ancient-meteor impact crater (Dragoo 1973:1-5), a unique situation for archaeological sites in any area. However, that the impact occurred during the late Mississippian geologic period, some 315 million years ago, detracts from its application to Paleo-Indian cultures in the area.

The excavation of the Wells Creek site met with limited success, since no artifacts were found below the plow zone. This limits the potential for vertically oriented interpretations at the site, but it is no excuse for the complete lack of data on excavation method. No information is provided on the manner of excavation or on any screening techniques that might have been used. Only the barest of verbal descriptions is given of the soil matrix, in contrast to another mixed plow zone site (the Plenge site in New Jersey) reported in the same issue of the *Archaeology of Eastern North America* where a tabular reporting of quantitative soils data by a soil scientist is provided (Kraft 1973).

Leaving aside the obvious lack of vertical data, Dragoo (1973:7-8) himself reports the potential of horizontal patterning at the site, yet no explanation of the actual method of defining these patterns is given, and no data on the patterns are provided. No maps of the test unit locations are given, and the verbal description of the areas is insufficient to locate them. No information on individual units is provided, and no proveniences are given for artifacts.

The other professional site report reviewed here is also one of the earliest published articles in the sample. This article (Mayer-Oakes 1951) on the Starved Rock Archaic site in Illinois contains a section on methodology, which is equivalent to most of the amateur articles and is perhaps less detailed than the John Pearce report. Most of the other early sites lack specific excavation details. The Parrish site (Webb 1951) in Kentucky is a good example of this.

At the Parrish site, the description of the methods employed at this seven-month excavation is three-fourths of a page (Webb 1951:410). A verbal description of the layout of the excavation grid is not supported by corresponding maps or photos. It is literally impossible to figure out where the excavation was conducted with respect to the general topography of the site, since no map of the site area is included. A plan view of the greater part of the excavated area shows features and burials, but these are not tied into the site. No estimation can be made of the amount of the site excavated.

Other more modern sites also suffer from problems in reporting excavation techniques. The extremely important and often-quoted Debert site (MacDonald 1968) is a case in point. Where one might defend the Wells Creek report because of its magazine format, the Debert report is published as a long monograph. Yet no section on techniques is contained in the report. The reader must piece together the excavation strategy from short statements throughout the report.

Although excavation was obviously careful, there are no data on screening techniques or excavation control. No data are provided on the total amount of area excavated. All excavation data are given in terms of the 11 areas, which are interpreted as discretely bounded cultural units. Apparently no excavations were conducted in unproductive areas, and all of the remaining site was recovered (a large portion of the site had been disturbed by leveling).

These few examples are only a selection of the more dramatic reporting errors, but they are not unique. As mentioned above, most of the reports are flawed. It should be sufficient to point out that the problem exists, and although, the trend may be toward more detailed reports, there are still problems.

Interpretation

If the reconstruction of prehistoric cultural systems and the formulation of theories of cultural change were not dependent upon data and those data not ultimately dependent upon the quality of data recovery at archaeological sites, this paper would be meaningless. Fortunately, or unfortunately for the profession of archaeology, data form the basis for most valid interpretations. The following section takes a look at interpretation in the light of various forms of data collection.

Obviously, the quality of data collection influences the quality of interpretation. Certain archaeological data-recovery techniques can be measurably improved, and examples of this are seen in the 30-year span of eastern Paleo-Indian studies. An example of a change to a horizontal provenience, such as recorded at the Brand site (Goodyear 1974) in Arkansas, can be more useful in understanding camp and village patterns than provenience to a 10-foot unit, as at the Silver Springs site in Florida (Neill 1958).

Yet there is a limit to qualitative improvement of data recovery. How much more would be gained by digging a site with no natural stratigraphy in one-centimeter levels rather than five-centimeter levels? Or how much more data could be gained by screening all sites through window screen? In certain cases, these might be absolutely necessary procedures, but are the increased time and effort worth the increase in data for every site? The answer to this may lie in site-specific recovery techniques and data-dependent interpretation. Thus, just as it is ridiculous to compute a six-decimal place mean from data collected to one decimal place, it is equally ridiculous to overestimate the interpretive powers of certain recovery techniques.

Vertical Patterning

Vertical interpretations are the ultimate tool of cultural history--the reconstruction of cultural chronologies. As such, they have served a long and useful role in understanding archaeological cultures. More than half of the sites reviewed are directly concerned with the interpretation of vertically patterned data, and the remainder are concerned with the placement of their particular data set within a temporal sequence previously synthesized from vertically patterned data.

A critical question in vertical data recovery is how the data got to be vertical in the first place. This is patently obvious in alluvial terrace sites such as St. Albans or Rodgers Shelter, but less so in many upland sites. Even in alluvial sites, the "deeper is older" hypothesis may be difficult to sustain in some ordinary terrace sequences. The sequence of terrace formation at the Thunderbird site (Gardner 1974:28-33) illustrates this problem. Although the ground surface is essentially level across the terrace sequence, Early and Middle Archaic materials on the lower terrace are much deeper than the Clovis materials on the upper terrace.

In nonalluvial sites, the question of depositional processes should be an important one. In other words, how much of the site depth can be attributed to depositional episodes and how much to bioturbational and pedoturbational processes. In many sites, the lowest occupation is just above weathered bedrock or Pleistocene clays or gravels. A casual reader trying to put all of this data together might come to several interesting conclusions, i.e., that the world is from two to 10 feet thicker than it used to be, and the Paleo-Indians were fond of living on clay and gravels. To some degree this might be true. Those areas where we find buried sites are in continually aggrading areas (at least since the end of the Pleistocene), and there have been major climatic shifts since the end of the Pleistocene which caused soil to form in areas where there had been nothing but gravels for thousands of years. Two other active processes are not always considered as alternatives. One is the continual cycles of erosion and deposition that occur in many areas. The other is the possibility that artifacts might be moved downward by bioturbational or pedoturbational processes.

At the Hardaway site in North Carolina, Coe (1964:57) states that his earliest occupants (Hardaway phase peoples) were living on a two- to three-inch layer of humic soil, which overlies a clay residuum weathered from the greenstone bedrock. It is interesting to note that in very gradually aggrading soil on top of a landform essentially unchanged since the Triassic, two to three inches of soil had developed prior to the Hardaway culture and almost two feet developed subsequent to their departure. A simple calculation shows that the Hardaway culture must date to Jurassic times or approximately 150 million years ago. The Hardaway culture is well bracketed by cross dating to the Holocene, so other possibilities must be considered. Coe suggests that the recent soil buildup is due to human activity. This is possible, but not supported by any analysis of the sediments. Other possibilities are cycles of erosion and deposition, or that the older materials have worked their way down further into the soil. In this particular case, the natural levels used in stratigraphic separation at the site need to be carefully described and documented, and some data on their potential means of formation gathered.

Even in sites where the origin of the sediments is understood, the origin of the vertical patterning in the artifacts might not be clear. At the Silver Springs site in Florida, Neill (1958) outlines a very clear verbal stratigraphic sequence from Middle Woodland period ceramics down to Late Paleo-Indian or Early Archaic *Suwannee* points. The troublesome part of his interpretation is in his identification of the formation in which the artifacts were found: ". . . dune-like, and composed of homogeneous, seemingly windblown sand" (Neill 1958:34). Any archaeologist who has ever dug in pure sand deposits has to be somewhat amazed at the excellent cultural stratigraphy preserved at the Silver Springs site. Some of the problems with mixing in windblown sand sites are outlined in a discussion of the misleading artifactual stratigraphy at the Meer II site in Belgium (Van Noten, Cahen, and Keeley 1980) and the artifact mixing at the Debert site in Nova Scotia (MacDonald 1968:16-20). At both of these sites, identified as single component sites by various methods, artifacts of a single time period had been mixed throughout a half-meter section of the profile. Several deep sandy sites tested in the Coleto Creek Reservoir in the inland coastal region of Texas were also found to have lost any stratigraphic separation of artifacts due to intense bioturbation (Fox, Black, and James 1979:19-24).

One measure of the importance of an undisturbed site is the frequency of statements by archaeologists that their site is undisturbed even in the face of considerable evidence against it. In reality, there are no undisturbed sites, with artifacts lying just as the Indians left them ten thousand years ago. Postdepositional disturbances are a factor to be contended with or at least carefully considered at all sites.

Many deep alluvial sites are only minimally disturbed by postdepositional processes, but one wonders at the potential violence of the actual depositional processes in these cases. At any rate, even they are subject to some post-depositional disturbances. In alluding to the undisturbed importance of the St. Albans site, Broyles (1971:1) points out that, throughout the site, ". . . only one type of projectile point is found in a zone." This kind of data is reassuring when dealing with disturbances, but upon closer reading one finds that she had failed to read her own report. Perhaps she considers the two *Charleston Corner Notched* points and one *Kessel Side Notched* point found on top of the same hearth as the same basic point type (Broyles 1971:10). And, of course, this statement does not apply to the upper zone where a *St. Albans*, a *Kirk*, and a *Kanawha Stemmed* were found together in Zone 4 (Broyles 1971:24, 47), nor does it apply to *Kirk* and *LeCroy Bifurcated-Base* points found together in Level 8, or to *Kirk* and *St. Albans Side-Notched* points found in Zone 11.

The St. Albans site is still unquestionably an immensely valuable site with thousands of years of clearly bracketed cultural sequence. On the other hand, one can imagine the horror of an archaeologist who has just excavated a 20-foot deep alluvial site with beautiful stratigraphy and recovered nearly 200 identifiable projectile points, all of them exactly the same type. If such a situation is impossible in deep sites, it is just as nearly so in shallow sites. There is almost always the question of mixing of cultural groups. A very important exception is the shallow and highly bioturbated Debert site, which yielded 168 projectile points and fragments, all belonging to a single type (MacDonald 1968:70; Hans Mueller-Beck, personal communication). Such is not the case at most shallow sites, however, and many different approaches to separation are taken. In general, they boil down to a single basic method: ignore what you do not want to study and call it intrusive or the product of a transient occupation. In many cases, this may be justified, but the data are confusing. Contrasted to the more than 100 Paleo-Indian projectile points from the Holcombe Beach site in Michigan, there were eight non-Paleo-Indian projectile points found in the surface or in rodent burrows (Fitting, DeVisscher, and Wahla 1966:36, 41). Based on this, Fitting assigns all other flint artifacts to the Paleo-Indian occupation. Fitting is, in effect, ignoring the possibility that the later transient occupations have contributed significantly to the nonprojectile point artifacts. This may be the case, and it is fairly clear that at least 102 basal fragments are from fluted or lanceolate Paleo-Indian point styles. From another point of view, the statistics may be misleading. Only six Paleo-Indian points from the site are substantially complete, and only one of these is "typical" (Fitting, DeVisscher, and Wahla 1966:43), yet at least five of the eight non-Paleo-Indian points are complete. Could there be additional biface fragments assignable to the later projectile point? In addition, the majority were from surface collections by an amateur archaeologist apparently interested in Paleo-Indian remains. The easy dismissal of the eight Archaic projectile points suddenly becomes more questionable.

At the Thunderbird site in Virginia, there is more evidence from the intrusiveness of Late Archaic stemmed points. A series of post molds are assigned to the middle Paleo-Indian occupation, because of the quantity of jasper debitage and two (presumably jasper) middle Paleo-Indian points (Gardner 1974:20). Four Late Archaic points from the same area are of quartzite and rhyolite.

Horizontal Patterning

The concept of horizontal patterning is not a new one. In his report on the excavation of the Parrish Village site in Kentucky, Webb (1951:411)includes a plan map of all features in the excavation area. Yet he makes no attempt to explain it or to search for regularities within it. Less than 10 years later, Davis and Davis (1960:13-14) are actively searching for the horizontal patterning in the artifactual material from the Jake Martin site in east Texas. One suspects that this search, which proved essentially fruitless, was all the more important to them, because of the lack of vertical stratigraphy. A year after the publication of the Jake Martin report, the Eva site report was published (Lewis and Lewis 1961). The plan map presented for each stratum shows not only the distribution of burials, but of features and animal bone concentrations. A glance at these maps shows that intrasite variability was present in most, if not all, of the components. Yet there is no real discussion of horizontal patterning in the text of the report.

One type of horizontal patterning, which was actually observed rather early in the surface sites assigned to the eastern Paleo-Indian period, is the presence of discrete artifact clusters or "hot spots" at sites such as Bull Brook (Byers 1954) and Shoop (Witthoft 1952). This same kind of patterning was observed in the excavated areas at the Debert site.

At Debert, the excavated evidence was gathered to find the solution to a problem in horizontal patterning, which had a long history of speculation. Witthoft (1952:468), in discussing the artifact clusters at the Shoop site in Pennsylvania, suggested that they might be individual camps or hearths within a campsite. MacDonald (1968:134) finally concludes that they are likely to be seasonal campsites or groups not exceeding 30 to 40 individuals utilizing the site over the span of a few decades. This is indeed a strong possibility. It should be noted that he rejects the possibility of a single large campsite, with family or smaller band group hearths, with no adequate reason offered for the rejection.

Actually the evidence is ambiguous. Eight of the campsite areas are located close to one another in the "nuclear area," and all are discrete, separate sections with approximately the same number of artifacts and hearths. The exception is one area almost twice the size of the rest and interpreted as a re-occupation (MacDonald 1968:21-23). Three other areas are set apart and are interpreted as functionally different. Two of the functionally different areas, involved with the production or maintenance of stone tools and crossmends of broken tools, were made between one of these areas and several of the campsite areas.

While such a situation is easily imagined for the same group returning year after year, it makes as much or more sense for a large group to contain functionally specific intergroup work areas. In any case, the verification of the reality of MacDonald's hypothesis is dependent to some degree upon the intersectioned areas and his criteria for definition of these sections. It appears that he tested only in areas where there was a camp. Perhaps this was because he had prior information from some surface data, but the reason for placement of his pits is not stated.

The same problem in interpretation of the function of artifact clusters is encountered again at the Brand site. Here, however, the clusters are much smaller and dubiously separated. While one can visualize a band returning to the same hillside every summer for a decade and camping in the same place twice during only one of those seasons, it is immensely more difficult to imagine the same band of hunters returning to the same small mound (which may not be much larger than the largest artifact cluster at Debert) to butcher a white-tailed deer without the least bit of overlap with any of the 4-10 m^2 butchering areas from previous years (Goodyear 1974:110). On a large hill with widely scattered butchering areas, the chance of overlap in a number of years would be very small; at the Brand site, the actual clusters are considered discrete, but are separated by no more than a meter in any direction from the other clusters. The recognition of these clusters is highly questionable, and to imply function to the clusters must be done with caution.

Conclusions

Each of the subdivisions in this section has pointed out some obvious failing in methodological procedures commonly used on eastern Paleo-Indian sites. As already shown, the problems of eastern Paleo-Indian sites are not necessarily unique. Conclusions drawn here should be applicable to similar sites anywhere. In this last section, some of the earlier conclusions are reiterated in a cook-book format.

The two fundamental rules for the excavation of any site should be to understand the reasons for every methodological choice made in the excavation of a site and to make certain that the choice and the reasons for making it are reported. An explicit research design may facilitate some of the minor choices, but it should never be allowed to limit the research to the point where there is no longer any feedback from the collected data. Research designs <u>should always exist in a state of fluid homeostasis</u> with continual input from completed goals and collected data.

Often, in multiseason investigations, techniques are subject to some degree of evolution. Changes in excavation techniques at the St. Albans site are a good example of this progressive evolution (Broyles 1971:6-14). In this particular case, however, there is a lack of clarity in the description, which makes reader interpretation of the various excavation strategies difficult. This difficulty serves to emphasize the necessity for careful documentation of all techniques and all alterations in those techniques.

Site documentation should not only include reporting of what has been done. It should also include, depending upon the scope of investigations, reports of supporting studies that are written according to the professional standards of that particular discipline. For example, soil profiles, especially when they are used to guide naturally stratified excavations, should not be described as "brown soil" or "yellow sand," but rather in terminology that is acceptable to soil scientists for the description of a profile. Geomorphological investigations should be presented likewise. This is not easy, especially for archaeologists who have no training in these fields or who cannot hire specialists, but is nevertheless essential.

Excavations should be geared to the elicitation of not only temporal, but also spatial data. Vertically patterned data should be interpreted carefully with an eye to possible disturbances and the possibility of faulty strata identification. Wherever usable strata exist, they should be used, but their means of formation should be investigated. The recording of exact proveniences within a given stratum of occupation floor is essential, and the search for potential campsite patterns is extremely important. Chapman (1975:200) indicates an important direction for future horizontal studies in the area of computer graphic displays of artifacts and three-dimensional distribution studies of materials from the Rose Island site.

An obvious trend in increasing quality of data collection and supporting techniques has been observed in the eastern Paleo-Indian studies. This clearly suggests that future excavation techniques will be increasingly better and more data will be recovered. The theme of site preservation is strongly supported here. It is hoped that the recent increases in the number of archaeologists do not actually result in an enormous increase in the number of Paleo-Indian sites so that there will be none left for the next generation of sophisticated methodologies to investigate. However, there are probably enough Paleo-Indian and Early Archaic sites destroyed each month in the United States by various state, federal, and private construction and energy-extraction projects to satisfy the needs of most researchers for many years. It is to those endangered sites that we should concentrate our resources.

E. EXCAVATION ACTIVITIES AND TECHNIQUES AT EAGLE HILL (Gunn)

Sequence of Operations

As was discussed in the section, Preliminary Investigations, one of the primary objectives of the project was to determine the most advantageous locations to excavate. The problem was resolved when it was found that only a 50-m^2 triangle contained the full depth of the section. Apparently the rest had been eroded, graded away for the road which interdicts the site or ripped out by stumping operations to the west. In accord with these findings we centered our operational grid on the highest point on the remnant and began to excavate.

The project proposal called for the excavation of Area B followed by the presumed more difficult excavation of Area A. The complexity of Area A disappeared when we examined the profiles in the field and found that the contacts posed none of the problems suggested by Servello's field drawings. In Area B our subsurface testing showed that the area of consistent depth was relatively large and the phosphate readings consistently high. For geomorphical and strategic reasons, which were explained earlier, excavation of Area B was deferred.

During May, the core crew opened excavations, organized the recording system, and excavated a 1-m^2 control column in the deepest part of Area A. These events foreshadowed full-scale excavation during the month of June. Fourteen persons supplemented the core crew during June. They were sponsored by the UTSA Summer Field School in archaeology provided by the Division of Social Sciences. During this month, the participants mastered a complex excavation technology and, in the process, excavated a 5 x 5 m area in the Area A erosional remnant. The effort was abetted by nearly perfect weather. Only a couple of hours of one day were lost due to a rain shower. With few exceptions, the crew performed as near to professional standards as any novice crew it has been my privilege to observe. Their morale was high, their dedication admirable, and their accomplishments significant.

The trainee crew achieved its optimum pace relatively early in the month in terms of units per day closed. However, it was two weeks into excavation before they reached full proficiency locating and recording artifacts. Most of the time was spent in the upper three cultural levels of the site, horizons which were probably well selected for training since there is some evidence of disturbance. One visitor to the site, John Guy, suggested that the Eagle Hill erosional remnant was an ideal location for an observation-oriented military foxhole. There appeared, however, to be limited disturbance below the humic zone 9.

Figure 11 shows the rate of work over the course of the excavations. The number of field numbers (FNs) issued per week represents a combination of all units opened, artifacts recorded, features excavated, etc. These show healthy increases during the second and third weeks of the field school, level out during the third, and drop during the fourth, because of more difficult excavation in the lower levels. The relatively low projection during early July is a result of several factors: increased rainfall, difficulty in excavation and screening, and profiling and excavation of a geologic environmental soil sample column (see section on High Resolution Environmental Column, HREC). By the end of the field season, a 5 x 6-m block had been excavated in Area A and a 2 x 2-m unit in Area B.

In addition to the block excavation of Area A, three test pits were excavated around Area A to determine the nature and extent of the erosional remnant. The results suggest that there is little beyond the 50-m^2 triangle. There is limited potential to excavate northward from the present block since the lower sediments appear to be deep and intact.

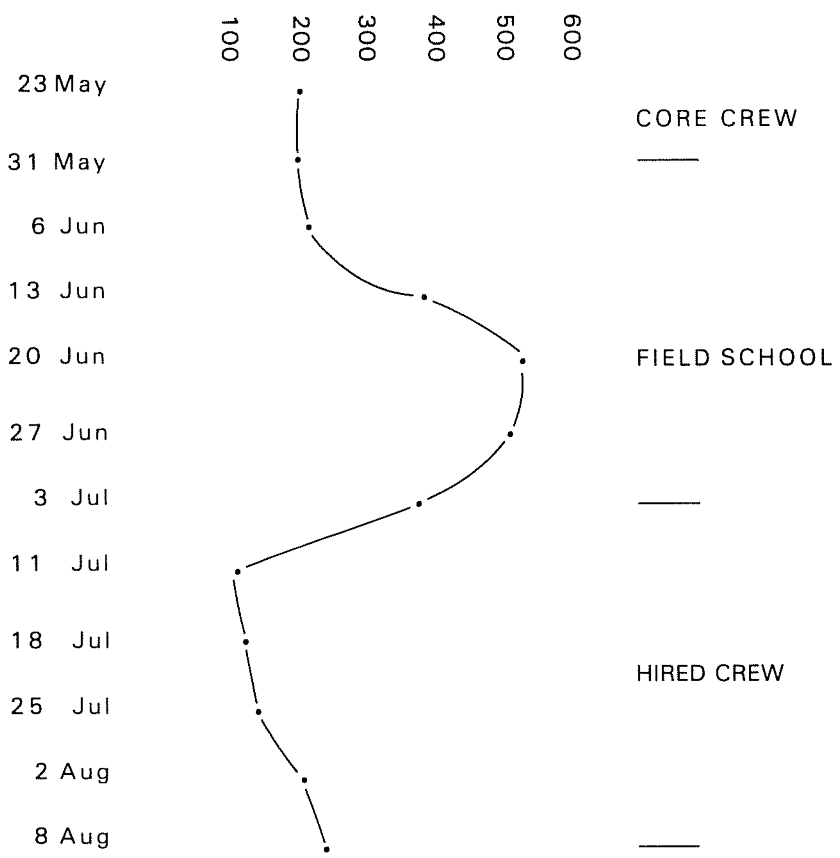


Figure 11. *Number of FN's Issued per Week During the Excavations.*

Geology, geomorphology, and soil development were clarified and expanded by a four day visit from Nials and Ed Garner. This knowledge along with some information gleaned from Servello's testing operation and analysis was combined to develop a vertical sampling procedure, which governed the progress of excavation during the second half of the month.

In July, after the field school, the remaining crew personnel were hired for the duration of the summer. They were forced to deal with the difficult excavation of Soil Horizon IIB23, rains which soaked the lower strata, and increasing humidity, and high temperatures. Temperatures rose consistently above 100°F during the middle of July. In order to give the excavators some relief from the tougher sediments, we opened a 1-m trench along the north side of the 5 x 5-m unit nearly completed in June. This expanded our excavation block to 5 x 6 m and allowed the excavators to alternate between easy and hard digging. Water screening also became a more complex problem. The IIB23 sediments had to be water screened with high water pressure. The Air Force Observation Station came to our rescue by allowing us to process buckets of dirt in their front yard.

The Area B control column was completed in time for a visit from Hession and Carbone on June 17. Examination of the contents of the column suggested that Area B probably was intact as pertains to stratified cultural levels. We had reason to believe, however, that the Area B sediments were equivalent in age to the modern soil horizon in Area A. It seemed to us, and Hession and Carbone, that it would be more profitable to continue to concentrate most of our efforts in Area A. We could expect the same information from Area A upper levels as from Area B in terms of changes in material types and technological and camping habits. By recovering this information from Area A, however, we would expose more of the older sediments in Area A. It was suggested by the government that we open some more squares in Area B with shovels to search for chronological diagnostics, which would support the geomorphological arguments for Area B being relatively young. The opening of three 1-m units revealed no diagnostic artifacts and few flakes.

During the first week of August, removal of the occupation floors immediately above the Miocene clays was finally completed. Difficult excavation and frequent rains during July had considerably slowed the work in the lower levels and caused us to concentrate most of our effort on the sixth meter north in Area A and on Area B. A break in the weather in the first week of August allowed us to complete the excavation. As a result an unfluted lanceolate point and several blades similar to the scraper found earlier were associated with a Paleo-Indian occupation. A High Resolution Environmental Column (HREC) was removed during the latter part of July and the first week of August, which resulted in 94 soil samples (1 x 50 x 100 cm), and a series of 94 pollen/biosilica samples were removed in one-centimeter arbitrary levels. Brown stayed in the Peason area for a week after the close of the field season to collect clay and lithic samples for experimentation and to supervise backfilling the site. The Air Force compound provided a front-end loader and an operator for the backfilling operation.

The Area A excavation was completed as a 5 x 6-m rectangle in all levels except a 20-cm ledge along the north side of the three northeastern units (Plates 1 and 2). The ledge consisted of substrata OP 4.15-4.17. The excavation was lined with plastic tarp before backfilling.

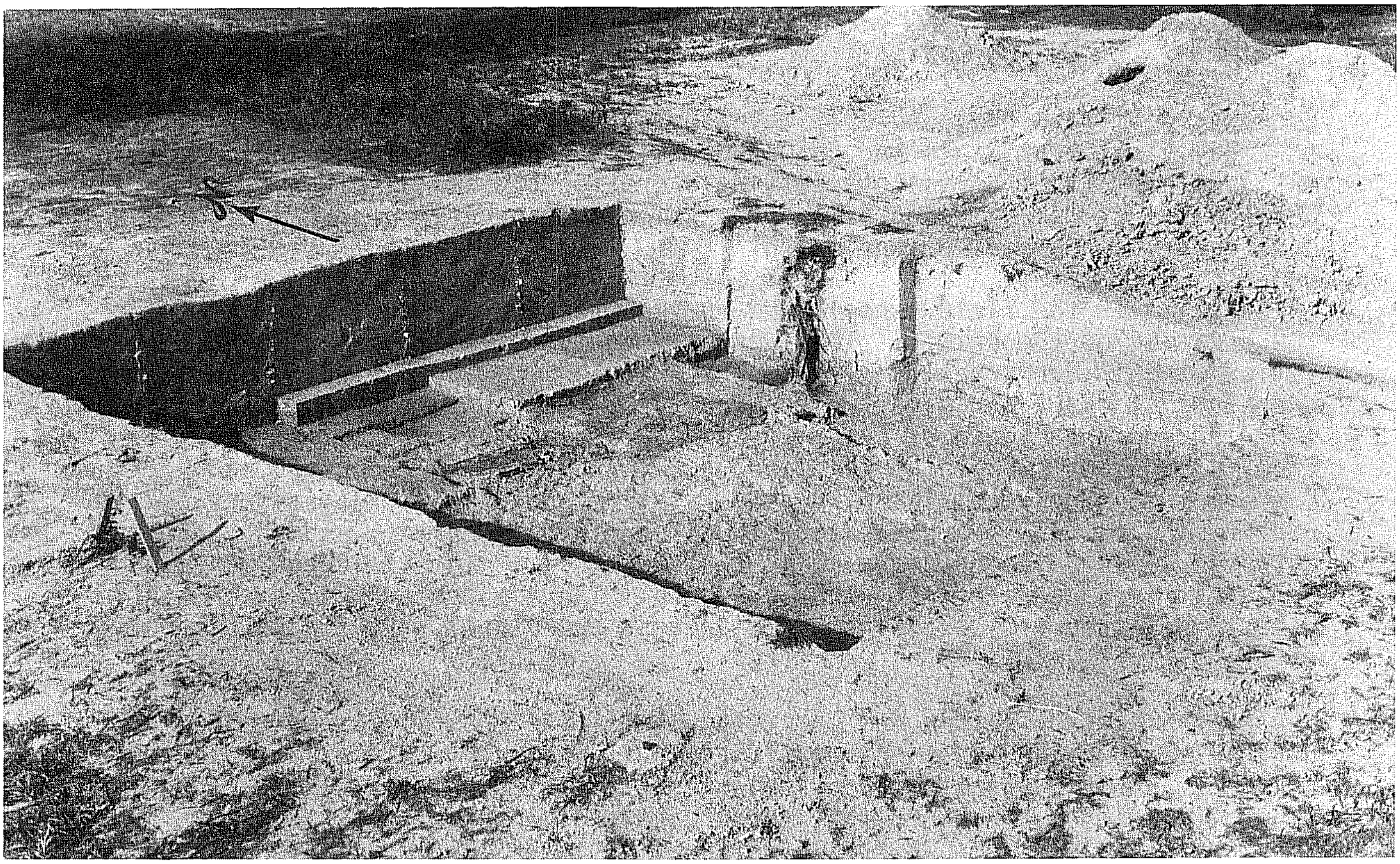


Plate 1. *End of Excavation, Facing Northeast.*

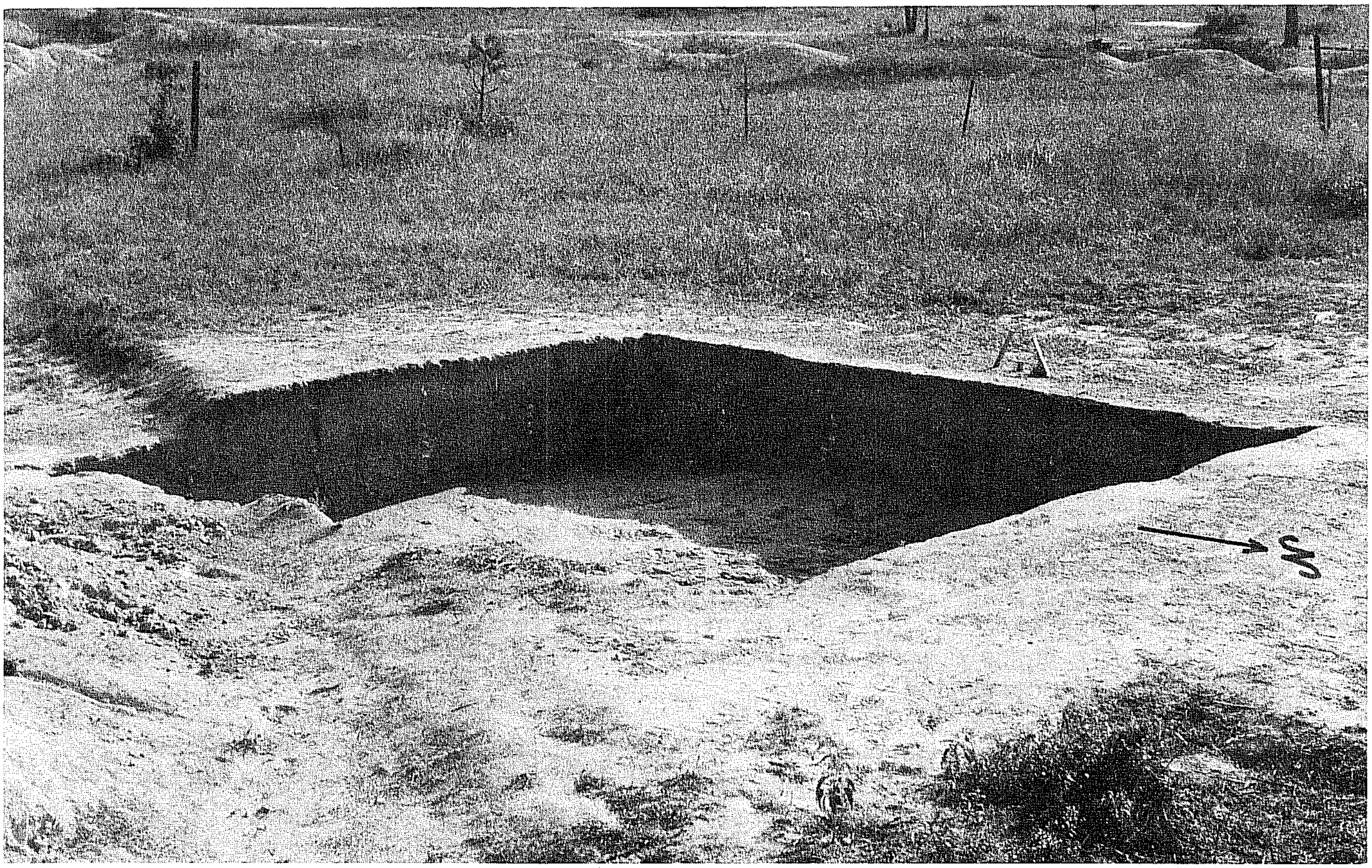


Plate 2. *End of Excavation, Facing Southeast.*

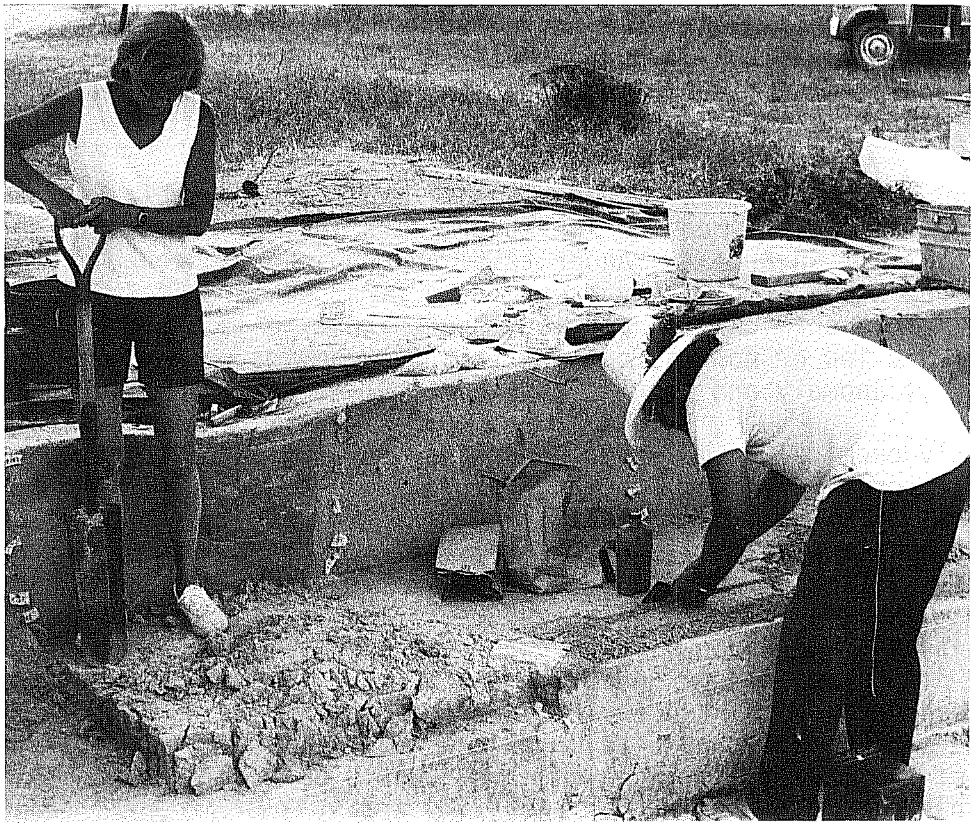


Plate 3. *Excavation of Units at One-Centimeter Resolution and One-Meter Resolution.* Right, High Resolution Environmental Column (HREC) and Left, Intermediate Level.

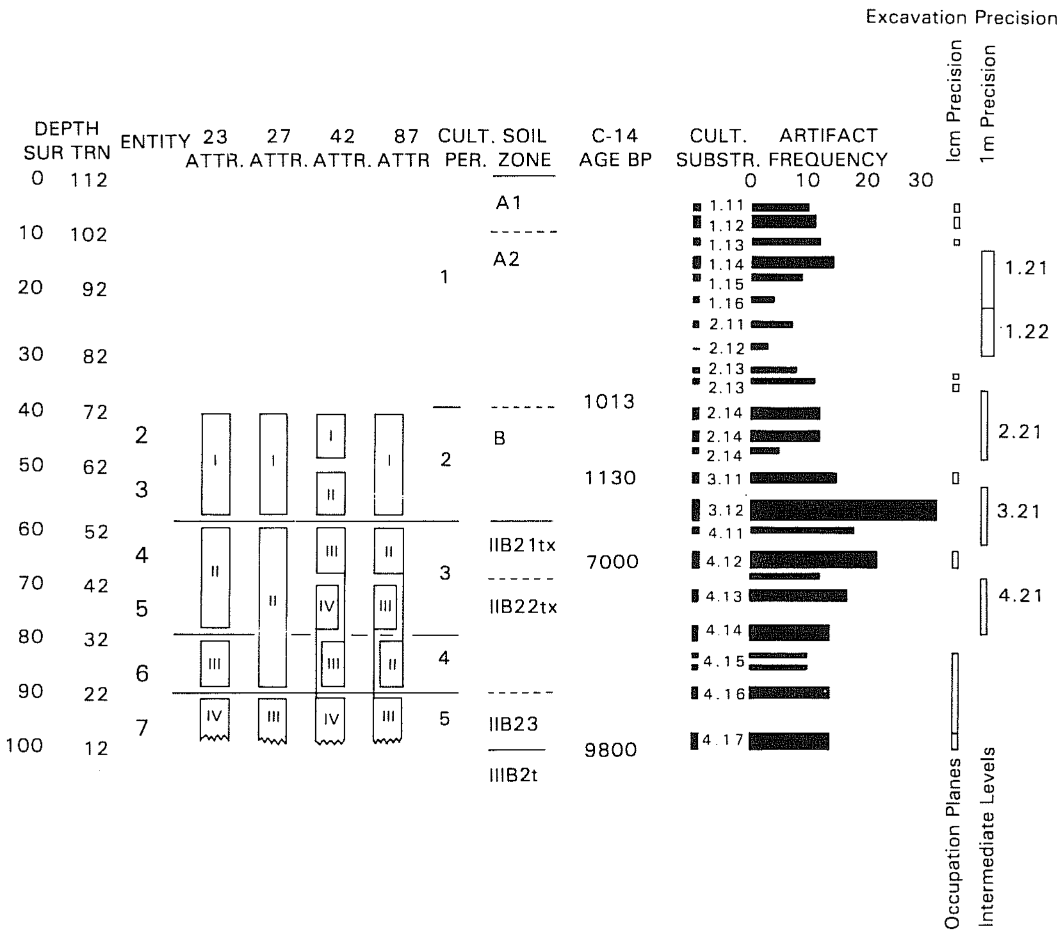


Figure 12. *Vertical Sampling Strategy.*

Horizontal Sampling Procedure

In addition to the practical and geological aspects of the block excavation location problems mentioned earlier, there were logical reasons to concentrate excavation effort in Area A. Auger tests and subsequent geochemical analyses defined three kinds of activity areas. The first two are those with artifacts with and without chemical signatures. The third type is areas with chemical signatures and low or nonexistent artifact frequencies. The first type of site is a cultural anomaly and the latter a chemical anomaly.

The strictly chemical anomaly represents an activity involving only perishable tools and materials or, at least few, if any, discarded nonperishable items. The possibility of studying chemical anomalies is very interesting. However, we felt that it would require probes sensitive to the appropriate chemicals attached to an infield computer, which would collect the data and analyze it on site with maximum efficiency. The process of collecting soil samples and analyzing them in the lab would be prohibitively expensive for a number of reasons. Also, much of our understanding of prehistoric cultures is bound up in lithics and ceramics. In the beginning, such studies would be fruitful only in conjunction with studies of surrounding artifact-bearing deposits. The function of the chemically anomalous areas could be studied as complementary relationships with the rest of the activity areas.

Following this line of reasoning, we decided to concentrate on Area A with its concentrated artifact-bearing levels with and without chemical signatures.

Vertical Sampling Procedure

Excavation of the 1 x 1-m column in Area A during May indicated that there were over 20 relatively discrete, vertical concentrations of cultural debris. Since our excavation methods and recording at full precision (accurate to one-centimeter) were progressing too slowly to recover an acceptable amount of cultural material in the time allotted, we decided to develop a vertical sampling scheme. Selected cultural substrata, "occupation planes," would be excavated at full precision, while "intermediate levels" would be removed at one-meter precision (Plate 3).

Occupation levels recovered at one-centimeter precision were excavated with trowels, with all artifacts recovered *in situ*, and important artifact locations measured to the centimeter. One-meter precision units were excavated with shovels and then screened, so that the locations of artifacts were noted to within a meter.

Substrata to be excavated at one-centimeter precision were selected by a two-stage decision-making process. For the first stage, we turned to Servello's analyses of lithic debris from the Area A pits. Servello ran a series of analyses, which showed that there were recognizable changes through time in the lithic technology being practiced at the site. These analyses show that there are about five technological periods at Eagle Hill. The second stage was to select an occupation floor to excavate at one-centimeter precision (from each of the five technological strata).

Vertical Sampling of the Technological Strata

Once it was decided that sampling the cultural strata would be necessary, our first concern became one of determining what cultures were represented at Eagle Hill, and where these cultures were represented in the strata. For information we turned to the test excavation analyses of Servello (n.d.). In an attempt to define an Eagle Hill complex, Servello performed an attribute analysis of flakes from levels of various sites on Peason Ridge. These included six levels from 16 SA 50. The results of these analyses are illustrated in Figure 12, along with depths (from surface = SUR, transit depth = TRN), soil horizons, and cultural periods. Servello ran four cluster analyses illustrated under the 23, 27, 42, and 87 attributes columns (ATTR). The rectangles in the ATTR columns span one or more 10-cm levels indicated in the column on the far left (SUR). The rectangles indicate which of the 10-cm levels or "entities," as Servello calls them, are most similar to each other as determined by average linkage cluster analysis of lithic data. For instance, the 23-attribute analysis shows that levels 40-50 and 50-60 cluster together. We have designated this Cluster I. Cluster II is levels 60-70 and 70-80, etc. The 27-attribute analysis is different from the 23-attribute analysis only in the combination of level 80-90 into Cluster II. In general, the 42 and 87 attribute analyses confirm the results of the less sophisticated runs.

The single most consistent characteristic of all four analyses is the break in clusters between levels 50-60 and 60-70. The difference between flakes above and below 60 cm is the single most characteristic pattern in the data set and corresponds to the erosional surface between the modern soil zone (A and B) and Soil Horizon IIB. The correspondence between geological and cultural unconformities is strong and lends a certain amount of credence to the analysis. It was eventually determined that the erosional surface represents a 6000-year time gap. During that time the Eagle Hill area saw a substantial change in lithic technology and possibly a corresponding change in cultures and populations.

If we proceed, assuming that each of Servello's clusters represents a technologically distinct period and a corresponding cultural episode, we can safely derive five cultural periods from the analysis (CULT. PER. in Fig. 12). These five cultural periods are as follows.

Cultural Period 1--Since Servello did not present an analysis of the upper levels, we must assume that they represent one cultural period. We know that the upper horizons contained ceramics. Stratigraphically, the period extends down to 40 cm from the ground surface and contains 10 cultural substrata, substrata 1.11 to 2.13, as is indicated in Figure 12.

Cultural Period 2--The second cultural period is defined by Servello's Cluster I (23 ATTR) and corresponds to Soil Horizon IB. It contains two cultural substrata, 2.14 and 3.11, and the deflation surface 3.12. Artifacts at the bottom of the level are probably on a deflation surface, so it is somewhat surprising that the 50-60 cm level did not cluster with the unit below. The high frequency of artifacts in cultural substratum 3.12 probably represents a concentration of artifacts from the deflated Soil Horizon IIA.

Cultural Period 3--This unit is defined by Cluster II and is pedologically located in the fragipan of Soil Horizon IIB. It contains four cultural substrata, 4.11 through 4.14. It is between 60 and 80 cm below the surface.

Cultural Period 4--A single 10-cm interval in the bottom of the fragipan appears from other analyses to be related to the levels above. We decided to separate and sample it, because it is near the bottom of the cultural deposits. It contains two cultural substrata, 4.15 and 4.16, and resides between 80 and 90 cm below the surface.

Cultural Period 5--The last cluster contains the IIIB deflation surface, 4.17. Soil Horizon IIIB is thought to be late Pleistocene in age. Several formal tools of Paleo-Indian vintage were found in substratum 4.17 between 90 and 100 cm below the surface.

Sampling of Cultural Substrata within Cultural Periods

Once the cultural substrata were stratified on the basis of Servello's technological studies, determining the substrata to be excavated with one-centimeter precision became a matter of selecting occupation planes within the cultural horizons. Since our control column was the only information available at a high enough level of resolution, occupation floors to be excavated with one-centimeter precision were selected on two criteria. Those selected were thought to be least likely disturbed and showed the highest frequency of artifacts; this is illustrated in Figure 12 (ARTIFACT FREQUENCY). Thus, cultural substratum 3.12 was removed as an intermediate level with substratum 4.11, since it was thought to be the IIB deflation surface, and additionally, substratum 4.11 was suspected as downwardly mobile artifacts from the destroyed levels due to the presence of occasional ceramics. The lower levels were removed with high precision in hopes of recovering early occupation floors.

The substrata excavated with one-centimeter precision were removed with trowels and processed by the screening methods outlined below. Intermediate levels were removed with shovels and screened through 1/4-inch screens.

Analysis of Area A Control Column (Gunn, Mahula)

Later in the field season a more sophisticated analysis of the control column became available as the laboratory staff completed quantification of the recovered materials. During excavation, 19 occupation planes were identified in the control column. Each plane was coded for 17 attributes. These are listed below.

1. Substratum--the substratum number was recorded to indicate the relative depth of the unit. Numbers range from 1.11 to 4.17 (see Figure 12 for complete sequence).

2. Potlidding--frequencies of actual potlids or flakes with potlids were counted to indicate the likelihood of fire.

3. Total Specimens--total number of platformed and nonplatformed flakes from the screens.

4. Pottery--sherd count.

5. Charcoal--weight in decigrams.

6. Mussel and Snail Shell--fragment count.

7. Clay Balls--count.

8. Pebbles--count.

9. Ferric Concretions--count.

10. Charred Resin--count.

11. Seeds--count.

12. One-Centimeter Provenienced Flakes--counts of platformed flakes and mapped chips. Chips (shatter without platforms) were mapped and bagged by the unit.

13. Average Size of One-Meter Provenienced Lithics with Platforms--all flakes were classified into seven sizes using a graded series of parallel lines. The method is discussed in Katz (1976) and Gunn and Mahula (1977). It is a means of characterizing assemblages as to lithic stage reduction. In other words, it classifies the assemblage into workshop, quarry, base camp, or satellite camp, if one is willing to accept flake size as a criterion. For this study, the size categories were reduced to averages per substratum. Averages were figured by assigning each flake the value of the midpoint of the class in which it fell. The average flake size per unit was calculated as the class midpoint multiplied by the number of flakes in the class, summed for all classes, and divided by the total number of flakes.

14. Average Size of One-Centimeter Provenienced Flakes with Platforms--computation same as above.

15. Average Size of Mapped Chips--computation same as above.

16. Average Direction--each artifact provenienced to one centimeter was observed to point in a direction measured in degrees east of north. See the discussion of the Cultural Unit form for further details. The downslope direction was taken as an indicator of disturbance and floor slope. Values were averaged per unit.

17. Average Slope--Each artifact observed to one-centimeter provenience was given a value for the slope on which it was resting. Values ranged from 0-90° below horizontal. Slope per unit was given as the average for the unit.

A principal components analysis was performed on the 19 substrata by the 17 variable data set to index occupation intensity and determine disturbed levels. Table 2 shows the varimax rotated principle components matrix (Nie *et al.* 1975). Principle components are clusters of attributes that tend to covary and, therefore, as a group characterize the substrata. In order to avoid confusion with the traditional archaeological connotation of "component," I will refer to the components as "factors."

TABLE 2. VARIMAX ROTATED FACTOR MATRIX FOR OCCUPATION INTENSITY/DISTURBANCE INDEXING

	FACTOR I Occupation	FACTOR II Trend in Disturbance	FACTOR III Deflation	FACTOR IV Fire	FACTOR V Charcoal and Flake Size	FACTOR VI Resin and Shell
Substratum	0.014	0.901*	0.076	0.188	-0.110	0.166
Potlidding	-0.150	-0.060	-0.144	0.854*	-0.047	-0.043
Total Specimens	0.726*	-0.060	0.461*	-0.188	0.070	-0.260
Pottery	0.900*	0.006	-0.138	-0.002	-0.073	0.065
Charcoal	0.644*	-0.082	0.065	-0.279	0.482*	0.156
Mussel and Snail Shell	0.199	0.190	-0.090	-0.076	0.067	0.781*
Clay Balls	0.819*	-0.083	-0.143	-0.249	0.222	0.074
Pebbles	0.152	0.427*	0.803*	0.030	0.148	-0.068
Ferric Concentrations	-0.166	-0.331	0.658*	-0.287	0.018	0.126
Charred Resin	0.300	0.460*	-0.004	-0.333	0.211	-0.556*
Seeds	-0.016	0.064	0.876*	0.029	-0.009	-0.079
1-cm Provenienced Flakes	0.890*	0.234	0.072	0.029	0.132	-0.054
Average Size of 1-m Provenienced Lithics with Platforms	-0.004	0.136	0.038	0.784*	0.418*	0.077
Average Size of 1-cm Provenienced Flakes with Platforms	-0.010	0.942*	-0.076	-0.050	-0.146	-0.102
Average Size of Mapped Chips	0.763*	0.136	0.060	0.283	-0.304	0.382*
Average Direction	0.094	-0.129	0.083	0.217	0.829*	-0.021
Average Slope	-0.049	-0.624*	-0.360	0.101	-0.134	-0.370

*High loadings

Factor I--Occupation. The positive co-occurrence of most of the cultural indicators on the factor suggest that it is an index of the intensity of occupation. It shows that the screened flakes, pottery, clay balls, charcoal, provenienced platformed flakes, and mapped chips appear in corresponding, greater, or lesser numbers depending on the substratum. All of these are clearly cultural phenomena except for the questions raised earlier about the clay balls. The co-occurrence of clay balls with other cultural indicators supports their human origin. Pebbles do not appear on this factor suggesting that they are related to other sources, most likely of geological or avian origin.

Factor II--Trend in Disturbance. The presence of the substratum number on this factor indicates that it measures those phenomena that change with time. Pebbles and charred resins become more frequent toward the bottom of the site. Platformed flakes become larger. The negative sign on Average Slope indicates that the upper levels have more tilted artifacts in them than do lower levels. As will be shown presently, it is the uppermost substrata that have the most tilted artifacts, and it seems most likely that the tilted flakes represent bioturbation and perhaps disruption of the upper levels by recent military and/or logging activity.

Factor III--Deflation. Factor III is most notable for the association of pebbles and ferric concretions. There is also a high frequency of screened lithics and some indication of tilting of artifacts. The overall picture is one of deflation/disturbance. As will be shown later, the level best characterized by this set of attributes is immediately above the B-IIB soil interface and is surely a deflated surface.

Factor IV--Fire. Factor IV suggests that fire-related activities, potlids, etc., are associated with larger flakes. It is probably a secondary indicator of occupation intensity, especially domestic occupation.

Factor V--Charcoal and Flake Size. Large flakes also tend to be associated with charcoal on occasion.

Factor VI--Resin and Shell. Charred resin and shell have a complementary vertical distribution, except the resins are lower in the section. The shells, no doubt due to poor preservation, are found only in the uppermost levels.

Factor scores were calculated by multiplying the factor matrix by the original data matrix. The resulting numbers are indicative of the relative strength of the occupation planes on the component. For instance, Table 3 shows the component scores for the levels on Factor I, the occupation factor. The units with the highest score are indicated to be heavily occupied. Those with low numbers are sparsely occupied. The scores are an effective, overall occupation index.

TABLE 3. OCCUPATION INTENSITY INDEX (FACTOR I SCORES) FOR THE SUBSTRATA, OCCUPATION FACTOR

Substrata	Occupation Intensity
2.13	2.54
2.14	2.05
4.12	1.47
3.11	0.34
4.14	0.04
1.15	-0.04
4.15	-0.08
4.11	-0.11
2.12	-0.15
3.12	-0.15
1.13	-0.19
1.12	-0.32
4.16	-0.37
2.11	-0.44
1.11	-0.46
1.14	-0.91
1.16	-0.94
4.17	-1.01
4.13	-1.26

As will become evident as the report progresses, the principle components analysis of the control column correctly indicated the second cultural period, especially substrata 2.13 and 2.14 as being intensively occupied. This is the Coles Creek interval. The Paleo-Indian 4.17 substratum rates low in occupation intensity at the control column. The Paleo-Indian occupation centers elsewhere in the site. Substratum 3.12, the deflation surface, has a relatively large amount of occupation debris. It, however, suffers from disturbance and so appears on the factors that register disruption.

Figure 13 is a plot of the factor scores for Factor II (Trend in Disturbance) and Factor III (Deflation). Substratum 3.12 clearly is demonstrated to be a deflation level. The substrata in the box at the lower right of the illustration are the sites that are low in disturbance as measured by tilting of artifacts and low in deflation characteristics. All of the substrata targeted for careful excavation fall in this desirable range except substratum 2.13. Substratum 2.13 is clearly not a deflation surface, but it does bear the mark of disturbance. Its proximity to the surface probably exposed it to root action. The analysis suggests that due caution should be used during interpretation of substratum 2.13 and vertically adjacent levels.

Rate of Excavation

In addition to selecting substrata, which would be desirable to excavate based on cultural criteria, we also had to work within a specified time frame. In a project confined to a certain time interval, as the Eagle Hill endeavor

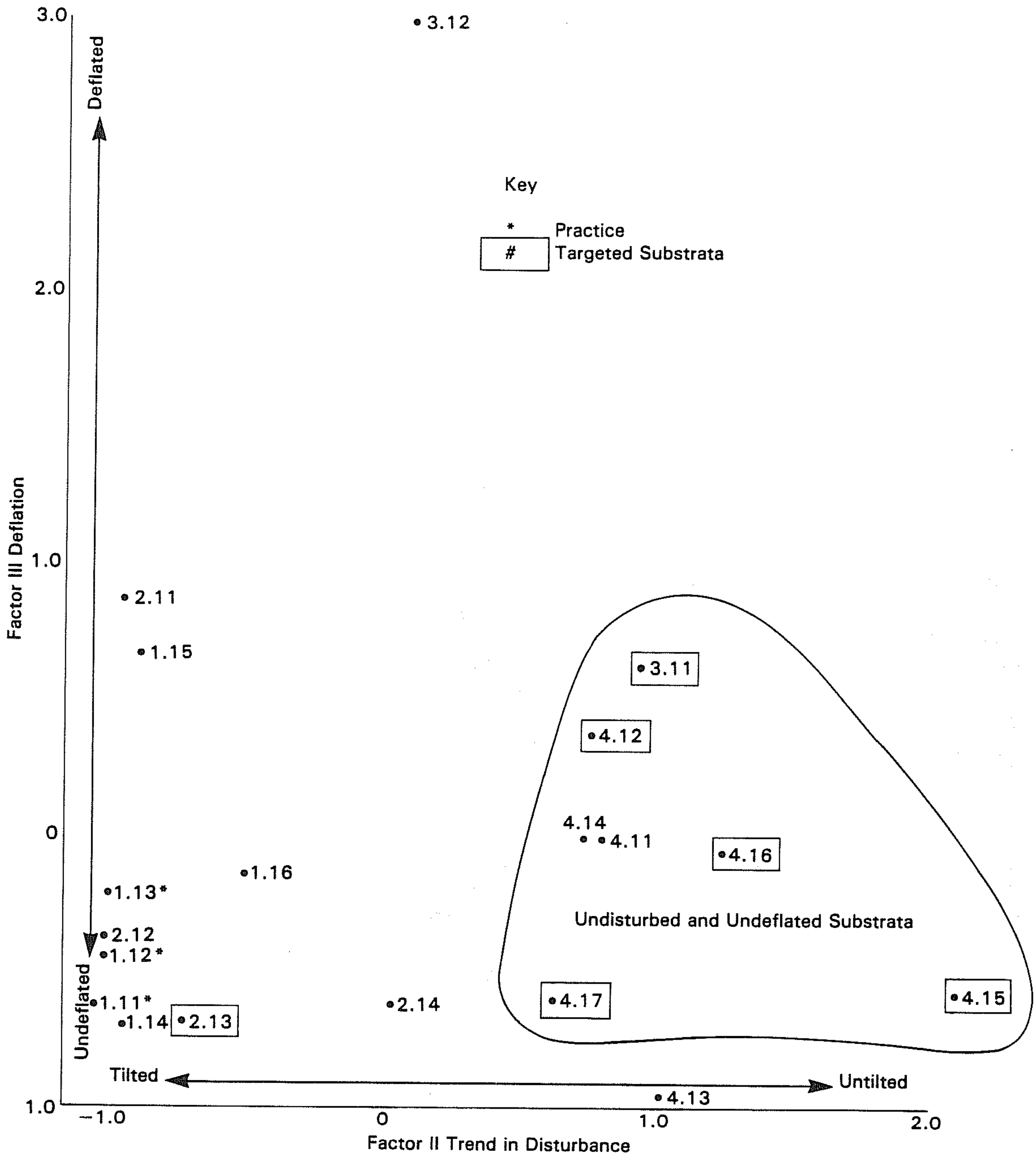


Figure 13. *Factor II (Trend in Disturbance) and Factor III (Deflation) Factor Scores.*

was, the speed of excavation was a matter of some concern to all involved. Naturally, there are a number of factors that must be taken into account when determining the desired rate of excavation. These include the amount of information to be recovered from a given excavation unit, the amount of area that must be excavated to recover a meaningful sample of cultural remains, and the amount of time within which these tasks must be accomplished.

The amount of information to be recovered is integrally tied to the excavation procedures and recording methods. In theory there are two basic approaches to excavation. The first is to remove sediments from predetermined units, usually in arbitrary levels of some specified depth, and recover artifacts from the matrix by screening. Although some larger artifacts and features may be recovered *in situ*, most of the artifactual material comes from the screens. There is no specific provenience to a resolution less than the size of the square, and no information recovered on the attitude of artifacts in the ground. Most information on vertical concentrations of artifacts and on the physical strata in which they reside is recovered in retrospect by profiling walls and by laboratory examination of vertical concentrations.

The second method involves following natural strata or cultural levels during excavation. Artifacts of specified importance are provenienced by Cartesian coordinates when found, and care is taken to find as many artifacts *in situ* as possible.

The first approach can be termed the "retrospective" excavation and the latter "anticipatory" excavation. Naturally any given archaeologist probably combines some aspects of both approaches, although there do seem to be two rather well-defined camps of thought. While it is always dangerous to generalize on such matters, retrospective excavation techniques have clearly dominated American archaeology. Some early professionals such as Alfred Kidder followed the anticipatory approach, but North Americans have generally preferred the retrospective approach, because it provides an element of efficiency in terms of "dirt moved." Except in cases of very low artifact densities, information is sacrificed for speed.

European archaeology, on the other hand, has developed more along the lines of the anticipatory model. This tradition was probably encouraged by the frequency of subtle cave and rockshelter deposits in karstic Western Europe and by an older and more mature archaeological perspective, which went through its "efficiency" period in the latter part of the 19th and first quarter of the 20th centuries.

The literature search recounted earlier suggests the desirability of a combined horizontal-vertical strategy. To this end, calculations were made with respect to person days remaining in the field season. A goal of a 5 x 5-m unit was set, and a schedule developed to assure its accomplishment. This, along with the vertical sampling strategy, guided the progress of the data recovery.

Excavation Procedures

While we came to the site with a basic outline of the techniques we expected to use for excavation, one can always expect a gap between theory and reality. Excavation procedures must be tailored to each site and to each group of excavators. Our first days of excavation were intended primarily to develop a consensus among core crew members as to approaches to be taken, the nature of the sediments to be excavated, the location of culture-bearing substrata within those sediments, how to record and package the artifacts found during excavation, and screening.

Excavation procedure was organized around eight concepts, each intended to define our means of control over some critical aspect of data recovery.

Control Face--This most basic concept literally dictates trowel movements in the hands of excavators. All excavation, whether it be following a strata contact, an occupation floor, or removing a rodent disturbance, is done against a vertical control face. The upper sediments at Eagle Hill are very sandy and lend themselves to easy excavation by troweling. The lower sediments proved more difficult, due to high clay content. A control face (Fig. 14) is composed of a vertical cut, the material being removed; a horizontal surface, the material being left; and the contact, the perpendicular juncture between the cut and the surface. An excavator normally works against a two-to-five-centimeter deep control face, which extends across his square. Moving his trowel conformant with the strata, the excavator slices off a defined amount of the control face with each pass, systematically moving across the meter unit. Each slice moves the contact back a few millimeters exposing more of the surface and removing more of the cut. In addition to giving the excavator a clear perception of the materials to be removed and those to be left, the control face allows supervisors to readily check the accuracy of the excavator's efforts.

Control Front--As with the trowel, the movement of the crew needs to be coordinated in a systematic manner. A control front is composed of a line of control faces crosscutting adjoining excavation units. Excavators aligned in this manner are encouraged to pay close and constant attention to the progress of excavation by their flanking comrades. The spirit of cooperation engendered by the excavators on the control front not only spurs efficiency, but also leads to constant communication on matters of density of artifacts, vertical location of artifacts, facies changes in lithology and pedogenic development, and field analyses of interesting distribution patterns. Such discussions insure cross referencing of unit excavation notes and help to avoid problems of after-the-fact correlation of occupation floors and lithologic contacts from square to square.

Planing--In spite of determined efforts and optimistic attitudes, we were not able to determine lithologic substrata or microstrata within the grosser sedimentary units at Eagle Hill. The strata were quite homogenous. We assumed that excavation could not proceed on pedogenic criteria, but had to be judged as part of the original sedimentation processes, which bear cultural units. Our only remaining option was to establish excavation strata on cultural criteria. "Planing" is the technique by which this is done. The first step in planing is to shave a profile leaving artifacts on pedestals until a battery of artifacts is exposed along the face. If good fortune is with the excavator, the artifacts will define a linear pattern across that face (Plate 4). This alignment of materials is taken to mark an occupation floor. At this point, the excavator establishes a control face with the contact two centimeters below the line of flakes, completes a Physical Unit Form (Appendix B, Fig. 91) on the substratum, and moves across the square pursuing the vertical concentration of cultural debris.

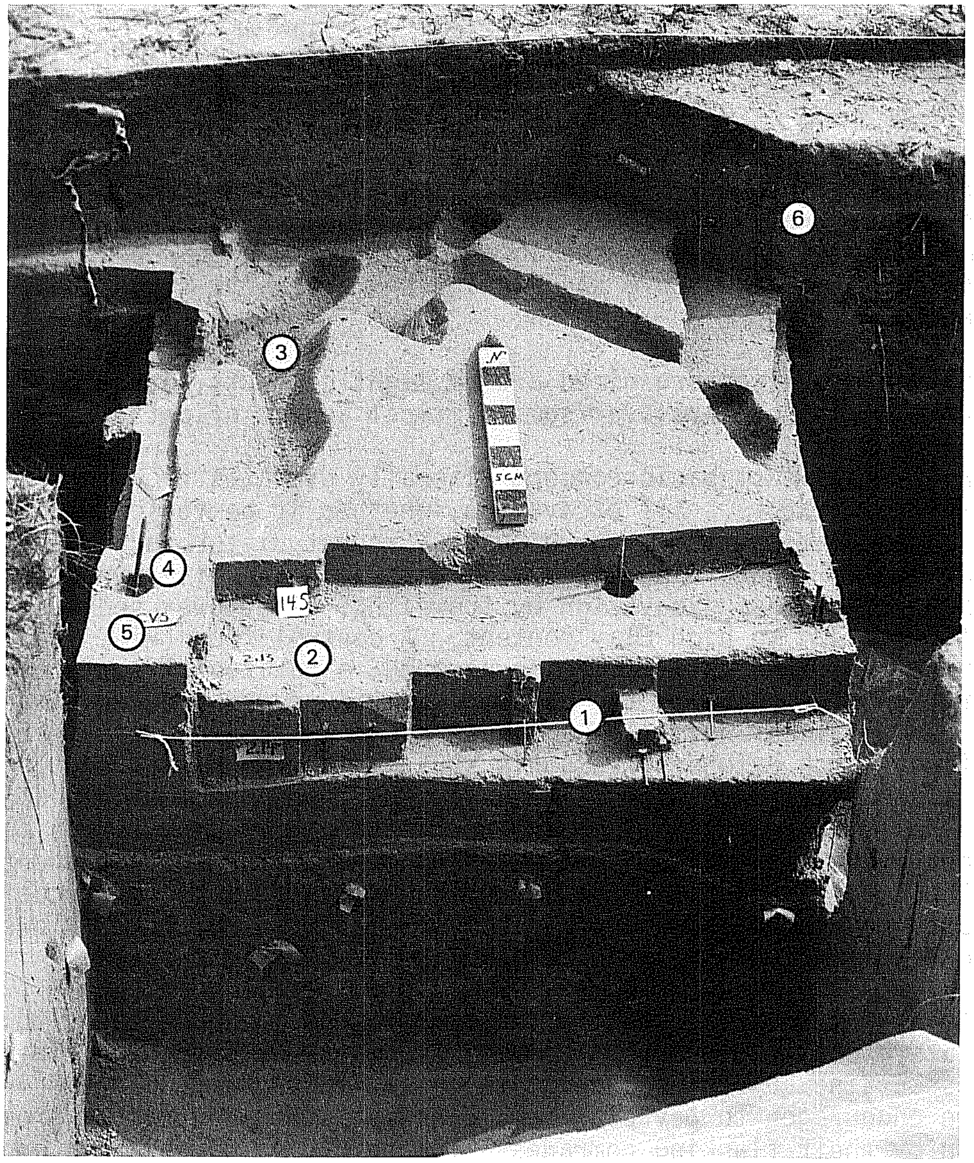


Plate 4. *Control Column (E1000-N300).*

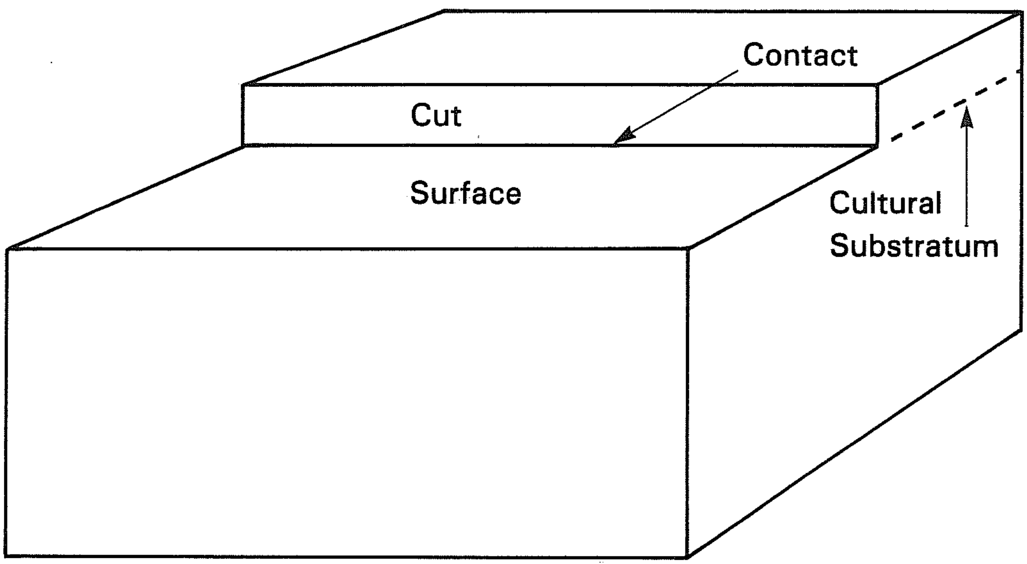


Figure 14. *Excavation Unit with a Defined Substratum Being Exposed.*

The surface exposed at the contact must be understood in a very special sense. It is not the bottom of an excavation unit as would be the case in an arbitrary unit, but a plane which estimates the location of an occupation floor. Therefore, artifacts found immediately above and below the plane are considered to be a part of that occupation floor. It is the responsibility of the excavator in consultation with the supervisor, to decide whether an artifact above or below the plane is a part of the targeted occupation floor. Normal procedure was to consider artifacts two centimeters above or below the floor to be a part of that floor. If artifacts appeared outside what the excavator felt to be the normal distribution of the floor, the artifact was tagged with a "+" for above the floor or a "-" for below the floor. If it was found that a pattern of tags existed in a quadrant of the unit upon its completion, one would suspect that the excavator was undershooting or overshooting the real occupation floor, a fact which was compensated for when tagging the wall with the substratum unit number.

Provenience--Artifacts that are considered to be important for one reason or another are provenienced by Cartesian coordinates. Horizontal coordinates are taken from the boundaries of the unit so as to conform with the site grid system. The vertical dimension is determined by transit. This information and description of the artifact, its orientation, slope, and volume are on the Culture Unit Record, Appendix B, Figure 92.

Provenienced items include the following: tools such as points, other shaped lithic items, and edge-altered flakes. Large flake fragments were provenienced, since there was reason to believe they were tools as well.

Platformed flakes were also provenienced. The reasons are as follows. Platformed flakes represent a single act of lithic reduction as opposed to the accompanying shatter. The frequency of shatter is variable and only roughly proportional to the amount of lithic reduction activity at the site. In addition, platformed flakes occur in about the right frequencies to provide opportunities for locating elevation points on occupation floors without overdoing the transit work.

Features such as caches and fire pits were also provenienced. The Culture Unit Form is designed to accommodate virtually any item of cultural origin. Naturally, more extensive cultural phenomena required more than just recording on a computer-oriented form. These items required such devices as plan and profile maps, verbal descriptions, etc.

Mapping--One-meter unit maps were kept for each floor in each unit. The Unit Mapping Record (Appendix B, Fig. 93) is designed so that it can be directly placed under a large sheet of graph paper and copied onto a plan map of the entire occupation floor. We customarily mapped nonplatformed chipping debris, charcoal greater than one centimeter in diameter, disturbances, and any item pertinent to the eventual understanding of the unit.

Bagging--A #4 paper bag, labeled for each substratum unit, was kept with the forms on a clipboard for that substratum until the floor was excavated. Excavation, of course, includes recovery of artifactual material from above and below the plane of estimation. A small plastic bag is marked with the FN of the unit/substratum and a "P" for items plotted on maps. The excavator retains the plotted items, such as pebbles recovered from within the floor, etc., in this bag. Items recovered from the screens are kept in a bag marked "S." Material from the "S" bag is somewhat problematic, because we do not know for sure if it is associated with the occupation floor above or below. In practice, however, occupation floors contain widely varying frequencies of flakes. In the event that important items are missed, they can be assigned with some certainty to one or the other floors. Plotted charcoal wrapped in aluminum foil is also kept in the unit bag. Provenienced items are placed in separate plastic bags with their unique FN noted on the outside and retained in the unit bag.

Constant Volume Sample (CVS)--A block of soil is left in the southwest corner of the unit until it has been excavated. At that point, when the excavator has become as familiar with the location of the occupation as he will ever be, a 2000-cm^3 sample is taken from the block.

We generally try to take this slice out of the block vertically centered on the occupation floor. Special care is taken to locate and remove disturbances from the CVS.

Plate 4 is one of those curious moments when several things happen together allowing rather economical illustration of several points. The following discussion is keyed to the numbers in the photo.

The six penny nails along the front edge of the square (1) point to a line of flakes across the square. The line of flakes and the decision to excavate them as substratum 2.14 are marked by the stringed line. Substratum 2.13 (2) was defined in a similar manner, and the control face of that unit has been followed about 1/4 of the way across the square. FN 145 is a cache of flakes, pottery, and charcoal fragments. A rodent disturbance (3) was noted on substratum 2.12 and removed before proceeding with the excavation of substratum 2.13. Also, two bug balls are visible (4) in the photo. One is on the CVS block. The other is at the substratum 2.13 contact in the right half of the unit. Bug balls were confined to the control column and probably permitted by the removal of surrounding dirt for a length of time which allowed bugs to nest. A CVS block (5) has been left in the southwest corner of the square awaiting removal of the rest of the square. A crayfish disturbance (6) is clearly visible as a vertical column in the wall. There are two such disturbances in the square.

Screening (Gunn)

Screening of the excavated sediments proved to be more of a necessity than originally anticipated. We found that we could not maintain full precision and excavate the volume of sediments stipulated by the contract or dictated by logic to provide a reasonable view of prehistoric camp life at Eagle Hill. Speeding up the excavators, however, insured that some possibly important artifacts would be missed in the excavation process, since the assemblage was composed of generally smaller artifacts than expected. Rather than the lithic workshop we had originally expected, the site was a satellite campsite with characteristic diminutive chipping debris from maintenance activities such as resharpening and reshaping of stone tools. To effect total recovery, it was apparent we would need a screening program. Wet screening is virtually the only efficient means of recovering such chipping debris.

Ideally lithic debris of the type found at Eagle Hill should be screened through 1/8-inch screen. A study by Gunn, Mahula, and Sollberger (1976) showed that 1/8-inch screen recovers about 80% of the most useful chipping debris. Our plans for screening were complicated by a scarcity of water on top of Peason Ridge but, thanks to numerous favorable circumstances, we were able to proceed with rather normal screening techniques early in June. The army's erosion prevention efforts provided us with a pond about 50 m southwest of Area A, and a wet spring season insured that the pond was full to the brim. Also, the upper sediments, those of the modern soil horizon, are very sandy and present virtually no obstacle to water washing. We therefore screened for the first ten days of June in the shadow of good fortune. As the initial phase of excavation passed, however, the pond dried, and the sediments became more clayey. Good fortune had to be replaced by ingenuity.

With our natural water supply gone, the number one priority became water conservation. The personnel of the Air Force observation post on Eagle Hill supplied us with a 500-gallon tank trailer known in military parlance as a "water buffalo" and the means to transport it. Even so, we could not launch a massive water screening effort. We were pleasantly surprised to find, however, that reasonable volumes of sediment could be satisfactorily managed through a multistage screening process that required very little water and was essentially as effective as more typical water screening techniques. Because of the increasing clay content of the matrix to be processed, the strategy had to be varied, sometimes from level to level. Essentially two processes were used. The first is utilized on sandier sediments, the second on those of higher clay content.

Water Conservative Screening of Sandy Sediments

Once removed from the excavation units, the sediments are dumped onto a suspended 1/8-inch screen and shaken until the majority of the matrix is gone (Plate 5). The use of trowels was held to a minimum to avoid damaging delicate pressure flakes. If the sediments had to be broken a wooden stake was used.

The residues of this operation were removed from the swinging screen and placed in the basket made of 1/8-inch screen. The wire basket was water screened in a washtub perched on the top of a 55-gallon barrel. Once washed, the residue was placed on a plank to dry and then bagged. The washtub and barrel served as a water recycling unit. Sediments washed from the basket settle, for the most part, to the bottom of the tub while the water flows over the edge of the tub and down into the barrel where it is retained. When the tub becomes too full to function as a screening basin, it is set aside for a time to allow the settling process to progress to an advanced stage. The water, so freed, is poured off and recycled through the system, while the sediments are removed to the backdirt pile. Water from the tub is normally recycled from the barrel, although a certain amount of water is acquired new from the water buffalo at each recharge. The process was quite efficient and required two screeners to keep up with eight to ten excavators.

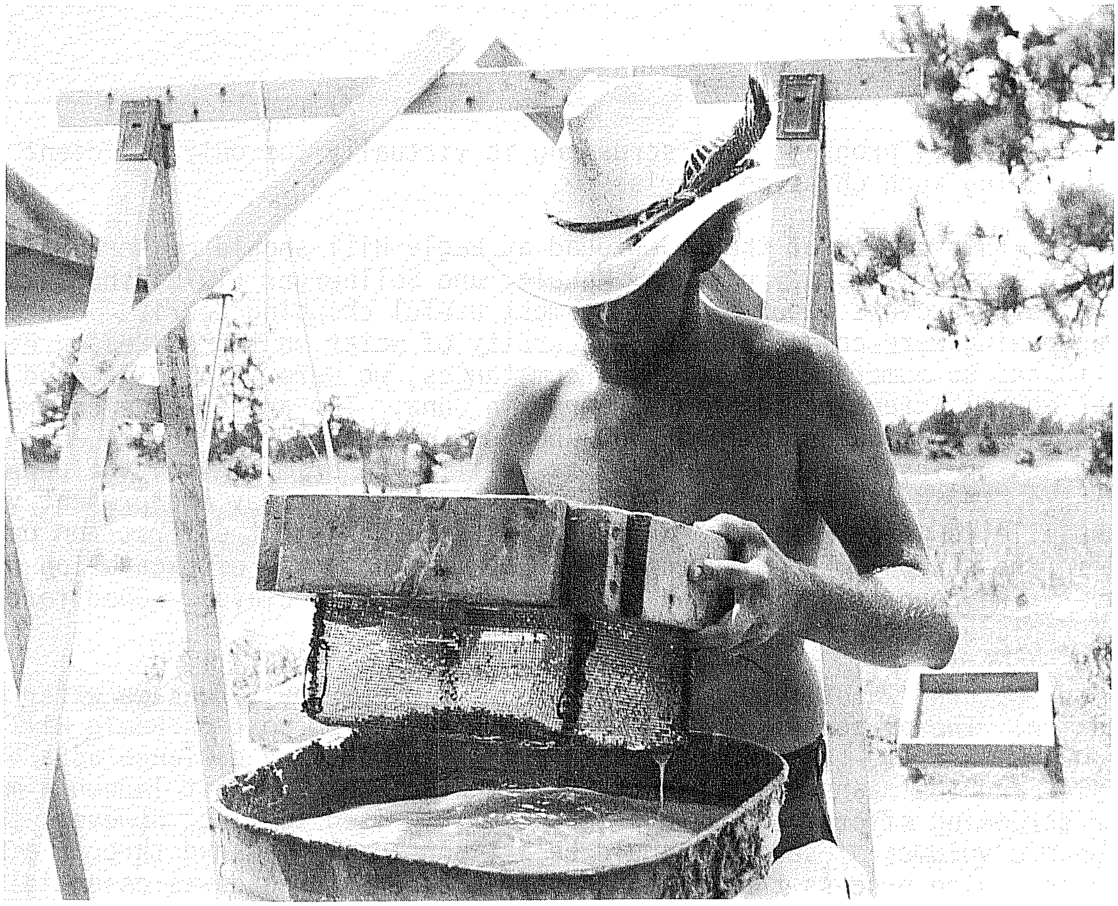


Plate 5. *Water Conservation Screening.*

Plate 6. *Dry Screening for Sandier Sediments.*

Water Conservative Screening of Clay Sediments

Screening of Soil Horizon IIB with a higher clay content required a noticeably more complex process, although the flow of motion was essentially the same. There were extra steps added to cope with the aggregating tendencies of clay. As before, the first step was screening on a 1/8-inch suspended screen. This process was quite slow and frequently bottlenecked the operation. We used two suspended screens normally with one or two persons per screen depending upon how difficult the operation was.

Once reduced as far as could be in a reasonable amount of time, the residue of this operation was moved to a plastic, gallon milk container with the top cut off to sit in water for a few minutes. The longer the wait the better, so containers were allowed to back up several deep. With the very difficult fine-grained clays toward the bottom of the section, ammonium hydroxide was added immediately after dry screening since the chemical must penetrate the clays from the first. Pre-wetting only slowed the penetration process. The wetted sediment residue was poured into the 1/8-inch basket and water screened in the tub-barrel water recycling unit.

If resistent clay globules remained after the water screening, the residue of this operation was allowed to sit in a 1:2 solution of 58% ammonium hydroxide until the clay was disaggregated. This solution was again screened in the 1/8-inch basket allowing the ammonium hydroxide to enter the water recycling system and encourage disaggregation of clay in the first water screening step. We found it most efficient to open an ammonium hydroxide dissolving-container with a unit, and process the disaggregated clays later after the unit was closed, and the ammonium hydroxide had time to do its work. This allowed the excavation and disaggregation processes to proceed together.

The measures described above are conservative of scarce water and are environmentally sound anywhere. The water recycling process insures that water screening does not add particulate matter to natural or constructed waterways. The use of ammonium hydroxide as a disaggregant only slightly fertilizes the soil, but avoids contamination of sediments with harmful chemicals. On the other hand, ammonium hydroxide is not the most effective disaggregant available, and more difficult clay matrices may require more effective chemicals such as hydrogen peroxide or trisodium phosphate.

Late in the summer in the deepest, clayiest sediments (IIB23; Fig. 13), yet another screening method had to be implemented. The clay content was high enough that we could not reduce the volume of the material to be water screened. The only solution seemed to be filling the buckets with water as soon as they were excavated. Then when a large number of buckets had accumulated, they were hauled to the Eagle Hill Air Force observation post and screened under water pressure.

Procedure for Chemical Screening

Place sediment on 1/8-inch suspended screen and screen out as much sand as possible.

Water screen the residue in a 1/8-inch screen basket. If any clay remains in residue place remainder in container of one cup ammonium hydroxide.

Add subsequent material from 1/8-inch screen as excavation proceeds. Let set for approximately one hour after last bucket from unit is screened. Do not screen until unit is closed--all material from a unit goes into this one container.

Pour ammonium hydroxide and residue through 1/8-inch screen basket over water screening bucket.

Dry and bag.

Be careful using the ammonium hydroxide--if any bodily contact occurs, wash affected area IMMEDIATELY.

Data Management

Present day excavation methods produce prodigious amounts of numerical data. Sometimes the numbers involved are staggering, even to those directly involved in the effort. For instance, there were 1519 objects provenienced to the centimeter during the field season at Eagle Hill. For each of these objects, 19 observations were made in the field and 32 in the laboratory. Observations ranged from the coordinates of the object, to the material from which it was made, to microscopic observation of wear patterns. Nearly 80,000 observations were made on this data set alone. Each 1 m^2 in the site received 106 observations ranging from soil color and texture to excavator number to X-ray fluorescence determinations. About 10,000 observations were made for the targeted occupation planes.

It goes without saying that the human mind is not well equipped to wrestle meaning from such masses of figures. However, masses of numbers properly collected in the field and examined with appropriate computer-assisted numerical analyses are often the key to unravelling the messages left by prehistoric peoples.

The problems of deciphering prehistoric "messages" are complicated for a number of reasons. Naturally the patterning of implements and living floors is obscure in itself, because we do not easily see the cultural norms that dictate these patterns. Also, nature has further complicated the issues by encoding her own patterns amidst the cultural remains. Thus, numerical methods are often as important in factoring out, or controlling for extraneous messages from nature, as they are in providing interpretable patterns from among the cultural data.

Numerous studies were conducted on materials from Eagle Hill in addition to the one-meter and one-centimeter resolution data sets mentioned above. Each individual type of material (charcoal, clay balls, etc.,) was studied for distributions both horizontally and vertically in the site. Neutron activation determinations were made on lithics and clay to determine similarities and differences of source materials.

The plan for controlling these massive flows of data has become rather standardized over the last decade or so, but each excavation has its own special problems, which requires tailoring data collection and management procedures. Also, the changing field of archaeological study often suggests innovations that better the potential for analysis and require modification of old procedures. The Eagle Hill procedures were developed out of several years of experimentation by personnel of the CAR. Data collection methods used at Eagle Hill were by far the most satisfactory we have developed to date. Naturally we have improved methods with each past excavation. However, the order initiated with the Hop Hill excavations (Gunn and Mahula 1977) was finally brought to a fully integrated and satisfactory system at Eagle Hill.

Coding Forms

The coding forms used in the project are in Appendix B. Field forms serve several purposes. In addition to data collection, they serve as prompting devices that insure not only that data are collected systematically from each square, but also when those data are collected. They also insure consistent performance of tasks such as collection of constant volume samples, tagging the wall of a finished unit with the occupation plane number, and observing the presence of various uncollectables such as charcoal flecks. Field forms are prepared with room for written remarks as to relationships between features and artifacts, hunches about stratigraphy, etc. Field forms are also as nearly self-explanatory as possible. Lists of artifact types, soil texture, presence and absence codes, etc., appear on the form so that no field time was lost looking up vital coding information.

Laboratory forms were constructed in a more compact format. The Soil Chemistry Record (Appendix B, Figure 92) for collecting pH and phosphate observations on soil samples is a good example. In the lab, verbal explanations are usually not so important. Explanations of coding procedures are not as likely to be lost as they are in the field. Therefore, the forms are usually designed to save paper and reduce storage space.

Any form, field or laboratory, has to be arranged to minimize confusion on the part of the coders and data-entry personnel. Open formats with carefully marked, meaningfully spaced columns assist in the constant battle against data-transfer errors.

It is also often helpful to know who is collecting the data. This allows for spotting of systematic errors and correcting personnel who are incorrectly implementing procedures. Even if the person who has committed a systematic error is no longer with the project, knowing often provides a key to unraveling problems. To this end, each excavator and lab person was assigned a number:

01 Joel Gunn
02 Fred Nials
03 David Brown
04 Lang Scruggs
05 Darrell Sims
06 W. L. Sullivan
07 Bill Huber
08 Patricia Wallace
09 Julia Baker
10 Elizabeth Nethery
11 Penn Jenkins
12 Mike Perez
13 Dianne Detrio
14 Beverly Marshall
15 Burma Hyde
16 Joan Sherwood
17 Eve Mathis
18 Luis Ramirez
19 Isabelle Ruben
20 Ian Shaw
21 Kevin Jolly
22 Robert Guy

In sites such as Eagle Hill, which have long periods of time contained in a relatively thin veneer of sediments, maintaining vertical control was often the most critical and difficult task relative to provenience. Given the proportions of depth and time at Eagle Hill, it was immediately apparent that line levels would not provide the necessary grade of depth measurements, so we determined to make all depth measurements with a transit. Therefore, we devised a transit form (Appendix B, Fig. 95). Our original intention was only to code the transit shot foresight and backsight in the field and let the computer calculate the depths to avoid problems with miscalculations.

There were problems with this scheme, however. Part of the "control front" excavation program discussed in the excavation techniques section was to keep the excavators constantly aware of the depths of prominent concentrations of artifacts. This necessitated many calculations in the field and resulted in having those acquainted with the transit spend more time than was desirable with matters pertaining to depths.

In future efforts, it would be well worth investing in one of the small computers now on the market to calculate depths, making them immediately available to the excavators and storing the results for future transmission to the ultimate data storage computer. Computers now available would even speak the resultant depths to excavators thus relieving transit personnel of all responsibility after entry of the foresight. It is also possible that the transit person could speak the foresight to the computer.

Three other forms were used in the field, which were not directly related to the data collection effort, but did lend some organizational stability to the program. The Substratum Plan Map (Appendix B, Fig. 94) was filled out with to-be-assigned field numbers when a new substratum or occupation plane was opened. The person in control of recording and assigning FNs (Field Numbers) could then make immediate reference to the FNs assigned to various locations without undue time loss.

Similarly, the FN Assignment Inventory sheets (Appendix B, Fig. 97) were used to keep track of blocks of FN numbers assigned to various phases of the excavation. Constant reference to the FN Assignment Inventory sheet during the field season prevented duplicate assignments of FNs in all but a half dozen cases during the whole field season.

Finally, field notes were kept on a form (Appendix B, Fig. 98) that allowed for entry of the time of day and the name of the person entering the notes. Each day was covered in a series of pages marked in the "n of x" pages convention. This assured proper closing and securing of the notes at the end of the day. Notes were kept in ACCO strap binders in duplicate. Duplicates were removed weekly and returned to UTSA.

The numbers assigned to the formats during the project are listed in Table 4.

TABLE 4. KEY TO RECORD NUMBERS

Record #	Data
01	Transit Shot Data
02	Physical Unit Record
03	Cultural Unit Record
04	Pebble/Granule Data
05	One Meter Resolution Study
06	Wear Pattern Analysis
07	Clay Ball Analysis
08	X-Ray Fluorescence Data
09	Core Field Record
10	Soil Chemistry Record
11	Lithic Material Type Count
12	HREC (High Resolution Environmental Column) Analyses
13	Sherd Data (preliminary ceramic data counts, etc.,)
18	Unit Mapping Record

Consultants

The Eagle Hill archaeological project developed its multidisciplinary breadth and archaeological depth through the assistance of several able consultants. Fred Nials and Ed Garner began their examination of the geomorphology and pedology of the locale immediately upon receipt of the contract in April 1980. Their efforts set the context for the definition of excavation procedures, choice of location for excavation, etc. David Brown did final preparation of the geomorphically related reports.

Immediately before the end of the excavation season, Albert Goodyear visited the site, inspected the geomorphical situation, and examined the lithics from the site. His first-hand knowledge of lithics in Arkansas and the Southeast in general provided many pertinent insights into our literature search problems, and he suggested several interesting directions that our lithic analysis could take. Of particular interest to our problem of developing a nonprojectile point tool typology is the fact that Goodyear had just toured a good part of the Southeast examining the so-called *Albany* spokeshave. He has identified the same tool, in several areas, named differently at different times by different people. Goodyear is of the opinion that the literature on lithic technology in the Southeast does not lend itself to wide-ranging generalizations about tool types. Virtually the only way that such a tool typology can be built is to visit collectors and archaeologists, examine their collections, and determine the nature and distributions of specific tool morphologies.

During laboratory analysis, Don Lewis of The University of Texas at San Antonio provided us with assistance in the interpretation of several difficult geochemical problems including the analysis of the X-ray fluorescence (XRF) data.

Various laboratories also assisted us. Jerry Hoffer of The University of Texas at El Paso ran XRF samples. The Center for Applied Isotope Studies at the University of Georgia ran radiocarbon dates. Ralph Rowlette of the University of Missouri at Columbia made the thermoluminescence determinations on fire-burned lithics. Mark Sheehan of the University of Indiana examined sediments for evidence of pollen.

Laboratory Activities and Procedures

Thanks to the efforts of Royce Mahula and a small staff of students and "work-studies," the Area A control column and the bulk of the one-meter precision excavated material was curated and some analysis done by the end of the field season. Upon returning from the field the crew organized the summer's records, keypunched the data collected, and began work on the one-centimeter precisioned materials. By the end of August the general provenience materials (plotted artifacts and materials from the screens) were nearly curated. The approximately 1500 provenienced artifacts were curated and studied in the fall of 1980 with sediment samples, tools, etc.

Processing of materials from Eagle Hill began following the preliminary test excavation of the Area A control column. Procedures for processing materials from this column served as the basic laboratory method for all subsequent materials. The purpose of the Area A analysis was to assist in vertical sampling decisions.

The following is a summary of the personnel involved and the procedures used in the study of Eagle Hill materials.

Preliminary processing of the control column was performed by Royce Mahula assisted by Betty Neumann (a student doing independent study in lithic identification) and Debra Jenkins (a work-study student). All work was double checked by Mahula. The laboratory procedures for the Area A control column were basically the same as for the rest of the project. Their detailed description will serve as a model for the entire operation. Discrepancies between control column and noncontrol column procedures will be noted in a following section.

Provenienced Materials

Artifacts provenienced to one centimeter (FNs) were removed from the level bag, inspected to verify field classification, recorded in a FN Log noting coordinates and artifact type, stapled to a 3 x 5-inch index card with the FN recorded in the upper right hand corner, and filed in a 5 x 12-inch file box by FN sequence for future material, technology, and wear analysis.

The more generally provenienced mapped chips (flakes without platforms that were plotted on substratum maps and then bagged as a unit) were checked and rechecked, counted, and refiled in the same manner as the more specifically provenienced lithic materials.

Bags of one-meter provenienced materials were washed and contents separated. Categories of materials include lithics, pebbles, clay balls, charcoal, charred resin, shell, and hematite/limonite concretions. All categories were quantified and recorded on coding forms.

Screen-recovered lithics were separated into those with platforms and those without platforms. Counts of each type were made and recorded.

Small polished quartzite pebbles were saved in the hopes of illuminating depositional situations. Pebbles were separated, weighed, recorded, and bagged.

Charcoal fragments were separated, weighed together, recorded, and bagged.

Implications of charred resin could be important. Therefore, clumps of charred resin were identified, weighed together, recorded, and bagged.

Although sparse, some specimens of mussel shell were recovered. Pieces of shell were counted, recorded, and bagged.

Nodules of limonite and, less frequently, hematite were in evidence. These were weighed, recorded, and bagged.

Potlids were isolated and bagged separately from other lithics. Counts were made and recorded. Evidence of firecrazing and potlidding on other lithics was noted and recorded.

In addition to the above weights and counts (i.e., FN artifacts, plotted chips), all lithics and one-meter provenienced flakes were sized according to Katz (1976).

Following processing and recording, all materials except FN artifacts were returned to the level bags and refiled by square and level coordinates. Data were then keypunched and analyzed.

After the commencement of the formal excavation season, materials from the field were returned to the lab at somewhat irregular intervals. Although handled in a slightly different manner, the basic categories and procedures implemented during analysis of the control column were utilized for the new material with the following exception. Control column materials were excavated at one-centimeter resolution, i.e., at the level of the occupation floor. Therefore, all levels contained precisely provenienced materials that were already classified, bagged, and labeled separately. During the course of the excavation when the general character of the various occupation floors became clearer and the importance of each more easily assessed, several levels were excavated at one-meter resolution. The dirt from these levels was removed in bulk from the unit, screened through 1/4-inch mesh and bagged. As a result, these levels did not contain previously identified and labeled artifacts (FNs). Consequently, while the incoming one-centimeter precision levels were treated in basically the same manner as the control column (materials were only washed, separated, and bagged, but not quantified); the level bags from the one-meter levels were processed differently.

Since the materials in the field were screened only, all materials were washed in the lab. Material was then sorted into the categories outlined above. All tools were identified, labeled (on card), and bagged separately. Other lithics were separated into platformed and nonplatformed flakes, counted, and bagged separately. Since all noncontrol column material was going to be further processed and quantified by a laboratory analysis class in the fall, all classes of materials including tools were returned to the level bags and refiled, rather than filed in card boxes.

Geo-environmental Samples

During the summer, incoming constant volume samples (CVS), soil, phytolith/pollen, and HREC samples were shelved by unit for later analysis.

Radiocarbon samples were sent to Dr. Barbara Brandau at the Center for Applied Isotope Studies, University of Georgia, Athens, Georgia.

After the field season and with an increase in available laboratory personnel, processing was concentrated on completing the remaining one-centimeter provenienced levels. Following the washing and sorting process, quantification of materials began.

Washing and Storing--Lithic artifact curation involved three classes of artifacts. Shaped tools such as points, scrapers and burins, edge-modified flakes, and platformed flakes were individually bagged in small plastic bags. These were not washed because the dirt on the artifacts was considered important. A second portion of the artifacts were cleaned and labeled in standard archaeological fashion. These were mainly whole flakes with platforms that were extensively analyzed by measurements, etc., and therefore needed to be individually distinguishable for technological studies. The third set included the bulk of the chipping debris, chunks, chips, shatter, broken flakes without platforms, etc. These were washed in a calgon or mild hydrogen peroxide solution, weighed, and studied in other ways *en masse*. It would have been an extremely time-consuming task to label these artifacts individually, and there would have been no particular benefit to come from it. They were stored in small plastic bags, stapled to 3 x 5-inch index cards and labeled as to their provenience.

This plan was discussed with Duke Revet of the Louisiana Division of Archaeology and Historic Preservation. He indicated that his institution is in the process of re-examining their cataloging procedures, and that the procedures we proposed were in accord with those they plan to implement.

II. PHYSICAL CONTEXT AND CONTENT

A. THE OPEN-SITE ENIGMA

The archaeologist comes to a site as an applied stratigrapher and through the clever and correct interpretation of sediments decodes the events of prehistory. There are, however, considerable variations in the complexity and subtlety of the interpretations to be made. Schiffer (1975) has discussed some of the natural and cultural transformations that alter site sediments after deposition. Logically we could suppose that stratigraphy in caves and rockshelters is potentially least complicated because of partial to complete protection from the elements. This simplicity is often unraveled by cultural perturbations associated with intensive occupation. At any rate, the natural forces are minimized in the effort to interpret the stratigraphy and passage of time.

Open sites, on the other hand, are subjected to a battery of altering processes following their stratigraphic deposition. The initial making of a site is primarily the product of geomorphic and cultural processes, which are often interrelated in their mutual affects on each other. For instance, a site on a gentle slope is geomorphically subjected to an influx of sediments from up slope. Whether those sediments remain is determined by numerous factors which may include the verdure of the vegetation fostered by the enriching effects of human activity. Such interaction often results in a steady accumulation of deposits that assist in the separation of units of time.

Ideally, open sites are composed of layers that can be followed during the excavation process. Subsequent to geomorphic deposition, forces are active that rework the colors, redistribute grain sizes of soil particles, and alter soil chemistry and the original geomorphic structures marking the archaeological horizons. In other words, the soils, or pedogenic processes, can mask the interpretive clues upon which the archaeologist depends to insure the integrity of archaeological components. The problems presented by pedogenic structures increase through time. Sites as old as Eagle Hill II represent thousands of years of alteration of the original geomorphic-cultural complex. To avoid errors of interpretation, it becomes necessary to understand the geomorphic development of the site and subsequent pedogenic developments that obsure the culturally related phenomena.

In this section a number of sources on paleoenvironmental information pointing to substantial climatic changes during the late Quaternary in the Southeast are reviewed. As will become evident in this and succeeding sections, sedimentation and human occupation on Peason Ridge are strongly related to climatic change in the general Southeast. Once the climatic stage is set, the geomorphic details of the Eagle Hill locale and its sedimentology are recreated by various means ranging from on-site observation to detailed laboratory analysis.

B. PALEOCLIMATOLOGY OF THE GULF OF MEXICO COASTAL PLAIN

Introduction

For a number of important reasons, ranging from oil to presumed isostatic stability, the Gulf of Mexico has been the focus of considerable paleo-environmental study during the post-World War II period. Landward, the Gulf of Mexico Coastal Plain is a recent arrival to environmental interests. There, too, however, is a growing body of knowledge relative to past climatic variation. While much of these data are products of purely environmental research, part are results of archaeologically related activities aimed at the discovery of the ecological conditions to which human inhabitants of the American Southeast were compelled to adapt.

While early efforts to determine climatic variability in the Gulf Coastal Plain have, to all appearances, roughed out the nature of past climatic change, few were conceived and/or executed on an interregional or interdisciplinary basis. Notable exceptions are the efforts of H. Delcourt (1979), P. Delcourt (1980), Delcourt and Delcourt (1980), Delcourt *et al.* (1980), Gagliano (1977), and Muto and Gunn (1982). Most existing models of climatic change in the Southeast are, therefore, verified by the same data from which they were drawn. While such reasoning may be satisfactory during the early and basically empirical stages of a problem, those models that are derived through processes involving circular reasoning must eventually stand the scrutiny of interdisciplinary and inter-regional crosschecking, or in other words, independent verification (see, for instance, step 3 of CLIMAP [1976:1134] methodology).

Given the apparent need for interdisciplinary cooperation on the matter of prehistoric climatic change, the author participated in a series of projects beginning in 1976 under the auspices of the CAR-UTSA. The CAR undertook these projects either alone or in cooperation with other institutions, notably Texas A&M University, the Benham Group, and the University of Indiana. Funding at various times was provided by the Ewing Halsell Foundation of San Antonio, Bureau of Land Management, Corps of Engineers, Texas Parks and Wildlife, The University of Texas at San Antonio, and Fort Polk Louisiana. While each of these projects served various immediate goals, the ultimate objective was to advance the integration of modern and prehistoric data into a conceptual whole, which could act as a model of Gulf Coastal Plain climatic process and progress. These ends were particularly abetted by the Tennessee-Tombigbee Early Man and Quaternary Environments project of which Victor Carbone was instrumental in designing and administrating.

This section is intended, in part, as a review of the progress of paleo-climatic studies on the Gulf Coastal Plain and adjacent related areas such as the Gulf of Mexico and continental areas to the west and north. While I have attempted to be as exhaustive as space and time would allow, I can only imagine that there are gaps in the review. For these I can only apologize to the neglected researchers and ask their indulgence until such time as their efforts can be incorporated.

A matter which might be profitably discussed at the beginning of this venture is the benefits that can be expected. This article is directed toward three methodological issues. There is the matter of scientific soundness of an independently verified model of climatic change for the Gulf Coastal Plain that was mentioned earlier. Second, it is also possible that a clarification of interregional and interdisciplinary consistencies could avoid a great deal of useless quibbling such as has occurred in other areas of North America. I am thinking specifically of the greater southwestern United States. During the 1950s and 1960s, seemingly contradictory empirical evidence from various regions led to a great deal of argument over whether the Altithermal interval was dry or wet. This argument spread to other areas, but was ultimately resolved by an understanding of atmospheric air streams, which suggest that all of the combatants were correct in their respective regions. In other words, a spatially broader and more encompassing interdisciplinary and interregional view of the problem rendered two decades of seemingly important issues unimportant. Much of what follows is specifically intended to provide a broad global and continental backdrop for paleoclimatic studies in the Southeast.

I think there is evidence that the Gulf Coast is susceptible to interregional climatic variations which could lead to similar misunderstandings. For instance, Wigley, Jones, and Kelly (1980) conducted a study of the five coldest and five warmest years on record between 1925 and 1974. Relative to the Southeast, their results showed the global warming causes increased moisture in the lower Mississippi Valley as is illustrated in Figures 15 and 16. The remainder of the area, in contrast, experienced drying associated with warmer global temperatures. If we assume that the five warm years are analogous to the Hypsithermal (4500-7500 B.P.) and the five cold years like a mildly glaciated Little Ice Age climate (A.D. 1450-1850), the analysis would imply that part of the Southeast would experience increased precipitation in the Hypsithermal and part would be drier. Without an interregional model of moisture response to global climatic change, needless arguments could very well result.

A third issue is most fundamental and overriding to this article. Virtually all meteorological work on climatic change and, in a sense, most paleoenvironmental investigations have been structured around a predominantly spatial fabric. Even those most oriented toward diachronic reconstruction are methodologically a series of spatial "snapshots" set end to end, notably Bernabo and Webb's (1977) synthesis of northeastern pollen data, Lamb and Woodroffe's (1970) circulation analysis, and CLIMAP's (1976) reconstruction of Pleistocene global surfaces. In this section an effort will be made to develop a time series oriented methodology that will be more useful to diachronically involved disciplines. Toward this end theoretical atmospheric, geomorphic, alluvial, botanical, zoological, and cultural chronologies have been set to 500-year resolution trajectories. If nothing else, this procedure shows the relative strengths of the various indicators of climatic change. In addition, the data are set to a format that facilitates analysis, as will be demonstrated on a subset of the data.

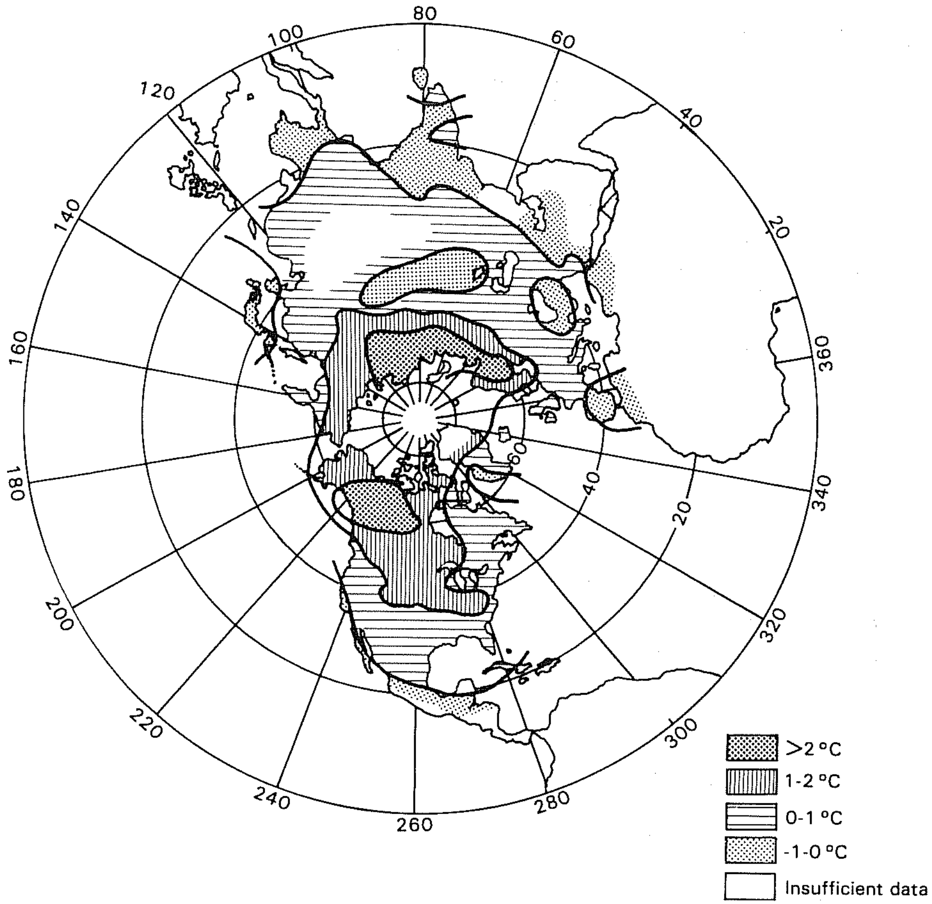


Figure 15. *Mean Annual Surface Temperature Changes from Cold to Warm Years*. The corresponding change in the hemispheric mean temperature is 0.6°C. For reference, the expected change in global mean temperature due to a doubling of atmospheric CO_2 concentration is ~2°C.

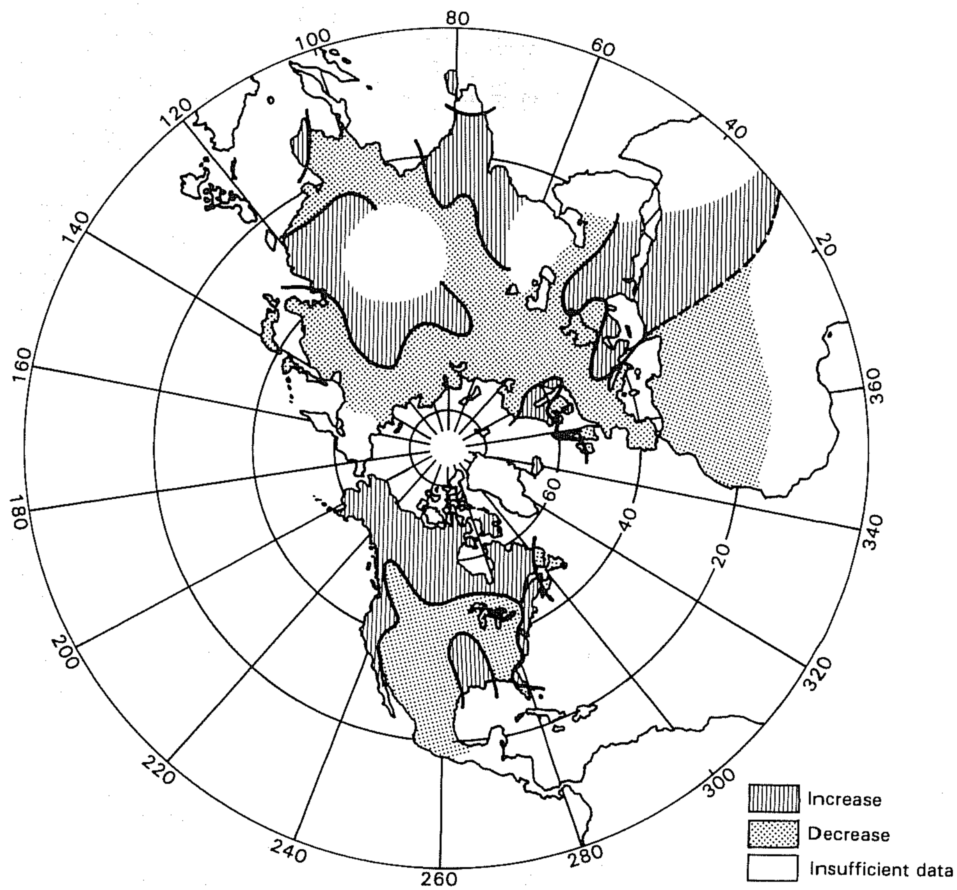


Figure 16. *Mean Annual Precipitation Changes from Cold to Warm Years*.

Changes and Lags

Since we will be discussing numerous data bases in a basically temporal context, it will be necessary to establish an understanding of the relative behavior of the variables involved. In this, I have largely followed Bryson and Wendland's (1967) lead as illustrated in Figure 17. Naturally, sea levels will follow glaciers instantaneously. Climate is defined by global forcing variables, such as variation in solar output (Eddy 1977a, 1977b; Mitchell, Stockton, and Meko 1979); variations in solar input to the atmosphere and hydrosphere, as controlled by orbital configurations (Kukla 1975); and atmospheric aerosols (Bryson and Goodman 1980). Surface albedo is taken to be a dependent variable controlled by orbital configuration (Kukla 1975) and by vegetational response to climate (see CLIMAP 1976 for a discussion of various surface albedos).

Important lag factors reside in some components of the marine energy reservoir (CLIMAP 1976) and the vegetational migration (Whitehead 1982), which may result in lags of hundreds or thousands of years.

Atmospheric Circulation

It is the belief of the author that local data bases such as have been generated by previous single discipline efforts can be best reconciled through an atmospheric model. Atmospheric circulation models have the potential to engage independent forcing variables, such as variation in solar output, to encompass the thermodynamics of the Earth's energy system, readily span interregional space, and dispense with lag times unimportant at the scale of interest, which is seasonal.

At this point, I hasten to add that an "atmospheric model" as used in this paper differs from the normal meteorological application of the term. Meteorologists are concerned with a great deal of space--the globe, over a very short period of time--the present. By contrast, the paleoclimatologist and archaeologist are concerned with great lengths of time or "time series." In the inevitable trade-offs that must be resolved to apply meteorological principles to prehistory, some of the spatial detail has to be sacrificed for a clearer understanding of climatic process through time. By necessity, then, much of what follows is a matter of selecting from what is available on the literature of modern climate and adapting it so that it can be applied to long temporal spans in the past.

Bryson and his associates have been particularly successful at constructing generalized atmospheric models which explain interregional climatic variation under varying global energy budgets (Bryson 1966; Bryson and Wendland 1967; Bryson and Murray 1977; Bryson, Baerreis, and Wendland 1968). Bryson's reconstructions generally involve application of knowledge of the behavior of the jet stream and related fronts as global mean temperatures vary. An understanding of jet stream behavior is basic to any serviceable atmospheric model (Reiter 1961). There are numerous jet streams at various latitudes and flowing in different directions all depending on the thermodynamic demands of the atmosphere and the effects of the Earth's rotation. Of most concern to the

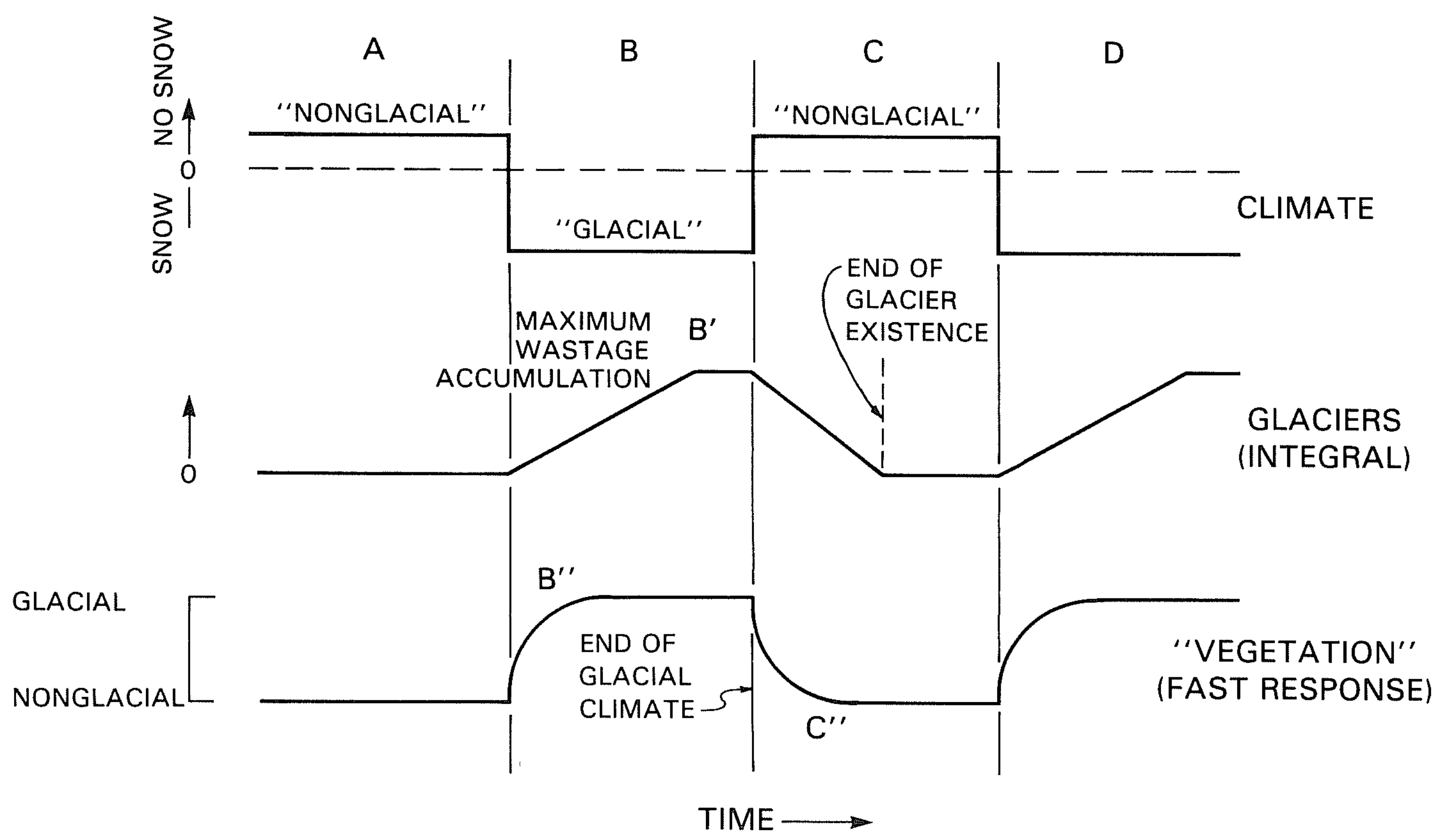


Figure 17. *Schematic Glacial and Vegetative Response to Abrupt Climatic Change.* From Bryson and Wendland 1967.

climate of North America is the midlatitude jet stream and its tributary, the subtropical flow. The jet stream flows generally from west to east at about 10 km altitude and is accompanied at the surface by westerlies and westerly moving weather systems. The rate and latitude of flow is dependent upon the status of the global energy budget, the summed energy reservoir in the atmosphere, hydrosphere, and land mass (Budyko 1974). If the energy budget is high, as during the summer or a warm climatic interval, it flows relatively slow at a more northerly latitude (Sanchez and Kutzbach 1974). During winter or cold intervals, the jet stream speeds are faster and at a more southerly latitude. The fastest winds observed in the midlatitude jet stream are over 200 mph.

The details of temperature and precipitation patterns in an area such as the Southeast are dependent on the paths the jet stream takes under varying energy budget conditions. These paths may follow a more or less straight west to east pattern called "zonal flow," or they may undulate across the continent giving an element of north to south flow for surface winds, a pattern termed "meridional flow."

The undulations in the flow of the jet stream have a normal tract for various energy budget levels. These tracts are called "standing waves." The forces controlling the standing waves are of considerable interest since they ultimately control local climate. There appear to be two schools of thought as to what causes the standing waves. Whether the two modes of control are exclusive or complementary seems to be an unresolved question in the climatological literature. However, it appears to me that both may have their place in the paleoclimatic record.

Namias (1976) has shown that the pattern of winter severity over North America is related to summer water temperatures in the northern Pacific through a rather complex chain of causal factors. If the waters remain cool throughout the summer, winds flow unobstructed across the northern Pacific in a zonal pattern. If, on the other hand, the northern Pacific waters warm in the summer, there is enough energy given up in the fall to sponsor a cyclonic low over the Gulf of Alaska. The lows experienced in the Gulf of Alaska sponsor cold fronts and cold winters in eastern North America. Western North America under a high, enjoys warmer, although drier conditions.

This model supports the normal meteorological point of view that the Gulf of Alaska is the maker of weather in the United States. There are some interesting sidelights to the model. Figure 18 illustrates data drawn from a publication by Angell and Korshover (1978). The data are radiosonde temperature readings, averaged from the surface to the 100 mb level of the atmosphere over all the world, and a good estimate of the atmospheric energy budget. The winter of 1976-1977 was clearly a cold one. It is also the example <u>par excellence</u> of a winter controlled by high summer water temperatures in the northern Pacific. Thus, we have the interesting situation of a low energy budget year and warm northern Pacific waters generating the coldest winter on record in the East. It would also be interesting to know what the mechanisms producing warm water in low energy budget years are. Namias mentions the effect of cloud cover, although he offers no further explanation. Perhaps low energy budget years produce fewer clouds allowing sunlight to reach the waters of the northern Pacific.

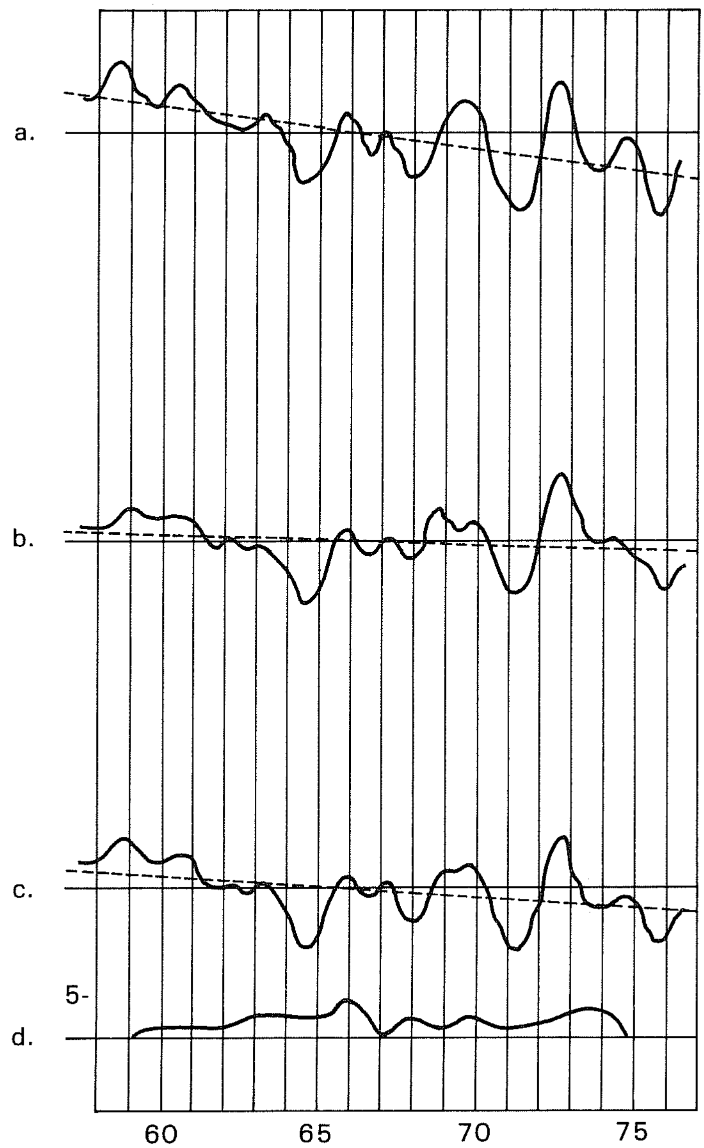


Figure 18. *Energy Budget Estimates for Northern Hemisphere.* a, southern hemisphere; b, the world; c, as determined by Angell and Korshover (1978:761) from radiosonde observations at 63 globally distributed stations. Slashed lines are regression lines between temperature observations and annual sequence of observation. Observations are seasonal; d, frequency of major volcanic eruptions.

In our search for an effective paleoclimatic (paleometeorological) model, we need to ask whether this winter bears elements of an ice age winter. We will return to this question later.

First, let us examine an alternative explanation of the cause of cold winters in eastern North America. The idea that weather is controlled by lows and highs in the lower troposphere was developed in the 1930s by Reiter (1961) before high-flying B-29s discovered the jet stream during World War II. Reiter heralded the discovery of the jet stream as a more effective means of explaining weather behavior and a new age for meteorology.

From the point of view of jet stream meteorologists, an explanation for standing waves is as follows. The behavior of the jet stream over a particular land mass depends on the topography of the land mass. In the case of North America, the high north-south trending mountains along the western edge of the continent are an influential surface feature. When the energy budget is high, the jet stream flows easily across the Sierra Nevadas and Rockies. Presumably, for reasons we will discuss later, the higher the energy budget the stronger the influence of the jet stream on North America east of the Rockies. This influence was clearly demonstrated in the 1930s when the midlatitude jet stream and its accompanying dry westerlies acted to keep moisture out of the Central Plains. Mitchell, Stockton, and Meko (1979) have demonstrated convincingly the sun's 22-year Hale cycle. Paleoclimatic evidence indicates that the dry prairies trailed the jet stream all the way to western Pennsylvania during the Hypsithermal creating the so-called "Prairie Peninsula" phenomenon. This influence would tend to shrink precipitation on the western and northern periphery of the Southeast.

To this point, we have examined a warm weather climate scenario. It appears that the higher the energy budget the greater the influence of the jet stream across the central United States. Before extending the discussion to cold and glacial conditions, we need to examine the underlying controlling force behind the route the jet stream takes across the continent. The central issue seems to be one of turbulence caused by the western mountains. When the jet stream is moving faster, the mountains generate turbulence in a general westerly air flow as do rocks in a stream of water. The resulting areas of high pressure tend to disperse the jet stream route to the north and south. The slower the jet stream the less the turbulence and the more regular the west to east flow.

The principle of turbulence control can be extended toward the cold end of the temperature spectrum as well. As the speed of the jet stream increases, more turbulence and high pressure are created over western North America. At maximum speeds, the resistance to the passage of the jet stream is so great that it is forced to split into two tributaries and flow around the western mountains as mentioned before.

Judging by what evidence is available, it seems quite possible that both the turbulence and sea surface temperature mechanisms are effective, but operating under different global energy budget levels. Namias's (1976) analysis of 1973 air flow patterns and an examination of *Monthly Weather Review* weather and circulation reviews for the winter of 1976-1977 indicate that the Aleutian Low causes extreme northward deflections of the jet stream (Fig. 19,b), so that it coursed over Alaska and then down through Canada and the eastern United States. G. L. Wells demonstrated through an analysis of orientations of Pleistocene aeolian features that the prevailing winds were from a northwesterly direction, but not nearly so exaggerated as the Aleutian Low cases (Fig. 19,c). The course indicated is through the lower and narrower mountain ranges of the American Northwest and southern Canada, but skirting the broader Sierras Basin and Range and the Colorado Rockies. An alternative confirmation is to be found in the southwesterly features in the lower southwestern United States. CLIMAP (1976) reconstructed the northern Pacific climate as being cold in August at 18,000 B.P., another bit of evidence suggesting that the turbulence factor was the dominant weather maker during the extremely low energy budget, full glacial period.

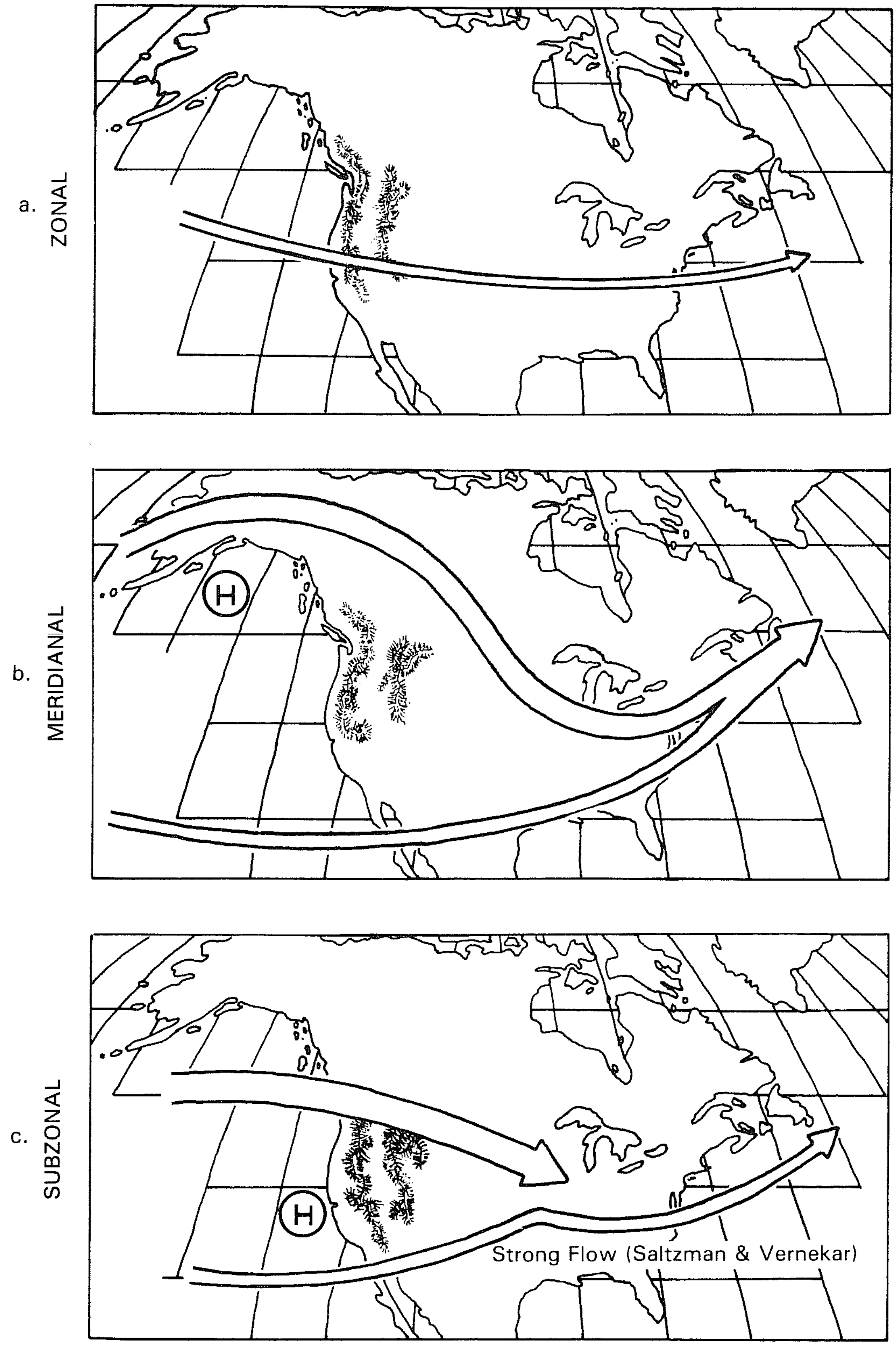
With turbulence defined as the weather maker in low energy budget periods, the Aleutian Low is probably active in moderately cool intervals below conditions which produce clouds, but above conditions which preclude summer warming of the northern Pacific. Such periods might be expected during intervals such as the Little Ice Age, the Subboreal and Preboreal.

One bit of possible contradictory evidence needs to be reconciled. The highest ridge of the ice mass delineated for the CLIMAP reconstructed climate suggests that the Laurentide ice sheet was fed by the exaggerated arc of the Aleutian Low's deflected jet stream. If the ridge is reconstructed from independent evidence it may suggest the intervention of some sea warming mechanisms to feed the glacier during its maximum stand (review Adam 1975).

The effects suggested for the Southeast are as follows. A full glacial, low energy budget indicates a moderately meridional flow as strong westerlies force their way across the continent. The increased strength of the westerlies (Saltzman and Vernekar 1975) probably acted to shield the Southeast from the harsh effects of the ice-chilled air mass to the north. Note that in this model atmospheric flow is taken to be causally prior to the ice stand. By the same token, the westerlies shielded the glacier from the ameliorating effects of southerly air movements.

A moderately low energy budget, which allowed for sufficient heating of the northern Pacific to sustain a low throughout the declining segment of the year, would result in a much more turbulent weather pattern in the Southeast. Once the jet stream arcs through Alaska, the accompanying westerlies are markedly chilled. Such strong arctic air masses would sponsor the movement of arctic fronts into the Southeast. At frequent intervals such fronts preclude the landward movement of moist air of the Gulf (Orton 1964). Namias, however, found a net increase in moisture in the Southeast during 1973, a year of the Aleutian Low.

Such turbulent meridional circulation replaced the persistent system of zonal flow that maintained the glacier and, probably explains, once established, the apparently abrupt disappearance of the bulk of the ice mass. This abrupt turn is noted both in Andrews and Miller's (1978) research on the ice mass itself and in Gagliano's (1977) examination of submerged features in the Gulf of Mexico.



Thermodynamics (Saltzman and Vernekar 1975) + Standing Wave → Very High Winds

Figure 19. *Jet Stream and Energy Budget Conditions.* a, high; b, medium; c, low.

In the final analysis, there are three extreme atmospheric states. At high energy budget levels, constant zonal flow dries the northern reaches of the Gulf Coastal Plain, while a northerly displaced subtropical high wets the coastal West and dries the coastal East. Under moderately low energy budget conditions, marked meridional circulation cools and dampens the area. Under low energy budget conditions, a modified zonal flow shields the Southeast from extremes, but probably also dries it.

Generating a time series from this model required a detailed understanding of the global energy budget. Figure 20 is an attempt (Gunn 1982c) to create an energy budget curve from orbital and volcanic data. It is based on two cycles. The larger cycle is 23,000 years and is drawn from Kukla's 1975 findings that the annual albedo and, ultimately, the energy budget are heavily influenced by October temperatures. Kukla, therefore, reasons that glaciers should occur in periods when the earth's orbital precision dictates low temperatures in the northern hemisphere during October. The second cycle superimposed on the first is based on data published by Bryson and Goodman (1980) on frequencies of volcanic eruption in the Holocene.

The time series illustrated in Figure 19 shows expected circulation patterns for different time periods: zone (Z) for warm periods, subzonal (S) for very cold intervals, and meridional (M) for intermediate periods.

There is some literature relative to assessing the validity of the time series. However, most previous work is short of the detail necessary for comprehensive evaluation. The range of approaches runs the gamut of scientific enterprise from very theoretical to very empirical, from very detailed to very general.

Full glacial circulation is most difficult to reconstruct. The theoretical efforts include simulations of atmospheric processes such as those by Saltzman and Vernekar (1975), Manabe and Hahn (1977), and Gates (1976). Presumably the latter two models should be more serviceable, because they are based on three-dimensional representations of atmosphere. However, their utility seems to be limited to the tropics for which they were directly intended. Their projections of North American full glacial climate are not borne out by the paleoenvironmental record. The Saltzman and Vernekar model on the other hand, provides a great deal of serviceable information on atmospheric thermodynamics in spite of rather obvious limitations, such as two-dimensional representation of the atmospheric, symmetrical air flow relationships to the poles, and lack of standing waves caused by physiographic features such as mountains.

The meteorologists' concern with short periods of time is clearly illustrated by attempts to apply simulation models to past climates. Since simulating the atmospheric processes is such a massive undertaking spatially, pairing them with thousands of years under varying energy budget levels, such as would be most useful for archaeologists, is a financial and practical impossibility. For this reason, such efforts have been limited to the simulation of glacial maximum conditions around 18,000 B.P. While this is unfortunate in a way, it is fortunate that simulators have chosen the glacial maximum to devote their efforts. As will be discussed later, less glaciated conditions can be approached through other means. Glacial maximum, however, is completely foreign to our present experience and can only be estimated in theory.

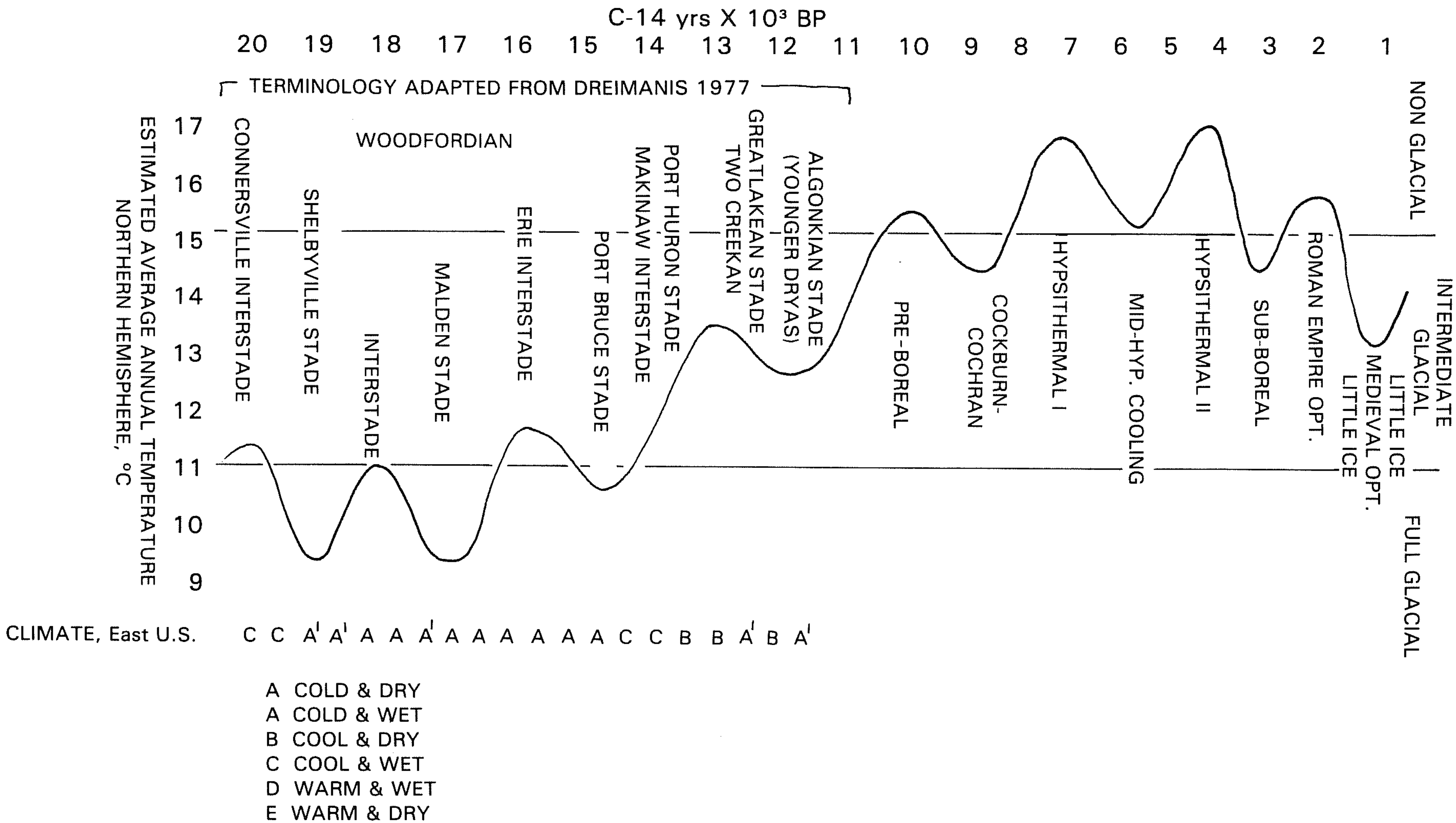


Figure 20. *Estimated Energy Budget for the Last 20K Years*. From Gunn (1982c). Glacial terminology from Dreimanis (1977). Most confusion between estimates and empirical evidence occurs when the energy budget is at about 13°C. Pleistocene-Holocene boundary is where energy budget permanently crosses 13°C. 13°C may be system threshold between glacial and nonglacial climate.

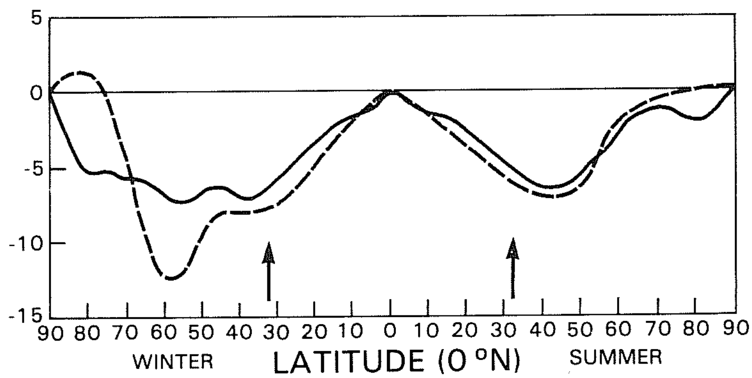
Figure 21 illustrates three of many helpful graphs presented by Saltzman and Vernekar (1975). The solid line represents present temperature gradients at various degrees of latitude north and south of the equator. The dashed lines represent simulated conditions at 18,000 B.P. Notably, there are major increases in temperature gradients over the ice between 50 and 70 degrees north latitude. Areas as far south as the Gulf Coast, however, experience much smaller drops in temperature, perhaps as little as two or three degrees Kelvin (Fig. 21,b) in the midlatitude. Saltzman and Vernekar suggest that the strong zonal winds, or subzonal as we have determined them for North America because of the mountains, were instrumental in maintaining the sharp temperature gradient which in turn sponsored the ice sheets. The Southeast must have been windier and cooler if not nearly so deviant from modern conditions. As is illustrated (Fig. 21,c), the Saltzman-Vernekar model correctly infers a drier full glacial at the latitude of the Southeast.

Intermediate glacial and Holocene circulation can be approached more directly. There are several empirical studies designed to mark the air flow patterns during the relatively warm present century and the moderately glaciated Little Ice Age of the last century. Sanchez and Kutzbach (1974) utilized the cooling trend of the last quarter century to demonstrate southward movement of belts of rainfall and temperature. Blasing's (1975) analysis of tree ring data and modern pressure data indicates a strong meridional or north-south component to colder winters (Blasing's Type 4 Winter). Both Dzerdzeevskij's (1968) analysis of 20th-century atmospheric flow and Namias's (1976) study on the Aleutian Low, and numerous analyses of the very cold winter of 1976-1977, support a general chilling of the eastern United States during periods of global cooling. This is in contrast to the western United States, which warms as the world cools.

Virtually all of the literature supports a strong zonal flow for high energy budget intervals. The meridional circulation pattern, however, is much less visible and is, in my opinion, an important blind spot in our understanding of moderately cold periods.

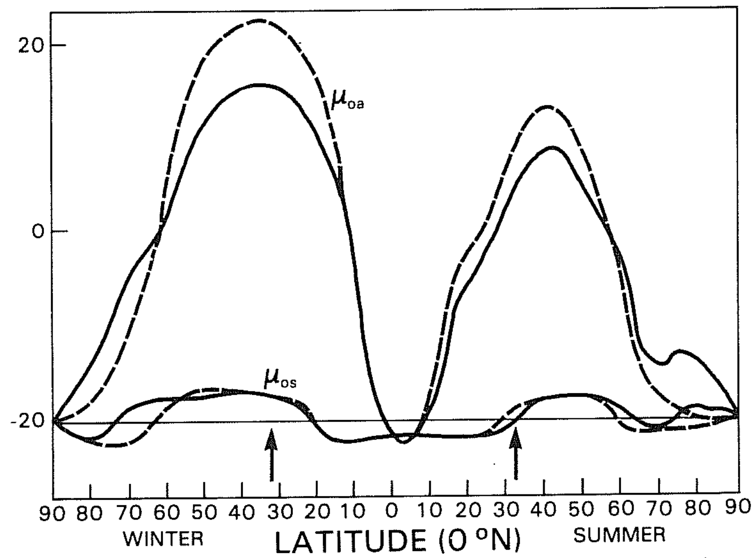
Lands, Glaciers, and Seas in Eastern North America

The late Quaternary conditions of eastern North America were regulated by the atmospherically coordinated ebb and flow of glaciers and seas. Along the Gulf Coast, lowered sea levels exposed a low latitude plain apparently rich in fauna and flora and possibly a refugium for many of the plant species now extant over much of eastern North America. To the north, glaciers advanced and retreated over higher latitude landscapes. In a sense, eastern North America was a shifting corridor of land whose position was controlled by the ratio of water and ice. Within the corridor the habitat was equally unreliable. As we have seen, colder times saw a strong westerly flow, which shielded the ice sheets from inroads by warmer southern air. At the same time equal protection from arctic air was afforded the South, so temperatures were only moderately colder on the Gulf Coastal Plain. Moderately cold climate exhibited wetter conditions as meridional flow led to the collision of cold and warm air masses. During warm periods the Gulf watered the Southeast saving it from the desert climate that one would ordinarily expect at latitudes equal to that of the Sahara a.



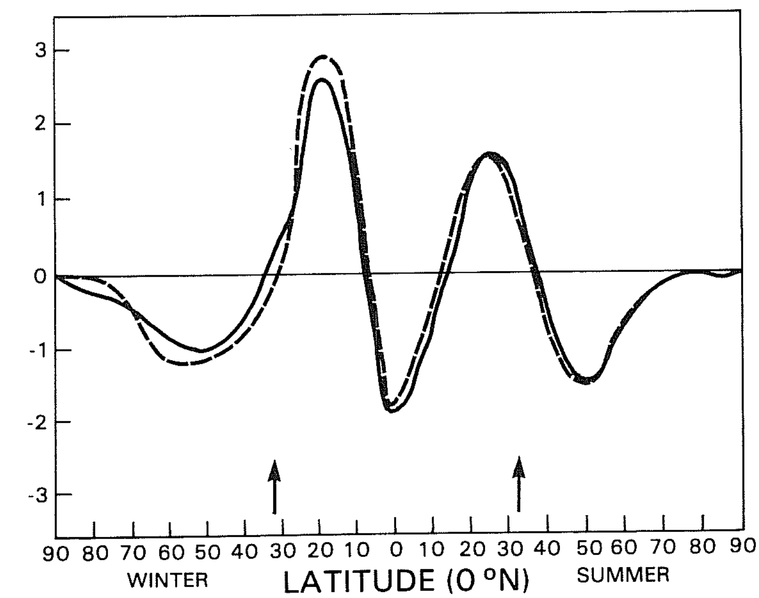
Mean surface temperature gradient $\partial\Theta_{os}$ a $\partial\phi$ for present (full) and 18,000 BP (dashed).

b.



Mean surface zonal wind speed μ_{os} (lower curves) and vertically averaged zonal wind speed μ_{oa} (upper curves) for present (full) and 18,000 BP (dashed).

c.



Mean difference between evaporation and precipitation (E_0 -P_0), for present (full) and 18,000 BP (dashed).

Figure 21. *Selected Simulation Variables.* From Saltzman and Vernekar 1975.

and Sonora Deserts. In the following two sections the implications of sea levels and glaciers for life in the Gulf Coastal Plain will be examined.

Sea Levels

Sea levels in the Gulf of Mexico have been of considerable interest because of the relative isostatic stability of the Gulf Coast. Mahula (1982a) has reviewed the research. Beginning in the 1950s several curves were generated by various researchers in attempts to describe the ups and downs of Gulf sea levels during the late Quaternary. Utilizing the methods of bathymetry, submerged landforms were studied and dated by radiocarbon assays of shell and peat deposits bored from submerged beaches.

A discussion of two of these curves will facilitate our examination of the Mexico Gulf Coast climate. The first is by Curray (1960, 1965) and the second by Stapor and Tanner (1977). The Curray curve is the most generally accepted curve for the late Quaternary spanning the time period from about 20,000 B.P. to the present. The Stapor and Tanner curve is not from the Gulf of Mexico, but from St. Vincent's Island off the coast of Florida. However, it is sensitive to the more subtle sea level fluctuations of the last 5000 years. Figure 22 is drawn from the Curray and Stapor and Tanner evidence. It is plotted on a logarithmic scale to exaggerate the importance of the Holocene sea level fluctuations.

Curray's work shows six periods in late Quaternary sea level changes:

1. 18,000-20,000 B.P., Full Glacial. The sea surface is about 120 m below present mean sea level. Winds, currents, and drifts are much like they are now. Shores are over the edge of the continental shelf, where slopes are about 600 feet per mile, so shallows rich in marine fauna and flora are scarce or lacking. Gagliano's (1977) examination of continental shelf bathymetry indicates that the 120-m stand was brief, and that the sea rose rapidly to the 82-m stand (see section on geomorphology for details).

2. 16,000-18,000 B.P., decline of Tazewell. Sea level rose from 120 m to 80 m. Winds, currents, and drifts are similar to the present.

3. 12,000-16,000 B.P., stand or reversal. Sea level is at 82 m and may have dropped back to 88 m at some time during the period.

4. 11,000-12,000 B.P., corresponds to the Two Creeks and Alleröd interstadial. During the 64-m stand winds were strong and southwesterly, the northward longshore current along the Rio Grande coast was intensified, and the westbound currents along the upper Texas coast were reversed. After the cold episode, waters warmed as indicated by foraminifera, and currents returned to their present condition.

5. 10,000-11,000 B.P., Mankato glacial advance. Sea level is at 40 m at the beginning of the period and recedes to 64 m. There was a 46-m stand early in the period.

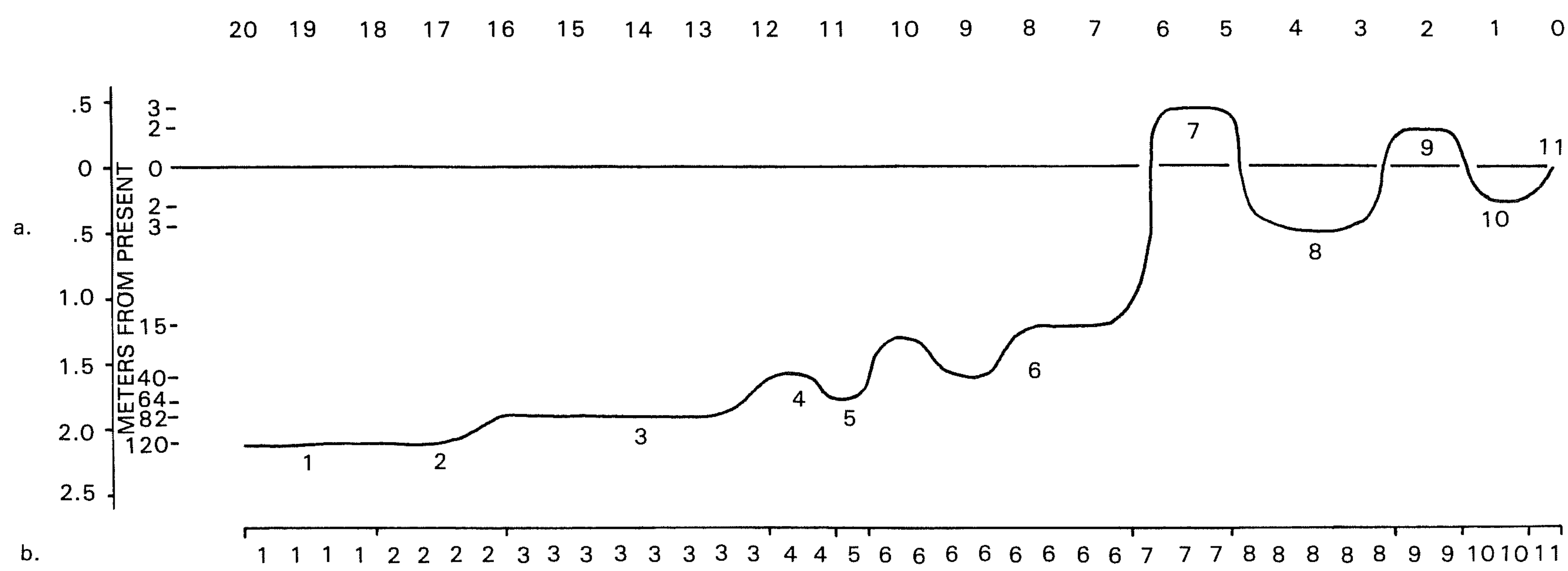


Figure 22. *Sea Level Fluctuations*. a, sea levels for the last 20,000 years; b, time series for sea levels.

6. 7000-10,000 B.P., early Holocene. Sea level was at 18 m and then regressed to 38 m. Winds and currents responded as in a cold period. Then sea level rose to a stand at 15 m below present sea level.

Sea levels show a slow, but continuous rise from 7000 B.P. to the present in Curray's graph. Unlike the Curray curve, the Stapor and Tanner curve shows subtle variations in sea level during the last 7000 years. They drew evidence from a number of sources including prehistoric sites, beach ridges, and shell mounds. They define five periods (the names are mine). The period numbers continue from the Curray curve.

7. 4900-6200 B.P., Hypsithermal. Sea level was higher than it is now, perhaps as much as two meters.

8. 2600-4900 B.P., Subboreal. Sea level was lower than present, probably somewhere between two and three meters.

9. 1400-2600 B.P., Roman Empire Climatic Optimum. Sea level was above present levels. Exact figures are questionable, but it is estimated to be between one and two meters.

10. 1400 B.P. to present, Little Ice Age. Sea levels were below those of the present, probably at the order of minus two meters.

11. Present, warm century.

It is of interest to note that both the Curray and Stapor and Tanner curves correlate well with the Denton and Karlén (1973) tree line data.

Figure 22,b illustrates a time series for sea level changes.

Ice Levels

The ice mass at full glacial was reconstructed by the CLIMAP (1976) task group to show the extent and elevation of permanent ice as is illustrated in Figure 23. As was indicated earlier, glaciers waxed behind a shield of strong slightly subzonal westerlies.

Andrews and Miller (1978:175) have suggested that the glaciers in North America were substantially reduced after about 16,000 B.P. The hypothesis is supported by a marked sea level rise in the Gulf of Mexico universally dated to the same time period (Ballard and Uchupi 1970; McFarlan 1961; Curray 1960; Poag 1973). This suggests that the energy budget conditions, which sustained the cold zonal westerlies, were altered probably by an increasing energy budget sponsored by precession of the earth's orbit (Kukla 1975).

The atmospheric flow patterns somewhat typical of the 19th and 20th centuries resumed at this time. The late glacial would have resembled the brusque climate of the 19th century, while the various Holocene climatic optima paralleled the very warm mid-20th century.

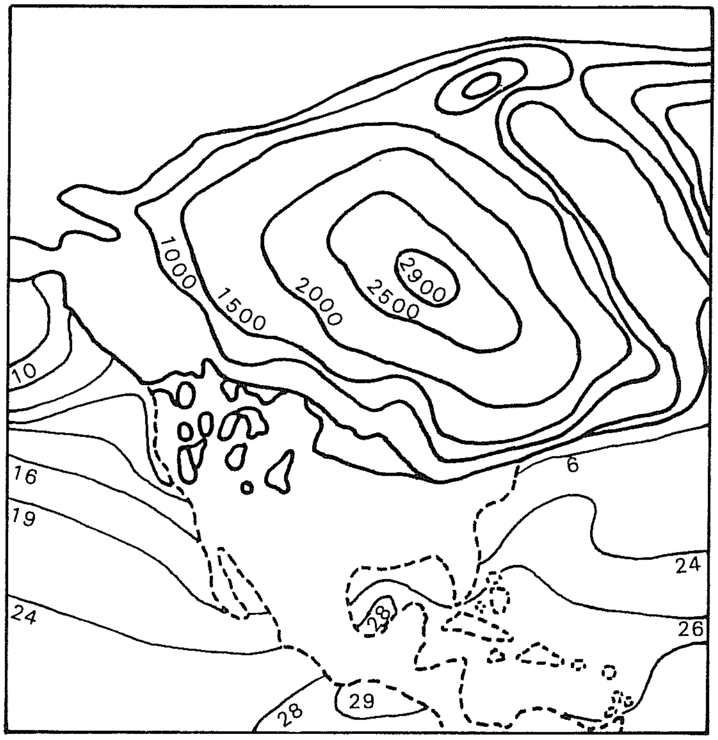


Figure 23. *Ice Mass (Meters) and Sea Surface Temperature* (°C) *at 18,000 B.P.* From CLIMAP 1976. Wendland (1977) indicates that sea surface temperatures in the Atlantic indicate no tropical storm activity is likely from the East. Sea surface temperatures in the northern Pacific fall far below the <25°C necessary to effect an Aleutian Low (Namias 1976).

The model being used in this paper, which takes the behavior of the atmosphere to be causally prior to that of the ice, suggests very little direct influence of the glaciers on the Southeast during glacial maximum. However, we must note water and sediment outflow in the Arkansas and Mississippi Rivers (Saucier 1974) and the increased land area along the coast (Gagliano 1977). On the other hand, increased meridional flow during the late glacial probably chilled outbreaks of arctic air below temperatures experienced during the present or last century.

Geomorphology of the Gulf Coast

When Bernard and LeBlanc (1965) wrote their general description of the northwest coastal plains of the Gulf of Mexico, over 350 publications had been prepared on the geology of the Gulf of Mexico, the Atlantic Coastal Plains, and the adjoining continental shelf. The Gulf of Mexico Coastal Plains from northeastern Mexico to the panhandle of Florida (Fig. 24) are characterized by landward uplift and seaward subsidence. The process is driven by the loading of sediments onto the continental shelf by nine major river systems (Fig. 25). The juncture between subsistence and uplift, or "hinge line," is generally just landward of the present coast except near the mouth of the Mississippi River where heavy sedimentation has deposited a delta nearly to the edge of the continental shelf. The extended loading has moved the hinge line nearly 30 miles seaward.

The continental shelf is composed of sediments from the river systems, which are smoothed by high water stands, such as that of the late Holocene. It is relatively flat and extends seaward 200 km at the Sabine River. From there it narrows in both directions until it reaches the Florida and Yucatan peninsulas. The continental shelf is considered to extend to the 200 m contour. The slope is very gradual to the 100 m contour, between 0.2 and 1.7 m per km depending upon location. Slope increases and becomes more variable beyond, five meters or more per kilometer.

Beyond the continental shelf, the continental slope grades rapidly down to the Sigsbee Abyssal Plain, which is 3500-4000 m below the surface. Down to 130 m the topography is very rough and shows signs of instability such as landslide scars. These are probably the sediments that were built up during the low stands of sea level during the Pleistocene. Below, on the continental slope are more stable sediments.

Coastal Environments, Inc., under the supervision of Gagliano (1977) produced an extensive examination of sea level variation and near-shore environments and their cultural implications for the late Quaternary. The study concentrates on phenomena seaward of the hinge line.

Coastal Environments' study of continental shelf bathymetry adds numerous interesting details to the record of glacio-marine interaction. For instance, close examination of contours at the 120-230 m depth of the mouth of the Rio Grande indicates that the river stood only a brief period of time before sea levels rose rapidly to 80 m to stand for a considerable interval. The long stand is witnessed by a large delta, shoreline features, etc. Similar features appear at 54, 44, 28, and 18 m. The equivalent of the 44-m stand is

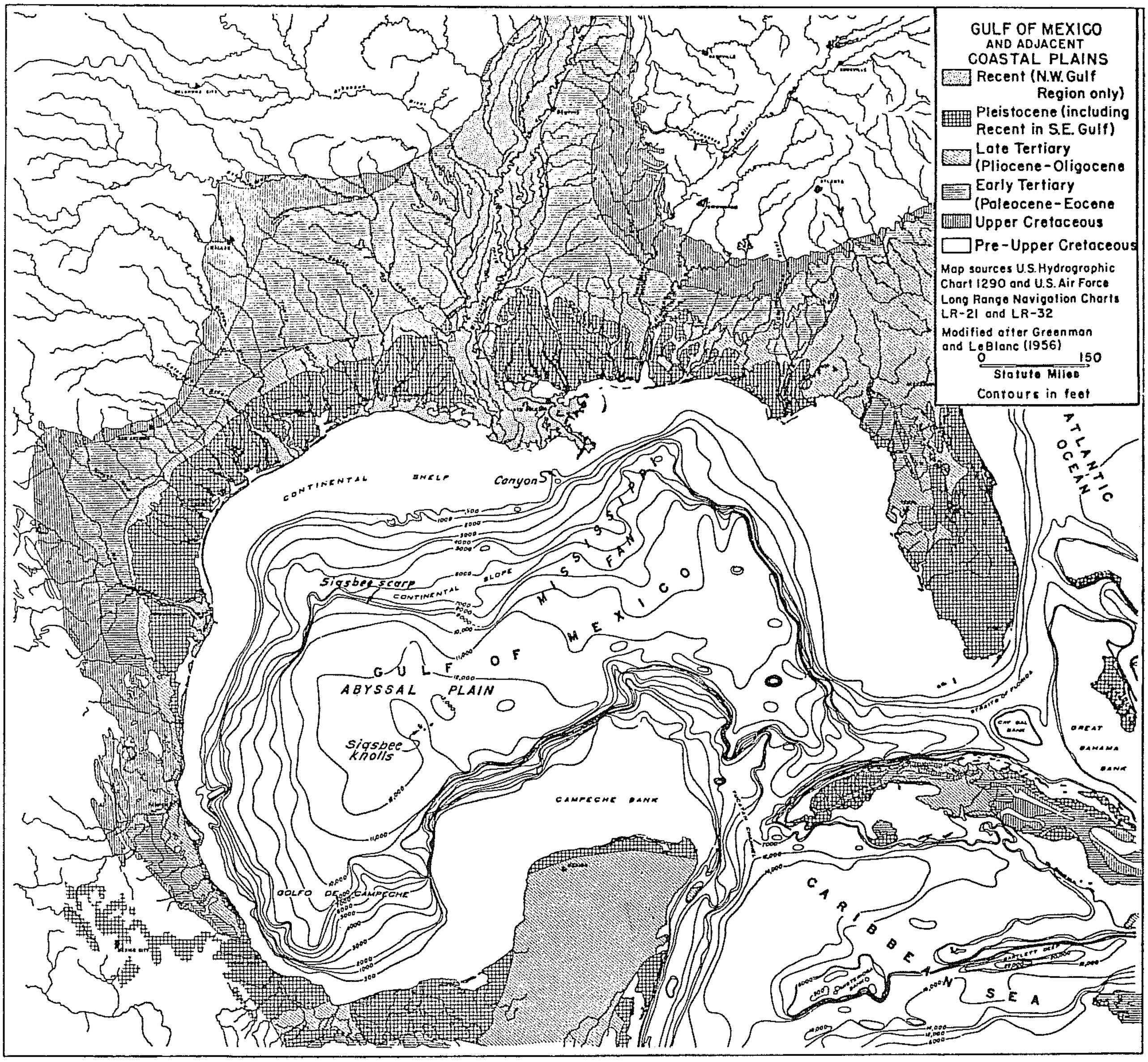


Figure 24. *Generalized Geologic Map of the Gulf Coastal Plains and the Principal Hydrographic Features of the Gulf of Mexico.* Modified after Greenman and LeBlanc (1956) and Ewing, Ericson, and Heezen (1958).

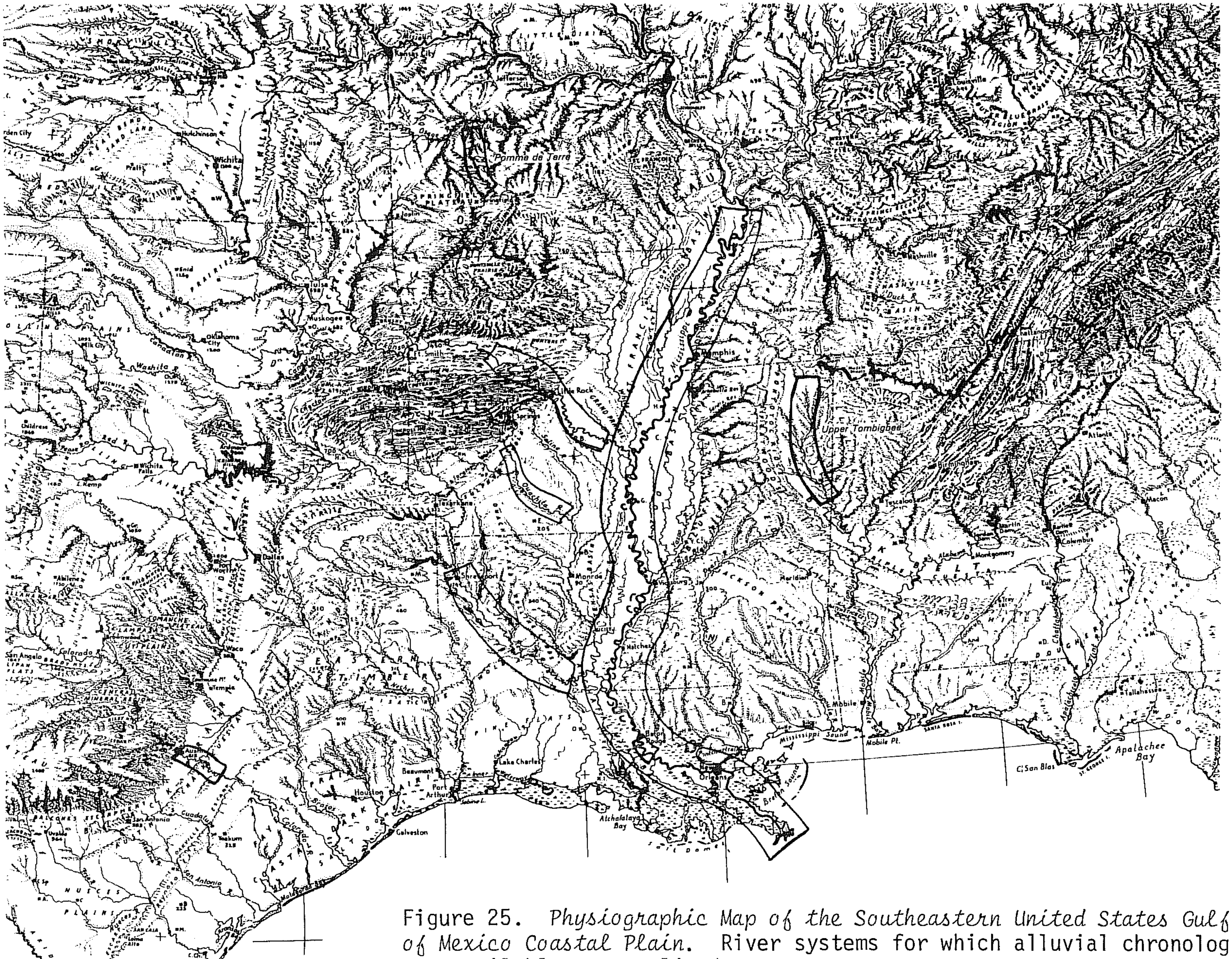


Figure 25. *Physiographic Map of the Southeastern United States Gulf of Mexico Coastal Plain.* River systems for which alluvial chronologies are available are outlined.

associated with freshwater forms and extinct megafauna on the central Texas coast. Such features appear around the bulk of the Gulf Coast, at or near the same depth. Along the Texas and Louisiana coasts, there is evidence that the Colorado, Brazos, Trinity, and Sabine Rivers with adjoining lesser systems met at a point on the then exposed continental shelf to form one large river.

Salt domes have forced Tertiary sediments upward in areas of the Louisiana and east Texas coasts. These submerged islands, or "banks," may have been appealing shelters to human occupants of an otherwise windswept and relatively dry plain (Gagliano 1977:86).

Before 17,000 B.P. the Mississippi River is thought to have emptied into the Mississippi trough, a canyon in the continental shelf off the Louisiana coast. Subsequently the river began to develop deltas. Gagliano (1977) details a sequence of 10 delta complexes and lobes that marked the activities of the river to the present. The rich deltaic environments attracted habitation during and since Paleo-Indian times, and each delta lobe was found to contain a distinctive array of archaeological sites indicating its date of activity. The delta chronology suggests a relatively stable sea level between 8500 and 12,000 B.P. The sea level may have been nearer that of today rather than 20 to 45 m lower suggested by other researchers. Since a sea level stand at 58 m is well dated at 12,900 B.P. (Neumann 1958), the possibility of a rapid rise or rapid fluctuations around 13,000 B.P. seems to be indicated. An additional note of interest is that the size of the delta lobe of the Brazos-Colorado River at 60 m may suggest a lengthy stand, perhaps indicating relatively stable sea levels in the period 17,000 to 13,000 B.P. (Gagliano 1977:90).

The delta complex dates range between 6000 and 8500 B.P. and is associated with the Early Archaic. During this interval sea levels fall, reaching its lowest point about 7000 B.P. Because of falling sea levels, swamps in the shore zone and delta were drained, suggesting a somewhat resource-reduced environment. Archaic sites are associated with a complex of deltas between 4000 and 6000 B.P. Poverty Point and Tchefuncte are found on yet another lobe, which was active between 2000 and 4000 B.P.

Landward from the hinge line are a series of narrow plains paralleling the coast. Landward each plain represents a successively older period and is slightly more tilted toward the sea. In the region of the Sabine-Neches Rivers, early Pleistocene deposits have been uplifted by this process as much as 180 m. Uplift decreases along the plains to the east and west to about 120 m.

Rivers approach the coast at a much lower gradient than the tilted plains. The oldest plains grade as much as 3-4 m per km. The rivers generally are entrenched with a gradient of about 0.25 m per km. At the hinge line gradients slack, and stream deposits change from alluvial to deltaic.

Alluvial Chronology

Rivers aggrade or degrade alluvial floodplains and change their mode of sediment transport from meandering to braided depending on the amount of sediment and water they carry. The changes are ultimately related to climate, although the relationships are often complex and not entirely transparent to analysis (Schumm 1965).

Numerous river systems in the Southeast have been subjected to analysis (Table 5) in such a manner as to outline the history of changes over the last few millenia. A survey of these "alluvial chronologies" will serve not only to direct the purpose of outlining the effect of climatic change recorded in the river valleys, but it will also serve as a basis for the study of uplands. In streams whose water originates within the environmental context of the Southeast, sediments are derived from the uplands so alluvial aggradation is an obverse history of the upland erosion.

TABLE 5. PRIMARY SOURCES FOR ALLUVIAL CHRONOLOGIES CITED BY VARIOUS REVIEWERS

Arkansas River	Saucier 1967*
Big Black River	Saucier 1967*
Red River	Gagliano and Thom 1967* Frye and Leonard 1963; Frye 1961+
Sabine River	Gagliano and Thom 1967*
Pearl River	Gagliano and Thom 1967*
Ouachita River	Saucier and Fleetwood 1970* Fleetwood 1969*

* from Saucier 1974
+ from Schumm 1965

While understanding alluvial sequences is basic to any climatic context, Brakenridge (1980) has suggested a scheme that has broader implications, e.g., that of alluvial dating. The Pomme de Terre River in southern Missouri (see Fig. 25 north of Ozark Plateau) has been extensively studied in relation to the Truman Reservior project. Brakenridge noted that the cut and fill sequence defined for the Pomme de Terre River corresponded with synchronous events in other areas of the northern hemisphere. The Pomme de Terre River is wholly contained within the southern woodlands, although securely related to the prairie-forest ecotone. As with most southeastern rivers, sediments begin relatively low in the late Pleistocene and aggrade through the Hypsithermal. Post Hypsithermal events result in a steady degradation, although the process is systematically stepped downward. Brakenridge notes that the periods of downcutting are systematically related to the periods of glacial advance defined by Denton and Karlén (1973).

Neither water or sediments of the Mississippi River originate within the Southeast in any significant proportion. However, there are aspects of the behavior of the Mississippi River that seem to reflect local climatic influences. Also, a review of the Mississippi River alluvial history will serve as a broader backdrop for local river systems.

The Mississippi River is the focal drainage of central North America and as such bears the marks of the complications that implies. Saucier (1974) has updated earlier efforts by H. N. Fisk to define an alluvial chronology for the lower Mississippi Valley. During the advancing phase of the final Wisconsin stadial, 20,000 to 25,000 B.P., the Mississippi River downcut its valley as did its tributaries and nearby rivers. Entrenchment was 75-80 feet below Baton Rouge and 20-25 feet between Baton Rouge and Vicksburg. A combination of increased precipitation and the laying down of the last major loess sheets to the east of the Mississippi River suggest to Saucier substantial, warm-season precipitation, while the cold season was dry and windy.

Glacial outwash sediments increased significantly between 18,000 and 20,000 B.P. A braided stream regime resulted, which marked the declining stage of the glaciation. The Arkansas River, which was also carrying glacial outwash from the Rockies, developed a braided channel. The Red River without glacial outwash maintained a meandering mode throughout the late Pleistocene and Holocene.

The Mississippi River changed suddenly to a meandering stream about 12,000 B.P. below Baton Rouge probably in response to rising sea levels during the Two Creeks interstadial. The Arkansas River also changed to a meandering regime. By 9000 B.P. the glaciers withdrew north of the Great Lakes and so ceased to contribute a heavy sediment load of glacial outwash. From that time the stream changed to a meandering system progressively northward reaching Memphis by 6000 B.P.

The last 9000 years are a complicated history of changes from one meander belt to another. The Mississippi River alluvial floodplain is very wide; as a result there is little bedrock structural control of its course. Where the meander belt is located could very well be as much a response to climatically regulated discharge and sediment load of tributaries to factors internal to the Mississippi River system itself. While Saucier (1974) offers no climatic explanation for changes in the meander belt, it is worth noting that there were major changes at 7500, 6000, 4700, 3500, 2800, and 1200 B.P. Streams, whose origin is within the Southeast, can serve as a more direct entrée to climatic effect on stream behavior.

The upper Tombigbee River was studied by Nials (1982). Previous to about 16,000 B.P. the valley was largely scoured out. After 16,000 B.P. the valley began to aggrade, and a braided stream regime was established. The increase in sediments implied episodic precipitation, perhaps falling mostly in the summer. The unevenness of the rainfall reduced vegetation and increased erosion of the uplands.

After 8000 B.P. the regime changed to one of a meandering stream which implies a moderated bed load in conjunction with increased and more evenly spaced precipitation relative to the braided stream.

Baker and Penteado-Orellano (1977) conducted an alluvial study of the Colorado River in Texas from the edge of the Balcones Escarpment, the edge of the Gulf Coastal Plain, to about 100 km downstream. The central Texas area is subject today to highly variable annual precipitation as is typical of the prairie-forest ecotone. The study is ideally situated to mark the western terminus of this survey and of the southeastern woodlands of the United States.

Studies were made of the variable grain size and sinuosity of the river's relict meander scars. Dry conditions were assumed to be associated with low sinuosity and coarse-grained sediments. Wet periods are marked by high sinuosity and fine sediments. The transition from wet to dry resulted in the scouring of fine-grained sediments from the previous period followed by depositions of coarse-grained sediments at the top of the unit. Aggradation seems to be slower in the mesic periods.

The sequence of events is shown in Table 6. Unfortunately, the dating prior to 700 B.P. is insufficient to define with any certainty the temporal placement of the critical late Pleistocene-early Holocene events. One might suspect that the incision before 7000 B.P. is the beginning of the Hypsithermal and the previous wet period, the Preboreal. This would suggest a dry mid-Wisconsin interstadial and final stadial. Confirmation must await a more refined radiocarbon chronology.

TABLE 6. LATE QUATERNARY ALLUVIAL CHRONOLOGY FOR THE COLORADO RIVER ON THE BLACKLAND PRAIRIE BELOW AUSTIN, TEXAS

Channel Phase	Climate	Indicators	Radiocarbon Date B.P.	
			0	
1	Modern			
2				Late Holocene
3				
			2000	
4	Mesic	high sinuosity		
			3000	
		fine sediments		
5			7000	Early Holocene
	Xeric	coarse sediments, aggradation		
		incision		
6B	Mesic	high sinuosity		
6A	Xeric	finer sediment		Late Wisconsin
6	Xeric	course sediment, aggradation		

SOURCE: Adopted from Baker and Penteado-Orellano 1977.

At a nearly microenvironmental scale is the alluvial stream sequence delineated by Gagliano (1980) for the Salt Mine Valley site on Avery Island. The sequence (Fig. 26) shows Holocene filling of a downcut Pleistocene valley with some erosion of the fill in the mid-Holocene.

Figure 27 illustrates the alluvial trajectories of several of the rivers and streams reviewed. The various water courses are marked by 500-year intervals as to their status, "A" for aggradation and "D" for degradation. If the valley is aggrading it is superscripted by an "m" for meandering and a "b" for braided, where the information is available and pertinent. A subscripted "c" indicates a change of meander belt.

Certain of the alluvial chronologies are of higher resolution than the others. Brakenridge (1980) points out on the Pomme de Terre River that there are synchronous degradation episodes in many northern hemisphere streams (Fig. 27). There appears to be some concordance after 8000 B.P., which is marked by degradation in several streams. It is clear that the late Quaternary is generally a period of aggradation. Braided streams earlier in the sequence point to the aridity during intervals of glacial outwash sediment loads. Meandering streams during the Holocene suggest moister conditions and/or less sediment load. When other rivers in the Southeast are as well understood as the Pomme de Terre, the timing of aggradation and degradation will be of considerable interest to archaeological climatology. It will be especially helpful if the sequences are synchronous. Present information only supports broad and modestly useful generalizations.

Uplands

Uplands in the Gulf Coastal Plain show evidence of strong wind action during full glacial and the last Wisconsin interstadial. There are loess deposits on the uplands east of the Mississippi River as illustrated in Figure 28, the related dates are shown on Table 7 (Snowden and Priddy 1968; Otvos 1975; Gagliano 1977:214-218; Saucier 1978; Saucier and Fleetwood 1970). The east Mississippi loesses are correlated with the Peorian Loess in Illinois (Gagliano 1977:218).

Saucier (1978) has reported on dune fields in the Mississippi River valley. They seem to have been active during glacial maxima and perhaps during the Hypsithermal. While not strictly within the scope of this survey, Thom (1967) has reported dune fields in the last stadial of the Wisconsin in South Carolina, and Whitehead (1973, 1982:203) has examined other similar features in the same area. It would be of some interest if active dune fields were found on the continental shelf clearly separable from shoreline developments. West of the Mississippi River, Gagliano (1977) reports numerous sand-related features on the continental shelf. However, none are clearly identified as being climatically related rather than as a product of normal shore processes. In addition, sandy features are nearly ubiquitous on the northwestern shores of the Gulf. However, there does seem to be some stabilization of the south Texas sand sheet after the Pleistocene (Gagliano 1977:151).

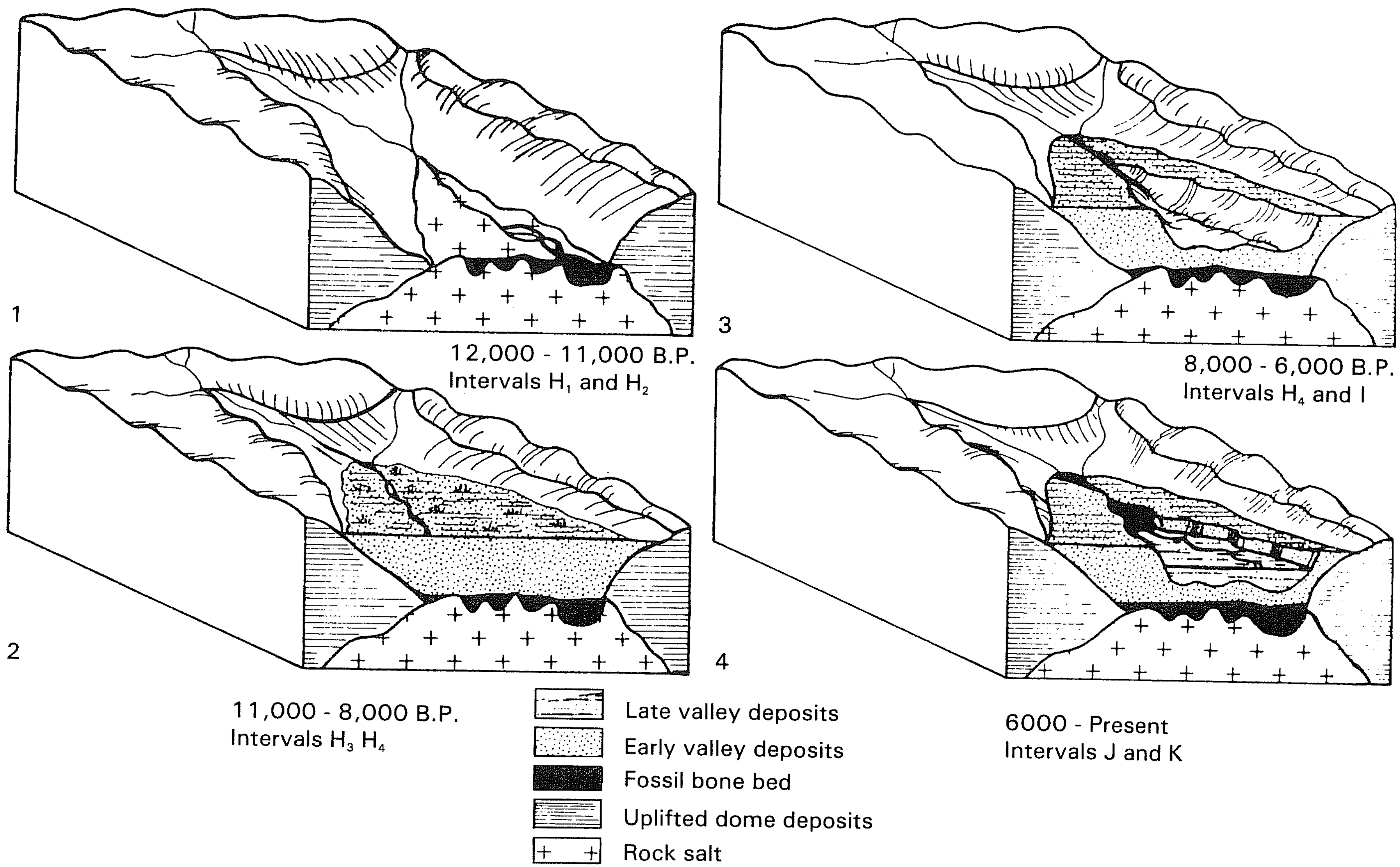


Figure 26. *Four Idealized Phases of the Geological History of the Salt Mine Valley Site (16 IB 23) Showing Stream Cutting and Valley Filling.* After Gagliano 1970.

RADIOCARBON YEARS B.P.

	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
RIO GRANDE	
COLORADO	D? A A A A A A A A A A A A A A
BRAZOS	
TRINITY	
NECHES	
SABINE	
POMME DE TERRE	A A A A A A D A A A A A D A A A A D A A D A
RED	AMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAM
OUACHITA	
ARKANSAS	ABABABABABABABABABABABABABABABABAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAM
MISSISSIPPI	ABABABABABABABABABABABABABABABABAMAMAMAMAMAMAMAMD DcAMAMACAMACAMAMACACAMAMACAMAM
SALT MINE	D D A A A A A A D D D D A A A A A A A A A A A A
PEARL	
TOMBIGBEE	D D D D D D D D ABABABABABABABABABABABABABABABABAMAMAMAMAMAMAMAMAMAMAMAMAMAMAMAM
BLACK WARRIOR	
ALABAMA	
CHATAHOOCHEE	
FLINT	

Figure 27. *Time Series for Alluvial Chronologies in the Southeast.*

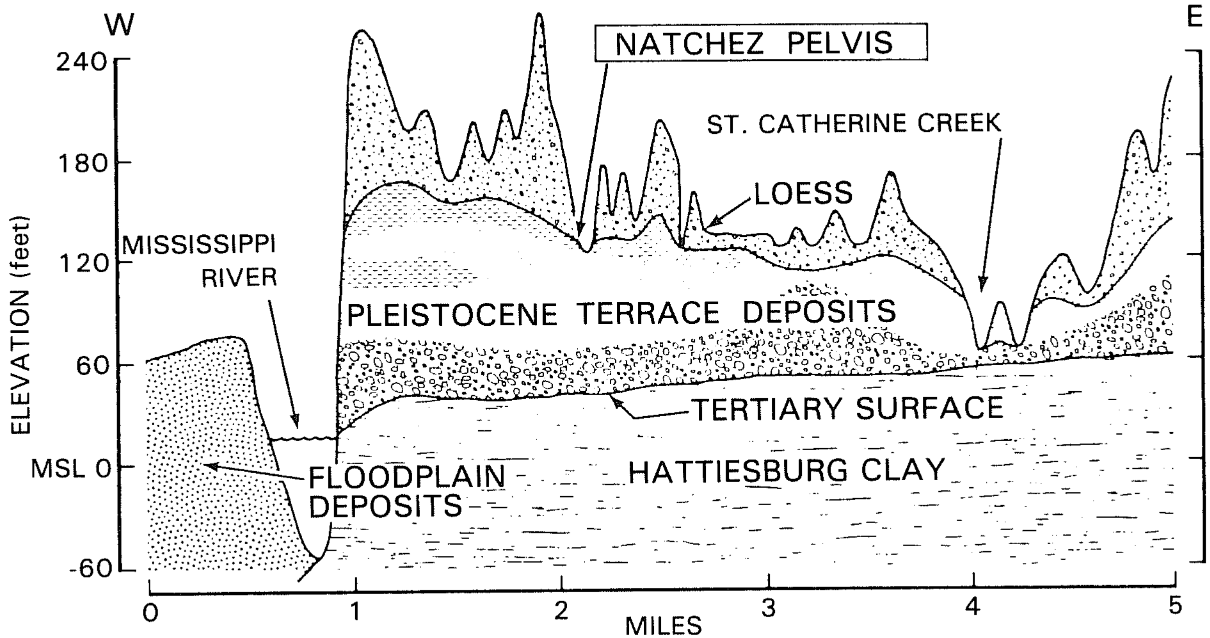


Figure 28. *Idealized Geologic Section in Vicinity of Natchez, Mississippi, Showing Sections of Natchez Pelvis Find.* Geology modified from Saucier (1967).

TABLE 7. RADIOCARBON AGES OF VICKSBURG, MISSISSIPPI, AND TUNACA BAYOU LOESS DEPOSITS

Stratigraphic Unit	Radiocarbon Age (Yrs. B.P.)	
	Tunaca Bayou	Vicksburg, Mississippi
		17,850 ± 380*
		18,200 ± 500*
WOODFORDIAN LOESS		18,640 ± 380*
(INTERVAL "F")		19,200 ± 420*
		19,250 ± 350*
	20,690 ± 250	20,500 ± 600*
		21,270 ± 440*
WOODFORDIAN LOESS (INTERVAL "E")	21,750 ± 310	21,800 ± 500*
		22,600 ± 700*
		22,600 ± 800*
FARMDALE LOESS		23,550 ± 750*
(INTERVAL "D")		23,550 ± 1000*
FARMDALE SOIL		25,600 + 1000Δ

SOURCE: Snowden and Priddy 1968

Otvos 1975

* Fossil pulmonate gastropod shells

Δ Fossil Wood

East of the Mississippi River the modern coast appears not to be sand oriented. Even so, there is an extensive dune field at a depth of 36 to 42 m off Bonsecour Bay (Gagliano 1977:115) on the Alabama-Florida coast. In the event that this field could be interpreted as an indication of dessication, it would be of interest to know the age of the dune fields.

A study of paleosols along the Colorado River by Sorenson, Mandel, and Wallis (1976) provides some insight into terrace surfaces in the East and east central Texas regions. They noted that paleosols of the type found under relict pine populations in east central Texas appeared in the area of present-day Austin, considerably west of any present-day pine stands. Chemical and mechanical examination of those soils confirmed the similarity. Sorenson, Mandel, and Wallis (1976) suggest that, based on paleosol evidence, pines migrated westward along the river terrace during ameliorated conditions during the Pleistocene. Since such soils appear to be limited to river terraces, they concluded that the botanical regime was galleria in general outline.

Biological Indicators

Climate and physiography provide the environment in which biological organisms and communities flourish. As if climatic change and alteration of the landscape were not complicated enough, the organisms have their own complicated means of adapting to environment and, as we have seen, with erosion, can have major feedback effects on the environment, particularly physiography. The botanical picture is clouded by lag times in colonization. Zoological organisms often are so mobile as to be impervious to short term climatic change. Perhaps the most complicated subset of the biological milieu is human culture, which is not only constantly adapting, but also displays a tendency toward qualitative evolutionary jumps during the time interval with which we are concerned.

Vegetation

Climatic variation in the Southeast has been marked enough over the last 20,000 years to produce considerable restructuring of botanical communities. Whitehead (1973, 1982) proposed an azonal, southward displacement of boreal species of about 1000 km at full glacial. More recent analyses from the Gulf Coastal Plain by various investigators (notably P. Delcourt, H. Delcourt, Watts, Whitehead, Sheehan, and Robinson) indicate that the vegetational response to late Quaternary warming was spatially complex. P. Delcourt and H. Delcourt (personal communication) are in the process of publishing a series of maps showing vegetational changes in the declining stages of the Wisconsin and Holocene.

Recently a physiographically based model of botanical response east of the Mississippi has emerged (Delcourt and Delcourt 1979; Delcourt *et al.* 1980). The model suggests relatively brief lag times for vegetational response to climatic change east of the Mississippi and adds some much needed regional character to a previously bland theoretical landscape. Central to the model, the "Bluffland's Hypothesis," is the highly dissected bluffland east of the

Mississippi River. The bluffs are composed of the loesses discussed earlier; they range from Tennessee to Louisiana. During colder intervals, ravines act as microrefugia for more temperate species.

During warmer times the bluffs orographically generate fog from the moist air of the river, which cools the blufflands. The river further contributes to the system by moving northern species rapidly southward at the beginning of cold intervals.

For the following discussion I have selected botanical sites along two transects. The blufflands hypothesis is valuable for two reasons relative to the selection of climatically sensitive localities. First, it indicates that sites in the blufflands should be relatively insensitive to climate, because of the refugia. Second, it indicates that sites to the east of the blufflands' effects reduces lags in vegetational response time to the east. Transect A-A' is located east of the Mississippi River and out of the blufflands. It is within the area almost wholly dominated by maritime air masses at present (Bryson 1966). Transect B-B' is west of the Mississippi River and traverses coastal and east Texas and then on to southern Missouri. Transect B-B' is on or subject to continental air masses and is loosely related to the prairie-forest ecotone.

Transect A-A' is composed of three sites. Anderson Pond, Tennessee (H. Delcourt 1979), spans the entire interval of study and is probably the most highly resolved and completely analyzed sequence in the series. B. L. Bigbee (Whitehead and Sheehan 1982) is in northern Mississippi on the Tombigbee River. It spans only the last 11,000 years. Goshen Springs, Alabama (Delcourt 1980), is located on an upland interfluve in southern Alabama. I have only secondary sources on this site. On appearances it seems to span the entire study interval, but the sedimentation rates must have been very low during glacials.

Transect B-B' begins with the biosilica site of Coleto Creek (41 GD 21) east of Victoria, Texas (Robinson 1978). Boriac Bog (Bryant 1977) is in east central Texas, and the Old Field Swamp northeast of the Ozarks (King and Allen 1977) completes the series.

Transect A-A'

At full glacial the foot of the Cumberland Plateau in Tennessee was marked by a boreal pine/spruce forest, while coastal southern Alabama is thought to have had a xeric oak/pine regime. Little change is observable in the coastal pollen record until the end of the Hypsithermal about 5000 B.P. Tennessee, on the other hand, shows substantial changes. Between 16,300 and 12,500 B.P. jack-pine/spruce pollen gives way to deciduous elements. Between 8000 and 4500 B.P. there is evidence for a warm, dry Hypsithermal indicating the effect of the Prairie Peninsula Phenomenon.

Northern Mississippi shows evidence for reduction of mesic elements from the lowlands during the period 3500 B.P. to 7300 B.P. in favor of more xeric oak and hickory. Late in the Holocene, after 3500 B.P., moister conditions return.

Moisture indicators show a peak at 2300 B.P., and there appears to be some drying in the final segment of the record. This could very well be a product of a more meridional air flow pattern during the Little Ice Age, which blocked a portion of formerly available Gulf moisture. The last 2500 years have seen a general increase in pine on the Gulf Coastal Plain. Pine increases began in southern Alabama as early as 5000 B.P.

There is some conflict between the pollen and alluvial indicators for the upper Tombigbee River during the Hypsithermal (Whitehead and Sheehan 1982). The stream appears to retain a meandering mode through the Hypsithermal indicating a relatively well-watered situation. Analysis of modern discharge data, however, indicates that the Fall Line Hills at the north end of the drainage orographically collect more precipitation during warmer years, while the mid-valley turns dry (see Modern Temperature and Salinity of the Gulf of Mexico section, p. 112). Thus, the Hypsithermal may well have had dry midvalley conditions, while the hills acted as rain collectors to water the river.

Transect B-B'

A study of biosilica from an archaeological site on the Texas coast (Robinson 1978) indicated a high biomass, mesic forest before 8000 B.P. Subsequently, the forest largely disappeared to be replaced by a seasaw battle between tall and short grass prairies. Phytoliths from mesic tall grasses appeared with evidence of human occupation and radiocarbon datable materials at 5000 B.P. and 3000 B.P., the dates correspond to Denton and Karlen's (1973) periods of glacial advance and lowered tree lines. A study of unirrigated sorghum yields (Jones 1979) showed that effective moisture moves westward in Texas with global cooling. It seems probable that the intervening dry periods, dominated by short prairie grasses, correspond to periods of warmer global climate. Bryant (1977) examined pollen from Boriac Bog in central Texas. Full glacial vegetation is marked by an open deciduous woodland with some conifers. The period 8000-12,000 B.P. shows a reduction in cooler indicators, and by the end of the interval the modern post-oak savanna is established.

North of the Ozarks a considerable amount of work has been devoted to southern Missouri (King and Allen 1977). Spruce persisted in the Ozark uplands until 12,000 B.P. Between 7000 and 12,000 B.P. oak and hickory forests dominated the region. Analysis of a pollen core from the Old Field Swamp in extreme southeastern Missouri, about 75 km north of the Tennessee border, showed vegetational changes reflecting a more prairielike environment after 8700 B.P. The change appears to have been more related to a drop in precipitation than a rise in temperatures. The dryness peaked at 7000 B.P. Around 6500 B.P. there was an abrupt turn toward moister conditions, although climate was basically xeric until after 5000 B.P.

King and Allen (1977) argue that the Old Field Swamp marks the southern boundary of the Prairie Peninsula. Given H. Delcourt's findings in Tennessee, however, the question of where the border is must be raised, if it exists. It seems possible, given present evidence, that the Southeast generally experienced drier conditions during the Hypsithermal. These conditions may have been moderated near orographic uplifts (Gunn 1982d) and in the lower Mississippi Valley (Wigley, Jones, and Kelly 1980). The evidence, however, remains to be reported.

Figure 29 displays the 500-year resolution trajectory for the botanical indicators. Mid-Holocene vegetation indicates virtually universal drying. The upper Tombigbee core (B. L. Bigbee) is the most anomalous. The variance with other cores may be due to dating (Whitehead and Sheehan 1982) or to the Fall Line Hills into which the Tombigbee River heads providing enough of an orographic uplift to locally delay drying (Gunn 1982d).

Based on less universal evidence, the declining stages of the last Wisconsin Glacial seem to be discernible. Full glacial cool and dry is replaced by intermediate glacial cool and wet about 16,000 B.P. Around 12,000 B.P. to 13,000 B.P. an apparently unstable transitional glacial Holocene period sets in with mixed readings. Contradictory readings may be due to varying levels of resolution from core to core. Anderson Pond records a highly detailed succession, while Goshen Springs and Boriac Bog seem to be less sensitive. Goshen Springs and Boriac Bog suggest cool, dry conditions, while Anderson Pond indicates warm and wet followed by cool and wet. Anderson Pond may have been moistened by orographic rainfall provided by the perimeter of the Cumberland Plateau.

Fauna

I have not systematically examined the faunal evidence. However, Lundelius (1974) and Carbone (1976) have undertaken such reviews. It appears that the fauna provide some fascinating insights into seasonality of glacial climate. A combination of milder winters and cooler summers is suggested, which allowed the mixing of creatures now only able to survive in geographically diverse regions. There seems to be, however, very little time resolution to paleontological data. A very important question for paleontologists to answer in the future will be when the so-called mozaic environments of the Pleistocene gave way to Holocene zonation.

The Mississippi State Museum at Jacksonville recently engaged the services of a paleontologist who has already extended the list of cold species known to have existed in the past in that state (Frazier 1982). Lundelius has studied the Pleistocene fauna of the Texas coast; these include some late Pleistocene fauna from the continental shelf.

While these studies are not highly time resolved, they may be useful through some sort of calibration process, which will allow a closer definition of time series by other methods.

A Methodology for Independent Verification

The five time series defined in the previous discussions represent the opinions of the respective disciplines as to the progress of climatic change over the last 20,000 or so years. Earlier, I expressed a desire to test the regional models internal to the Southeast against an independent model of climatic change.

For several reasons, the deep sea core work by Kennett and Huddleston (1972) in the western Gulf of Mexico seemed to offer the most promising source for an external, but relevant set of data. First, the deep sea core data offer a long, sequent, and datable time series, which reflects, in large part, the conditions in the seasonally responsive, upper few meters of sea water. Second, thanks to the relative homogeneity of the sea surface as compared to land, the climatic record of deep sea cores will be less susceptible to microclimates. Third, the Gulf of Mexico is strongly related to the southeastern United States, relative to moisture conditions. The relationship is such that most climatic conditions in the Gulf, whether they relate to temperature or moisture, appear as either direct or inverse analogues of conditions on land.

Radiocarbon years B.P. x 10^3	20 15 10 5 0
Anderson Pond, Tennessee	ccbbbbbccccccddccccdddeeeeeeedddddddd
B. L. Bigbee, Mississippi	cccccceeeeeeeecccccb
Goshen Springs, Alabama	bbbbbbbbbbbbbbbbbbbbbbeeeeeeecccccccccc
Boriac Bog, Texas	cccccbbbbbbbecceeeeeeeeeeeeeeee
Old Field Swamp, Missouri	ceeeedddcccc
41 GD 21, Texas	ccceeeeeedebcccccccc

Symbols

a. Cold and Dry
b. Cool and Dry
c. Cool and Wet
d. Warm and Wet
e. Warm and Dry

Each symbol = 500 years

Sources (in order as above)

H. Delcourt 1979
Whitehead and Sheehan 1982
P. Delcourt and H. Delcourt 1979
Bryant 1977
King and Allen 1977
Robinson 1978

Figure 29. *500-Year Resolution Trajectory for Botanical Indicators, Pollen, and Biosilica.*

Naturally, any analysis which involves the complicated set of variables outlined earlier, extraterrestrial, global, and local phenomena, must include a set of simplifying assumptions in a model which explains their interactions. The most important simplifying assumptions are concerned with the fact that, aside from the extraterrestrial variables, global climate is an interacting system with complex feedback loops which make analysis of the data difficult in terms of standard regression techniques. In the jargon of the causal analysts, the global climatic milieu is a "nonrecursive" system with complex feedback loops. It is desirable, from the standpoint of economy, to examine the system as a "recursive" system; that is to say without undue complications from feedback. In practice, I was able to develop a concept which allows the management of the data analysis in an uncomplicated analytical framework. The model is illustrated in Figure 30 and might be called a Global-Local Climatic model.

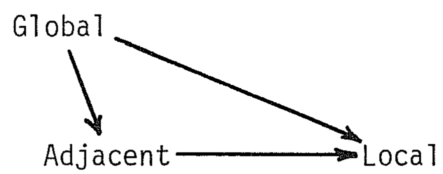


Figure 30. *Causal Model of Global-Local Effects.* Arrows represent the direction of causality.

Global variables include extraterrestrial forces such as solar output and "solar input," that is those variables that modulate solar output such as orbital configuration as defined by Milankovitch (1930) and modified by Kukla (1975), and aerosols in the upper atmosphere such as volcanic dust (Bryson and Goodman 1980). Adjacent variables are those that represent conditions in regions adjacent to the area of targeted interest, the local region. In the example I will use here, the upper Tombigbee River is our region of interest. The Gulf of Mexico is a strongly relevant adjacent region, because of the high frequency of air flow off the Gulf and into the Tombigbee as regulated by the clockwise circulation around the subtropical high. The model qualifies as a recursive model in that there is little feedback from the local region (it being only a few thousand square kilometers) to the global variables, because of the sheer magnitude of surface and volume of air involved. There is little feedback to the adjacent regions because it is "up" the air stream, from the targeted region. Naturally, there is some feedback. Temperature of the surface in the Gulf Coastal Plain has to have some affect on air temperature the next time it circulates around the world, and the temperature of Gulf waters is influenced by discharge from land. Since the variables are not completely independent of feedback it might be advisable to call the model a <u>predominantly recursive system</u>.

In a regression equation of the system,

$$Y = X_1 + X_2 + (u,f,e),$$

Y represents local variables, let us say moisture discharge and temperature indicators on the Gulf Coastal Plain, while X_1 and X_2 are the global and adjacent environmental indicators. Error in the predominantly recursive system represents regressional residual which contains, in part, measurement error (e), spurious correlation due to feedback in the system (f), and correlation due to unidentified variables in the system (u). The f component of the system is not necessarily harmful as long as it is reasonably low as measured by the Durbin-Watson (Johnston 1972:251-252) statistic. In most of our analyses, serial correlation of the residuals as measured by the Durbin-Watson statistic did not appear as a problem. In fact, much of the nebulousness that one usually sees in numerical analyses of global climatic data (low R^2, diffuse eigenvalues) disappears with the inclusion of a set of local variables. This suggests to me that perhaps linear models are better adapted to analysis of the model than to the more general models.

Examining the Model: 1956-1978 Data

The most comprehensive records of weather phenomena in the Gulf Coast date from February 1956, when radiosonde stations were established. Monthly upper air data collected by the radiosonde probes, Palmer soil moisture indices, and discharge volumes from rivers and tributaries can be used to measure climate in local regions (Gunn 1982d). The adjacent Gulf of Mexico was quantified as to water temperature and salinity measures at 10 and 100 m depths from three, two-degree squares stratigically located to represent different phases of Gulf waters: the western Gulf, which is relatively isolated from the Atlantic waters; the eastern Gulf, which is heavily influenced by the Gulf stream; and the northern Gulf near the mouth of the Tombigbee River, which was included to control for the affects of discharge interaction between the Gulf and the local study area. Global variables were represented as solar flux, optical depth of the atmosphere, atmospheric CO_2, season of the year, and frequency of global circulation type for the month.

A principal components analysis of this data set showed clearly that the global variables were active in the adjacent and local weather phenomena. Component VIII, for instance, indicated higher solar flux values (lagged one year) are associated with (1) higher water temperatures in the western Gulf of Mexico, (2) increased discharge and moisture in the rugged upper reaches of the Tombigbee River in northern Mississippi, but (3) less moisture and lower discharge rates in the Gulf Coastal Plain further downstream.

Extending the Model: Prehistoric Environments

As a product of several months of working with the modern data from Texas and Mississippi, I developed some insight into the weather processes that conspire to produce climate during the 20th century. The next concern was to extend this complex of principles into the past, and from it derive a set of conditions that would describe the climate with which humans of past eras were required to cope. There are certain limitations to the data. For instance, the period 1956 to 1978 (Fig. 31) comfortably spans the transition

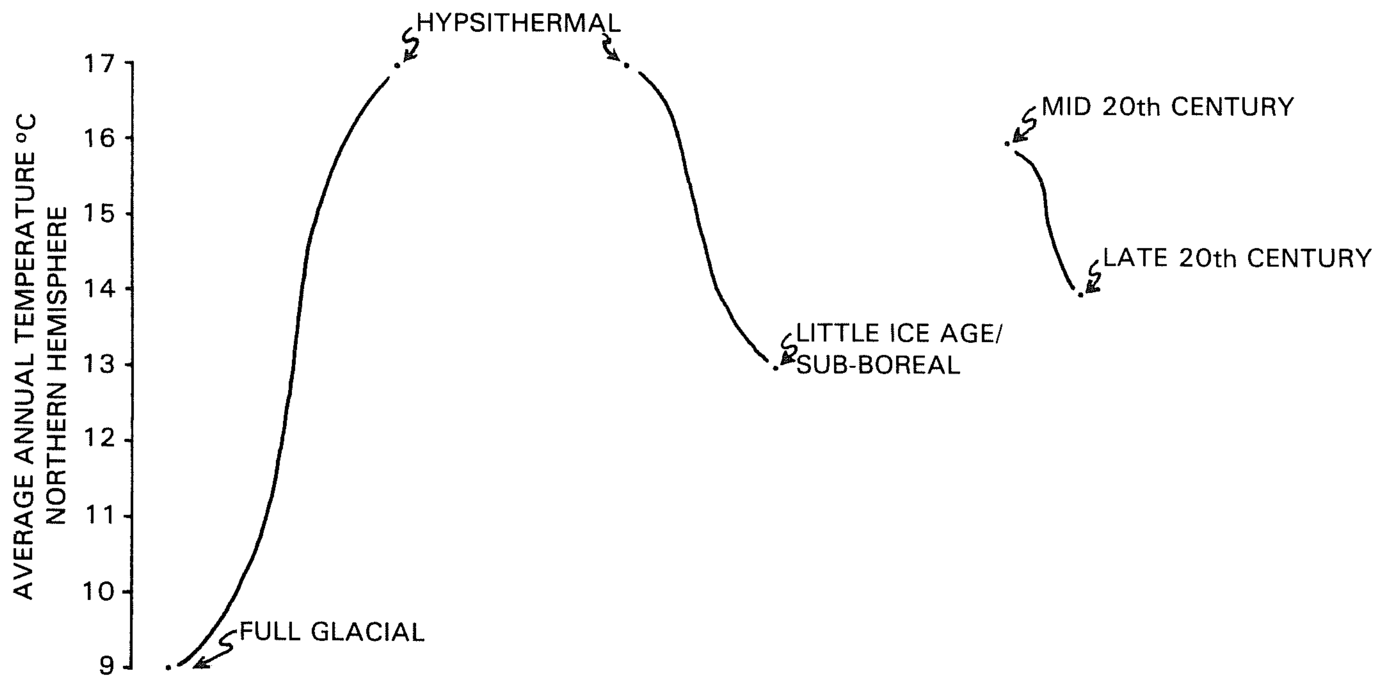


Figure 31. *Range of Temperature (Energy Budget) Movements.*

from what might be called the mid-20th century climatic optimum of the more characteristically Little Ice Age conditions of the 1960s and 1970s (Sanchez and Kutzbach 1974). We can therefore surmise with some confidence the affects on local conditions when global parameters move from those of climatic optima to the milder varieties of glacial advance. On the other hand, projecting into the times of the more serious ice advances demands more caution.

Deep Sea Cores

Kennett and Huddleston (1972) studied many deep sea cores from all over the Gulf of Mexico and found that those in the western Gulf contained enough foraminifera to determine communities of organisms representative of water temperature by principal components analysis (Malmgren and Kennett 1976).

I thought that it would be worthwhile to conduct our own analysis of the data from the deep sea cores, because most of Kennett's applications were concerned with relatively long periods, approximately the last 100,000 years and with water temperatures only. Our concerns for archaeological reconstruction, however, were limited to the last 20,000 years. We were also interested in salinity since it affects evaporation. The core, which appeared to have the most highly resolved record in the requisite time period, was selected and Kennett very kindly provided us with the data. The analysis (Mahula 1982b) showed there to be six components, or communities, of foraminifera. The first component, as is normal for such analysis, was demonstrably related to water temperature. Component scores are plotted in Figure 32. This time the scale is corrected for depositional rates and converted to radiocarbon years (Gunn 1982c; Gunn and Stuckenrath 1982).

In addition to the water temperature, we thought it might be of some interest to examine sea salinity as well. Salinity lowers vapor pressure and specific heat. Examination of the remaining five components showed Component II to be loading inversely for *Globigerinoides sacculifera*, which according to Berger (1969) prefers high salinities, and *Globigerina bulloides*; which prefers waters of low salinity (Berger 1969). The component scores for Component II are plotted in Figure 32 and reflect a pattern variable from that of the temperature curve and apparently heavily inflected by episodes of glacial melt water in the declining stages of the Pleistocene.

Modern Temperature and Salinity of the Gulf of Mexico

Namias (1976) demonstrated, through a rather long series of causal relationships, that the Aleutian Low exerts control on the rigor of North American winters. When the sun heats the waters to above average values off the south coast of Alaska and the Aleutians during summer, cyclonic activity is sustained over that area through the fall as the ocean gives up its heat to the atmosphere. The lows so generated move landward fostering a pressure ridge over the western United States and troughs over the east. The end result is temperature and precipitation in a relatively standard and recognizable pattern. This pattern includes a predictable pattern of temperature and precipitation over the southeastern United States.

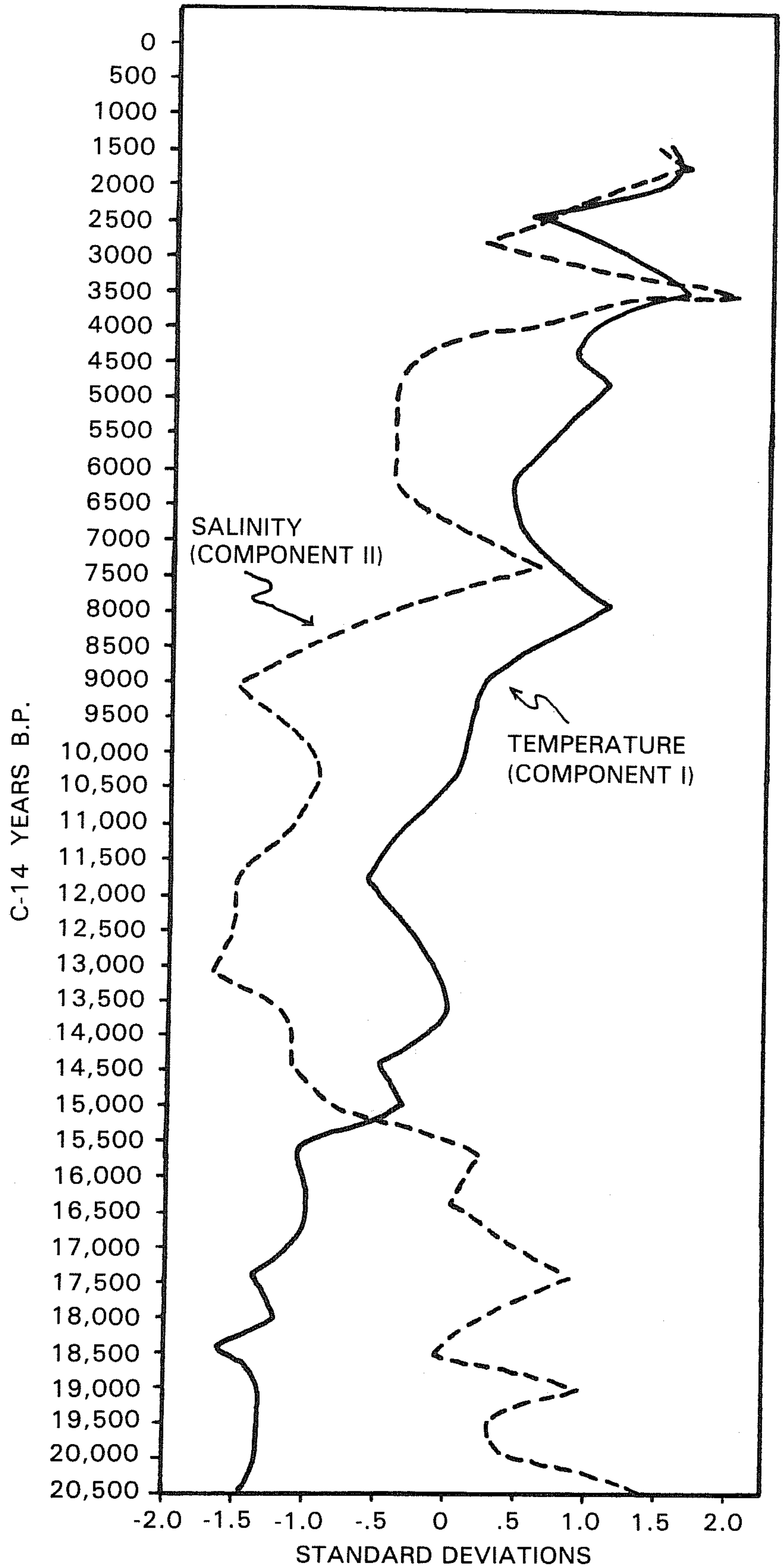


Figure 32. *Temperature and Salinity in the Western Gulf of Mexico*. From Gunn (1982e).

I have attempted to apply a somewhat similar methodology to the problem of independent verification of paleoclimatic data from the Gulf of Mexico and the southeastern United States (Gunn 1982b). As we have seen, paleoclimatic data are available from deep sea cores in the Gulf of Mexico and from the various regions of the Gulf Coast. There are also modern sea temperature and salinity data from the Gulf and various indicators of moisture and temperature on land.

The methodology for independent verification consisted of the following. A series of regression coefficients describing the relationship between modern sea temperature, salinity, and landward moisture were generated. These regression coefficients were then multiplied by the sea temperature and salinity trajectories described above. The curves resulting from these calculations were posed as models to be verified by the biological and physiographical data. Curves for east central Mississippi and east Texas are shown in Figure 33.

Previous efforts have concentrated on the Mississippi and Alabama regions. For the study a Paleo-drought-index was calculated for east Texas, the nearest point to Eagle Hill for which data were available. The results of these calculations are shown in Figure 33. Note that the Paleo-Indian period deposits date from the period of highest moisture. The end of early period sediments about 7000 B.P. radiocarbon corresponds to a relatively dry interval. Unfortunately the deep sea core record terminated before the A.D. 800-900 occupations. However, the later interval is notable for high volcanic activity as is shown in Figure 20, very much like the early period.

Pollen Analysis Test, East Central Mississippi

The B. L. Bigbee-2 core discussed earlier (Whitehead and Sheehan 1982) provided the most secure test information to date on prehistoric vegetation in the Tombigbee area. The core appears to span the last 10,000 to 12,000 years and is interpreted to indicate moist conditions between 7300-9800 B.P., dry conditions from 3500-7300 B.P., and a return to more mesic conditions after about 3500 B.P. The 8000-10,000 B.P. mesic period accords well with the climate projected from the deep sea core during Dalton times. However, due to problems with pollen preservation and resolution of the dating in the column, we cannot say at this point whether the two subsequent suspected moist periods can be supported or rejected by the pollen record.

Biosilica Analysis Test, East Central Mississippi

Eleven samples removed from archaeological sites were analyzed for microscopic opals that develop in the cells of many plants and some aquatic animals. In contrast to pollen analysis, biosilica analysis provides a very localized view of vegetation as well as some indication of local hydrological conditions as indicated by sponge spicules. A more detailed examination of the biosilica record than can be discussed here shows that as nearly as can be determined, the biosilicas support the projected climatic sequence in about the same fashion as the pollen. However, the biosilicas indicate a mesic climate during the Clovis period (about 11,000-12,000 B.P.). The east central Mississippian curve indicates the 11,000-12,000 B.P. interval to be the first late Quaternary mesic surge.

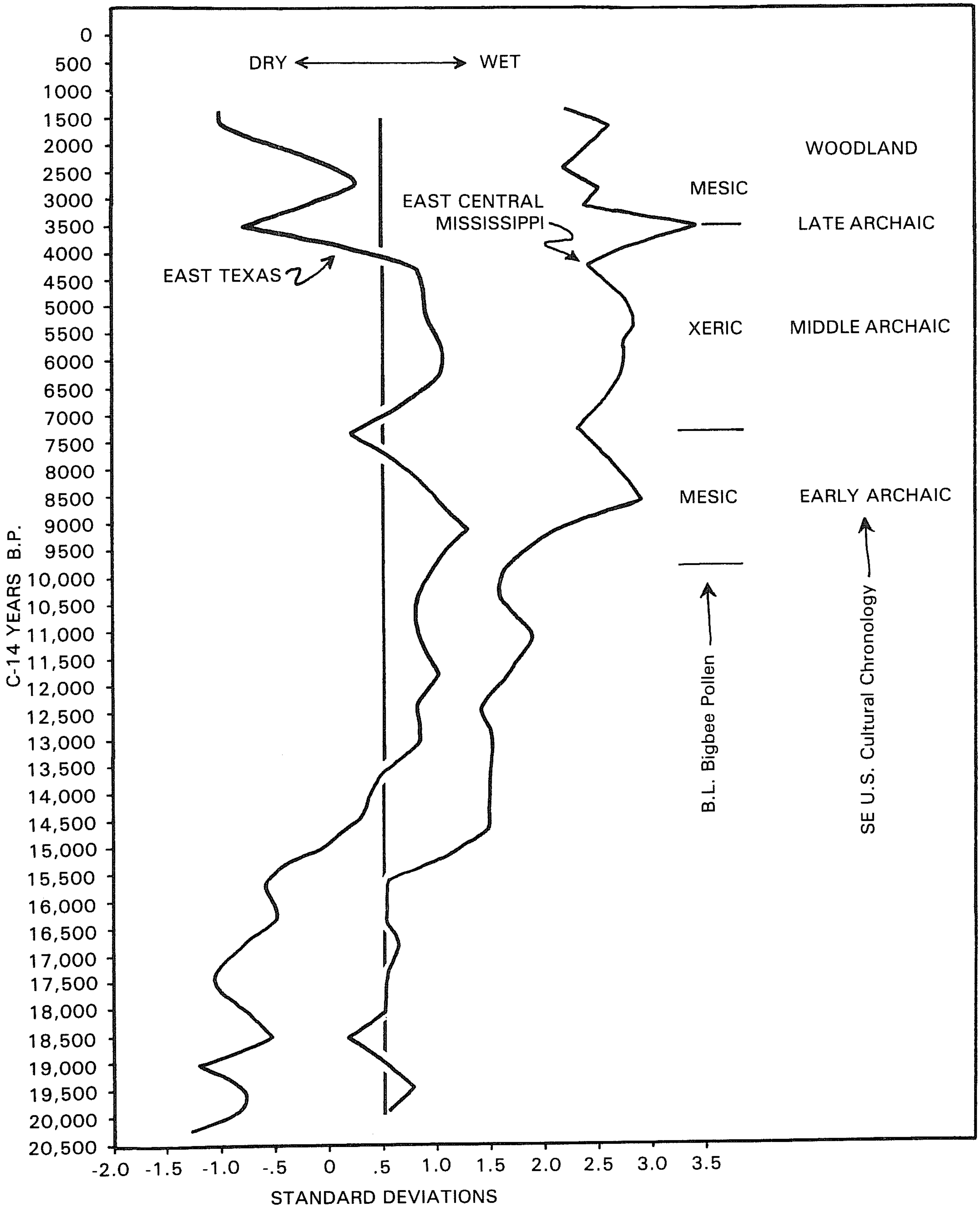


Figure 33. *Paleo-Palmer Index for East Texas and East Central Mississippi.*

Cultural Test

A considerable amount of archaeological work has been done on the Tombigbee River relative to the Tennessee-Tombigbee Waterway project. With the exception of some reports by Blakeman (1975a, 1975b) and Bense (1982), much of the information gleaned from the project remains to be synthesized. However, using Blakeman, Bense, and other sources, a tentative demographic chronology for the Tombigbee can be reconstructed. Evidence for early Paleo-Indian (Clovis) is very scarce. The Tombigbee Valley joins with most of the rest of the Southeast in a rather spectacular display of Dalton-aged archaeology suggesting a developed population.

The Early and Middle Archaic periods appear to be marked by low populations that camped at ecologically diverse ecotones and exploited a wide range of food resources. Late Archaic sites are numerous, thick middens that indicate a large population. A major economic shift occurred between Late Archaic and Early Woodland. Plant foods appear to have been emphasized, and hunting changed from generalized to specialized hunting of the most productive game (Blakeman 1975a:92). Uplands appear to have been inhabited and exploited.

During the Late Woodland, Mississippian peoples inhabited the valley, but the population appears to have been relatively low (Blakeman 1975b).

I suggest the following relationships between the projected climate in Figure 33 and the cultural chronology. During Clovis times the Tombigbee was dry and unappealing in contrast to the stable and rich Tennessee Valley to the north. Since the population was probably rather sparse anyway, most of the Clovis-aged activity was confined to the Tennessee Valley area.

During Late Paleo-Indian/Early Archaic the climate is projected as being moister, a condition supported by the pollen and biosilica data. There is also evidence of significant human activity during this time period. It would seem that the combination of more favorable conditions, and a probable natural upward trend in population conspired to encourage considerable human activity in the valley, notably at the Hester site on the middle upper Tombigbee River.

The Early Archaic/Middle Archaic period is projected as being somewhat drier, a surmise fully supported by the pollen. The deep sea projection indicates a subtle movement toward drought. The population seems to have dropped to correspondingly lower levels.

A resurgence of moist climate about 4000 B.P. apparently encouraged a large Late Archaic population, an event probably supported by the globally recognizable Subboreal cooling caused by massive volcanic activity. We lose the deep sea core at this point and have to turn to standard climatic chronologies for the late Holocene.

The Roman Empire Climatic Optimum corresponds to the Early Woodland. Warmer global conditions probably turned the Tombigbee drier. Speculation is large populations developed during the Late Archaic and were forced to turn to intensive food production and collecting in order to survive. Thus, the vigor of the food production and specialized hunting effort.

picture. North American and Mesoamerican cultural chronologies are marked by developments and catastrophies, which correspond in time with the 2600-year glacial cycle (Gunn and Adams 1981; Folan *et al.* 1982; Dahlin 1980). The coastal plain appears to be no exception to this pattern. Eagle Hill II depositional episodes clearly correspond to mesic periods. The critical controlling variable appears to be the amount of global volcanic activity.

C. UPLAND EROSIONAL EPISODES AND SOUTHEASTERN CLIMATE

Brakenridge (1980) pointed out the possibility of synchronized alluvial cut and fill sequences over a large portion of the northern hemisphere (Table 8). It is of more than passing interest that Brakenridge's globally synchronous, alluvial sequence shows virtually perfect correlation with Denton and Karlén's (1973) high-latitude glacial and tree-line sequence. Periods of alluvial cutting occur coincident with glacial advance and increased meridional air movements.

TABLE 8. SYNCHRONOUS ALLUVIAL DOWN-CUTTING EPISODES FOR THE NORTHERN HEMISPHERE

Radiocarbon Years B.P.	Episode
400-500	Main Little Ice Age
1500-1600	Early Little Ice Age
2500-2900	Subboreal
4900-5000	Mid-Hypsithermal Cooling
7700-7900	Cockburn-Cochrane

SOURCE: Brakenridge 1980

Naturally, one might suspect that erosion on Peason Ridge is related to this sequence in a systematic manner. If warm intervals are marked by alluvial filling, then ridge tops must be yielding sediments. With a Paleo-Indian component marking the beginning of deposition in the saddle of Peason Ridge, one might suspect that the overlying erosional event corresponds to the 7800 B.P. erosion on the Pomme de Terre River (Brakenridge 1980).

Figure 34 is taken from Brakenridge and illustrates the Holocene sequence of the Pomme de Terre River in southern Missouri, the point of departure for his comments on synchronized alluvial chronologies. The Pomme de Terre River is 900 km north of Eagle Hill and in basically the same climatic system in respect to the prairie forest ecotone and circulation of moisture of the Gulf of Mexico.

This Mississippian period is reported by Blakeman to be low in population. However, the time interval contains several important global climatic changes. It may be that the local Mississippian culture eventually participated in the general population decline observed by sequential reductions in stockade perimeters over most of the south (Haag 1965). However, it seems unlikely that there was no fluorescence during the Late Woodland, and it is probably best to await the results of excavations in progress before venturing a judgment of the interaction of Mississippian culture and climatic change.

Summary

This survey of modern and prehistoric climate, geomorphology, alluvial chronology, upland erosion and deposition, vegetation, fauna, and culture has at the level of evidence available revealed some things about regional climatic variation in the Southeast and shown that there are other questions which remain to be answered.

It would appear at this time that the idea of a wet Hypsithermal in the lower Mississippi Valley is largely unsupported. A mid-Holocene erosional episode on Avery Island indicates that there was an element of instability in the climate at that time. If it was wetter it was probably at a season of the year inappropriate to vegetation. The last few years have been relatively dry ones in the Southeast, and they have been dry in the spring and wet in the summer due to tropical storms. There is, in fact an element of shift from winter to summer moisture implied by the components plotted in Figure 33. Dry springs could very easily assume a causal role in alluvial erosions. Perhaps the one great gap in lower Mississippi paleoclimatology at this point in time is the lack of botanical studies in the coastal delta and delta plain. Dry springs and wet summers could also provide upland erosion in the Louisiana-Mississippi area delineated by Wigley, Jones, and Kelly (1980). Some of the answers to these problems may reside in Saucier's meander belt shifts in the Mississippi River which should be intensively interpreted for paleoclimatic information.

If the lower Mississippi does not provide ameliorated conditions during hot times, it appears that certain other regions do. The blufflands east of the Mississippi River and uplifts facing the air streams in the eastern coastal region appear to be providing shelter to plant species and discharging water to river valleys. Uplifts to the west of the Mississippi River may also provide islands of precipitation. Whether these are limited to late summer during the tropical storm season or support vegetation during the spring is a very important question to the study of upland sites. The uplifted coastal plain and the older features of the Ouchita Mountains and Balcones Escarpment are important in this category.

There seem to be at least two transitional phases to the last glacial period. Before 12,000 B.P. there is a true intermediate glacial situation with meridional circulation and dry climate. After 12,000 B.P. the situation is dominated by Holocene conditions with resurgencies of glaciation and glacial climate, probably related to Denton and Karlén's (1973) 2600-year glacial cycle of, as yet, undetermined cause. These cold surges, which continue on into the Holocene, appear to be the prime movers in the cultural change

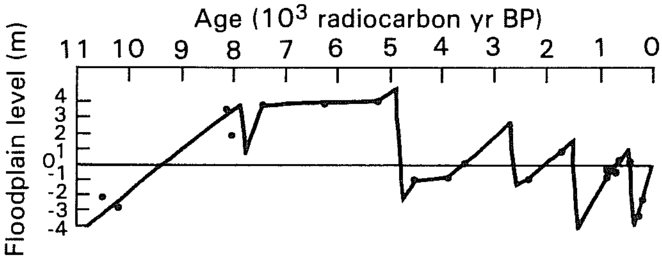


Figure 34. *Holocene Level History of the Pomme de Terre River in Southern Missouri.* Elevations are in meters above or below the modern floodplain, set at zero.

Since our evidence indicates that the upper colluvium is relatively late, after 1500 B.P., we might presume from the Pomme de Terre River sequence that the sedimentary contribution of Peason Ridge to stream loads was rather heavy throughout the middle Holocene. The return of moister, late Holocene conditions served to stabilize the sediments and retain the latter part of the record. Whitehead and Sheehan (1982) found a marked increase in pine in the Tombigbee River area in the late Holocene record. Since Peason Ridge was apparently a verdant pine habitat up to the present century, the evidence suggests that the stabilization may have been affected by pine forests.

D. GEOLOGY AND GEOMORPHOLOGY OF THE EAGLE HILL LOCALE IN THE UPLANDS OF WEST CENTRAL LOUISIANA (Garner)

Introduction

A geologic/geomorphic study was conducted in the vicinity of Eagle Hill, Louisiana, including part of Sabine, Vernon, and Natchitoches Parishes, and in the northern reaches of the Fort Polk Military Reservation, Peason Ridge Artillery Range, and adjacent areas. This study was conducted by UTSA (Purchase Order No. 0-05399) in support of the Eagle Hill (16 SA 50) project for Interagency Archeological Services-Atlanta, Heritage Conservation and Recreation Service. The modern geomorphic/geologic relationships have been studied in an effort to assess the physiographic and geologic setting that was present when early man lived in the region.

Mapping was accomplished by field examination and photogeomorphic interpretation utilizing color infrared photographs (scale approximately 1:30,000) provided by the U.S. Army. The final map is presented on a topographic base prepared from the U.S. Geological Survey (USGS) 7.5 minute quadrangle maps (scale 1:24,000).

Geology

The geologic units mapped during this investigation include bedrock sediments of Miocene and Plio-Pleistocene age, alluvial materials of Pleistocene-Holocene age, and colluvial materials of Holocene age. Anderson (1960) described a sequence of deposits in an exposure about seven kilometers north of Eagle Hill. The units described in this measured section (Fig. 35) are typical of Miocene and Plio-Pleistocene units recognized in this investigation and differentiated on the geomorphic map.

Description of Units

The Catahoula Formation (Miocene) in this study area has a total thickness of about 18 m (55 feet) and consists of two members, the Cassel Hill and Chalk Hills equivalents (Fig. 35). The Cassel Hill is composed primarily of buff to light reddish brown, fine- to medium-grained quartz sand, which is fairly well sorted and round. It is commonly cross-bedded and contains a localized thin zone of siliceous pebbles (0.3 to 0.6 cm in diameter) near the base. The Chalk Hill equivalent is the uppermost unit in the Catahoula Formation (Fig. 35).

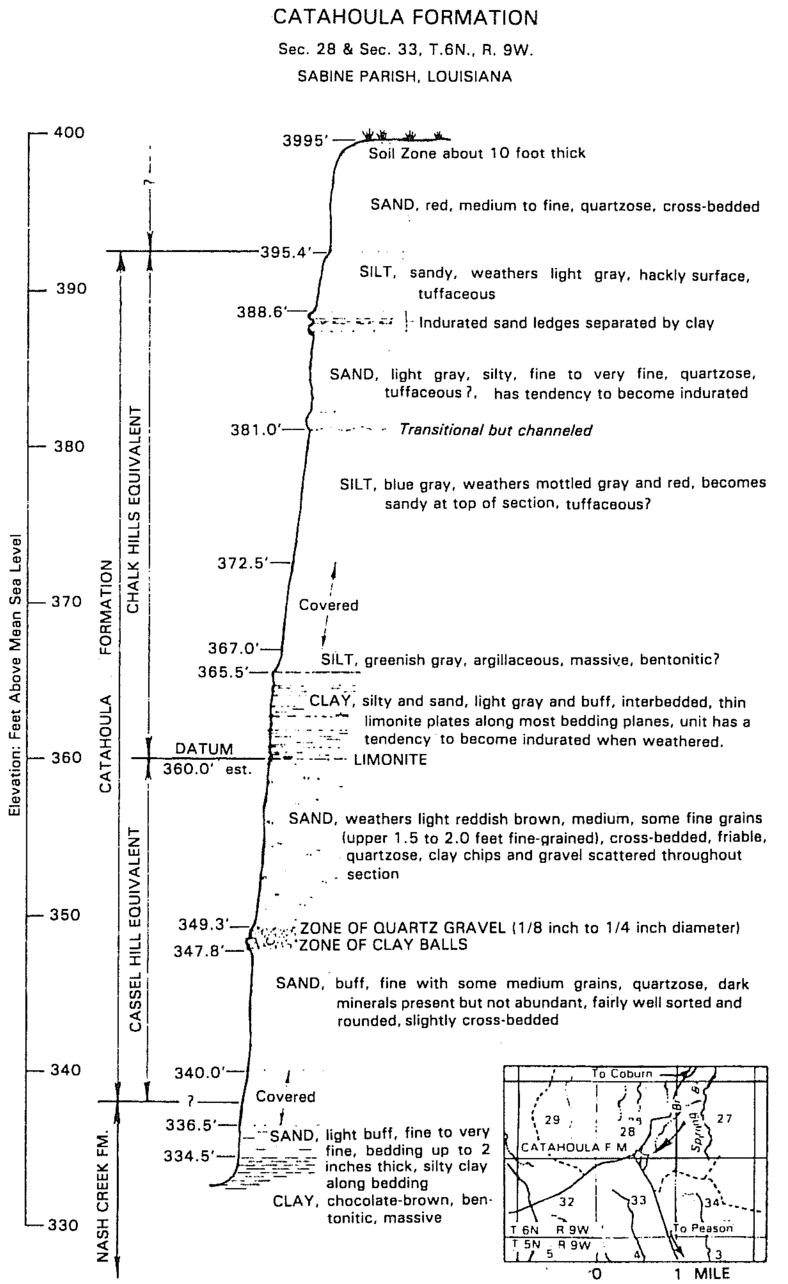


Figure 35. *Measured Section of Bedrock Material Exposed in the Vicinity of Eagle Hill.* After Anderson (1960).

It consists primarily of light gray to blue gray tuffaceous clays, silts, and sands. The basal part of this unit is characterized by thin-interbedded sands, silts, and clays with limonite partings, whereas the upper units are texturally more massive and have thicker beds. An indurated sandstone ledge occurs near the top of this unit in many areas. This sandstone ledge was observed in the bank of the small stream just north of the Eagle Hill II excavation site.

The Catahoula Formation is locally overlain by a reddish tan, medium- to coarse-grained, cross-bedded quartz sandstone. Siliceous pebbles of quartz and jasper ranging in diameter from about one to five centimeters are commonly found distributed throughout this unit. Concentrations of these pebbles occur in a few local areas. One such concentration has been reported at Eagle Hill (Woodward and Gueno 1940) where this unit caps the hill. However, only scattered gravel was observed at the surface (no borings or excavations were made). The exact age of this unit is unknown. Levert (1959) and Welch (1942) considered this unit to be of Pliocene or Pleistocene age and possibly correlated to the Citronell or Williana Formation.

Streams in this area are the uppermost reaches of large fluvial systems and are primarily erosional in nature. Since these streams are characterized by headward erosion and bedrock dissection, they have not established a sequence of fluvial deposits in the local area, but are actively transporting eroded materials during high flow conditions to downstream areas rather than accumulating them. Stream deposits occurring within the project area consist of accumulations of clayey and silty sands and sandy muds. These deposits are derived entirely from the local bedrock deposits described above and reflect the composition of these materials.

Colluvial materials occur along the margins of the alluvium and consist primarily of sheetwash from bedrock materials that overlap alluvial deposits. These deposits were mapped with the alluvium, because dense vegetation prohibited differentiation on photographs in most areas. In addition, these colluvial materials do not differ significantly from the alluvium.

In many areas, colluvial materials represent erosional remnants of Plio-Pleistocene deposits. These colluvial deposits occur along many ridge tops and on hills that lie downslope from the Plio-Pleistocene sands. Colluvium ranges from a few centimeters to a meter or more in thickness and probably covers most of the Miocene bedrock deposits. Generally, deposits less than 1/2 meter thick were not mapped. These deposits are significant, because they are the result of erosional processes that have been active since the last Pleistocene deposition. This erosive episode has produced the present landscape.

Geologic History

The oldest deposits that occur in this area are of Miocene age. During the Miocene this area was very similar to many parts of today's Gulf Coastal Plain. Processes active in this area reflect a complex of fluvial and lacustrine systems. Galloway (1977) indicates that fluvial systems were relatively small in extreme eastern Texas, and environments were probably dominated by a series of coastal lakes as indicated by the type of sediment, texture, bedding, and depositional sequence.

As sedimentation proceeded, materials gradually filled in the margin of the Gulf Basin and the coastline shifted southward. At that time (Plio-Pleistocene) fluvial processes gradually became dominant. Bernard and LeBlanc (1965) and many other authors have demonstrated the dominance of fluvial systems in the Gulf Coastal Plain during the Pleistocene and Holocene. Plio-Pleistocene deposits mapped in this area probably represent channel facies of fluvial deposits. The general lack of course gravel materials in Plio-Pleistocene fluvial deposits in this area is the result of the low gradients of streams typical of coastal plain streams. The physiographic character of this area at the end of the Pleistocene was one of a low relief coastal plain similar to the modern Gulf Coastal Plain.

Post-Pleistocene Physiographic Development

Since late Pleistocene, the landscape in this area has been dominated by erosional processes. Therefore, the total relief of the area is essentially the result of processes that are not active. The principal process active during this period has been the dissection of the low-relief topography of headwardly eroding coastal plain streams. Dissection has been accomplished by sheetwash and downslope movement of disaggregated bedrock sediments, erosion of bedrock along active stream channels, and the transport of eroded sediments to downstream segments of the fluvial systems. Three small fluvial complexes converge in the vicinity of Eagle Hill. These include Mill Creek and Dawden Creek, which are part of the Sabine River system and Kisatche Bayou, which is part of the Red River system. The dissected topography and the colluvial and alluvial deposits mapped on Figure 36 illustrate the main components of the physiographic development. Table 9 explains the notation used on the map.

TABLE 9. GEOMORPHIC MAP EXPLANATION

C	Colluvium - Medium- to coarse-grained quartz with minor amounts of gravel
A	Alluvium - Quartz sands and muddy-quartz sands occurring along modern streams
P	Plio-Pleistocene Sand - Medium- to coarse-grained cross-bedded sand, locally contained minor amounts of small gravel
M	Miocene Deposits - Silty montmorillonitic clay, fine to medium, cross-bedded, tuffaceous quartz sand, and clayey tuffaceous silt, locally contains thin indurated sandstone ledges
S-1	Measured section locality (Anderson 1960)
A-1	Archaeological site (16 SA 50).

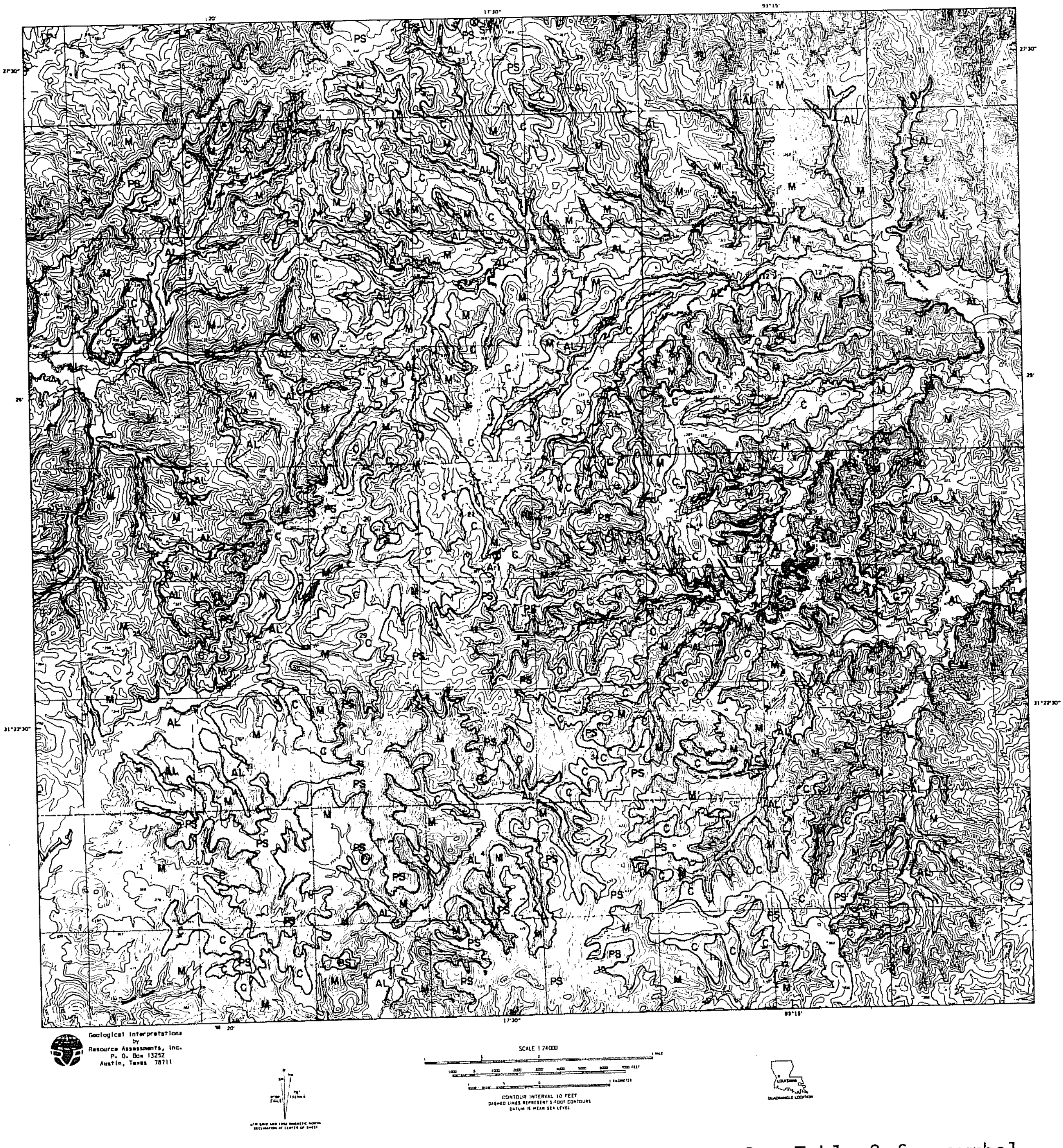


Figure 36. *Geomorphic Map, Eagle Hill Area, Louisiana.* See Table 9 for symbol explanation.

Eagle Hill is one of the highest points along the divide between the Sabine River and Red River. Since this area is relatively distant from the primary fluvial systems, it was probably one of the last parts of the terrain to be affected by the headwardly eroding tributaries.

No Pleistocene or Holocene chronology can be developed independent of archaeology based on fluvial or colluvial sediments of the Eagle Hill area. While it is obvious from pedogenic relationships that colluvial activity has interacted with development of the archaeological site A-1 (see following section), no chronologically significant geologic materials were found in the colluvium. The domination by erosional processes has almost eliminated the potential for long-term preservation.

Regional chronology should be based on studies of the Red River and Sabine River. In any case, the correlation of specific chronology with local upstream areas will be extremely difficult.

As previously stated, the present landscape is the net result of erosional processes since the late Pleistocene. Progressive dissection of the area has probably rendered a more rugged topography with higher relief than was present during the occupation by early man. The elevation of the early man site (A-1) excavated during the course of this project is approximately 115 m (380 feet). The lowest elevation occurring within the map area of Figure 36 is 73 m (240 feet). Assuming a minimum Paleo-Indian age of about 7000 B.P. for the Eagle Hill site, the maximum amount of erosion would be 43 m (140 feet). This erosion would require a rate of only 6 mm (0.02 feet) per year. It is unlikely that the original site was located at the lowest elevation on the landscape because of its relationship with colluvial deposits (Fig. 35). Therefore, the net erosion is probably significantly less than 43 m maximum.

Lithic Resources

Lithic materials available in the vicinity of Eagle Hill were probably obtained primarily from siliceous pebbles occurring in the Plio-Pleistocene deposits (Fig. 36). Pebble zones occur near the base of this unit in many areas. Woodward and Gueno (1940) noted the occurrence of siliceous gravels of Eagle Hill. However, they did not provide a description of the materials. Although the size of available pebbles is small (one to five centimeters), this deposit was probably the most significant occurrence in the area.

A second type of lithic material was found in the project area (David Brown, personal communication). Examination of a part of this sample revealed that the material is primarily opaline-cemented siltstone. The opaline silica, which is found in the locally cemented porous beds of the Miocene deposits, was probably derived from Miocene volcanic materials (tuff) incorporated in the deposits. Amorphous silica in tuffaceous deposits is readily dissolved by groundwater and redeposited in porous beds. Opaline cement is common to deposits in the Catahoula Formation in Texas and Louisiana.

Summary

Bedrock materials in the vicinity of Eagle Hill are composed primarily of loosely consolidated sandstone of the Catahoula Formation (Miocene age). The Catahoula Formation is locally overlain by discontinuous sand deposits that are probably equivalent to the Williana Formation (Plio-Pleistocene age).

The modern environment is dominated by erosional processes that have acted continuously since late Pleistocene. Headwardly eroding streams and colluviation have been the dominant processes in sculpturing the landscape. The relatively slow rates of erosion have not significantly modified the Eagle Hill area since the advent of early man.

Two basic lithic resources are available in the area that can provide satisfactory material for tool manufacture: (a) opaline-cemented siltstone and fine sandstones related to alteration of volcanic parent material occurring in the Catahoula Formation and (b) siliceous gravels that occur in the Plio-Pleistocene deposits. It is likely that the siliceous gravels have been the largest local source of lithic material, but very little direct evidence is available.

E. GEOMORPHOLOGY AND SOILS (Nials, Gunn)

Immediate Pre-Pleistocene Sediments

The physical strata below the surface layers on Peason Ridge is a clay level (Fig. 37). The clay is gray, although it has oxidized to yellow and red near the uneroded surface. The modified spots appear as mottles. The clay is reported to be the Miocene Catahoula Formation by Anderson (1960). Evidence for the relative great age of the deposits is to be found in the fact that the clay contains lenses of sandstone less than a meter down in the section and that most of the weathering is of groundwater origin rather than pedogenic. Further investigations into the age and origin of the subsurface clays sought by microscopic examination of the sediments showed no ostrocodes, foraminifera, etc. The clays are of terrestrial, near-shore origin and date to the pre-Pleistocene epoch.

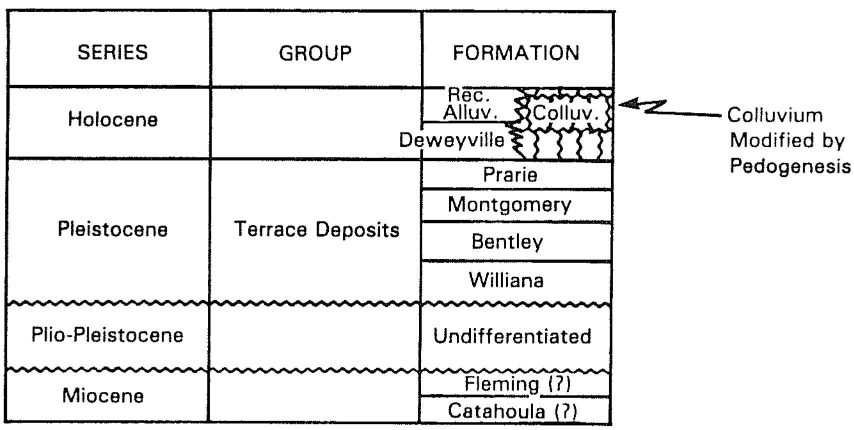


Figure 37. *Bedrock Stratigraphy in the Peason Ridge Area.* Geologic structure-bedrock dips slightly to the south as a result of uplift along the Sabine uplift.

The clays are topped by a rather regular lag deposit composed mainly of red jasper pebbles from one to five centimeters in diameter. The high frequency of the pebbles is attested by the fact that almost every three-inch bore hole produced a pebble at the interface with the clay. Archaeologically it is helpful to observe that wherever such stones are observed on the surface, the deposits have been deflated below the level of the pre-Pleistocene clays; and any artifacts found in such places will be deflated and/or laterally disturbed. This principle constitutes part of the support for some of the conclusions that follow concerning the condition of the Pleistocene and post-Pleistocene surfaces at the Eagle Hill site and environs.

Within the locality the clay bedrock is overlaid by sandy clay, sandy clay loams, and sandy soils, which range from about a meter in thickness on erosional remnants to 50 cm or less in more eroded areas.

Eagle Hill itself stands prominently above the surrounding landscape so as to constitute a geological curiosity. It is about 600 m northeast of the site and stands about 70 feet above the surrounding surface of the ridge. Before it was bulldozed off to prepare for an Air Force observation post, the top of the hill is reported to have been composed of several feet of sand (John Guy, personal communication 1980). Apparently there were substantial numbers of artifacts in the sand pushed off the hill by the bulldozing operation (Robert Guy, personal communication 1980). The sand on Eagle Hill suggests that it is a product of the same geological process that shaped the various knobs of lesser size which dot Peason Ridge and include the four prominences of the Eagle Hill locality. Given the tendency of primitive people to visit such prominences during ceremonial seasons and the fact that the knobs, as we shall see, represent our most likely source of archaeological information, their genesis bear discussion (Fig. 38).

Examination of the USGS 7.5' Peason Quadrangle shows that Eagle Hill, although peculiar for its abruptness and the fact that it lies at the divide of three drainages (Sabine River, Red River, and Kisatche River), is one of several 450-feet high prominences in the southern Sabine and northern Vernon Parish areas. This suggests to us that the landscape prior to deposition of Plio-Pleistocene sands and clays was once relatively flat, at least a few tenths of feet higher than it is now relative to the surrounding landscape (Fig. 38,a). Subsequent erosion generally lowered the surface, although erosional remnants of the former surface in drainage areas are common (Fig. 38,b,d). Anderson (1970) notes that most hills in Sabine Parish are underlain by sands. At least part of the explanation for the presence of these remnants can be posed in terms of the factors controlling erosion.

Under certain conditions sand can present an inhibition to erosion. Precipitation will infiltrate into sand more readily than fine-grained sediments, thus reducing the amount of runoff. Runoff will occur only after the sand becomes saturated or if the rate of precipitation exceeds the rate of infiltration. At the point of saturation, runoff occurs with consequent erosion. Thus, thicker sand deposits have relatively reduced amounts of runoff and erosion. As long as the ability of a layer to absorb moisture is not exceeded by precipitation, the sand will serve as a resistant sedimentary unit. Erosional remnants in the Peason Ridge area can therefore be accounted for by a

b

c

d

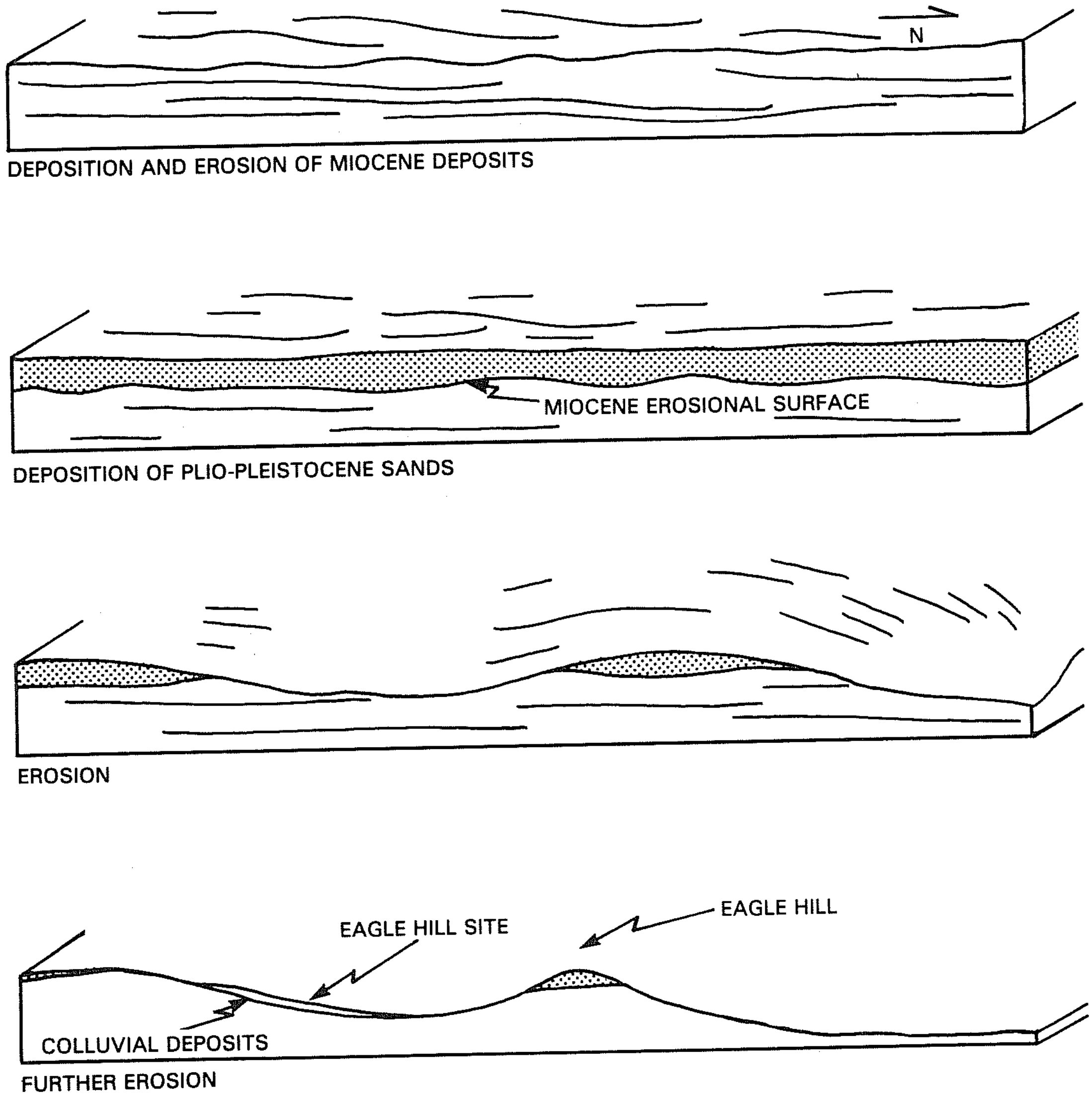


Figure 38. *Geomorphical Origins of Eagle Hill.* a, deposition of erosion of Miocene deposits; b, deposition of Plio-Pleistocene sands; c, erosion; d, further erosion.

the presence of sandy surface deposits. The source of the sand is weathering of Miocene sandy clay deposits and Plio-Pleistocene sandy deposits in the area. Wherever sands accumulate for one reason or another to depths whose capacity exceeds the precipitation minus evaporation budget, an erosional remnant can be expected.

The reasons for differential concentration of sands resulting in erosional remnants are more than likely numerous. It is likely that there is some unevenness in the distribution of sands in the substrate, which results in variances on exposure. However, once exposed, geomorphological forces redistribute the sandy sediments with occasional effects toward concentration. In addition, vegetation exerts considerable stabilizing effects on sand erosion resulting from water and wind. Dense vegetation can occur in thickets either due to natural or cultural causes resulting in concentrations of sands and increased ability to absorb water before erosion begins.

The implications of archaeological prospecting are evident. Some of the erosional remnants on Peason Ridge are likely to contain cultural remains. In fact, some may have been caused by cultural activity. It seems likely that these remnants most likely to contain cultural materials would be near sources of water in such a high and dry area. The potential for a seep spring in the area (Servello n.d.) of the sandstone exposed on the south slope of the ridge near the Eagle Hill locality may have provided an appealing spot for at least seasonal camps during the Prehistoric period.

Late Pleistocene-Early Holocene Sediments

Various lines of evidence suggest that the Miocene bedrock had been eroded to a relatively smooth surface in the vicinity of the Eagle Hill site during the late Pleistocene or early Holocene, and that the surface had been modified by a thin argillic soil. Colluviation during this time is assumed to be relatively inactive. Pedogenic modification of these sediments indicates that relatively stable conditions existed for a considerable length of time, at least 100,000 years.

The developed soils at the bottom of the profile are dated archaeologically to the late Pleistocene and suggest a flat-lying surface. Note that the underlying soil profile (Fig. 39) is flat-lying and does not follow the contour of the present-day surface. This independence of contour suggests a different, probably flat-lying profile for the earlier surface.

We sought further support for this idea by boring for the top of the clay surface on a 250-m transect centered on the Eagle Hill locality and paralleling the trend of Peason Ridge. A plan map of the transect is shown in Figure 4, Section I, page 15. The profile of the transect is illustrated in Figure 40. As can be seen, the surface of the clay bedrock and the present surface do behave as expected, particularly under Area A.

Holocene Sediments

During the Holocene there appears to have been a marked increase in colluvial activity as indicated by the general suspension of pedogenic development.

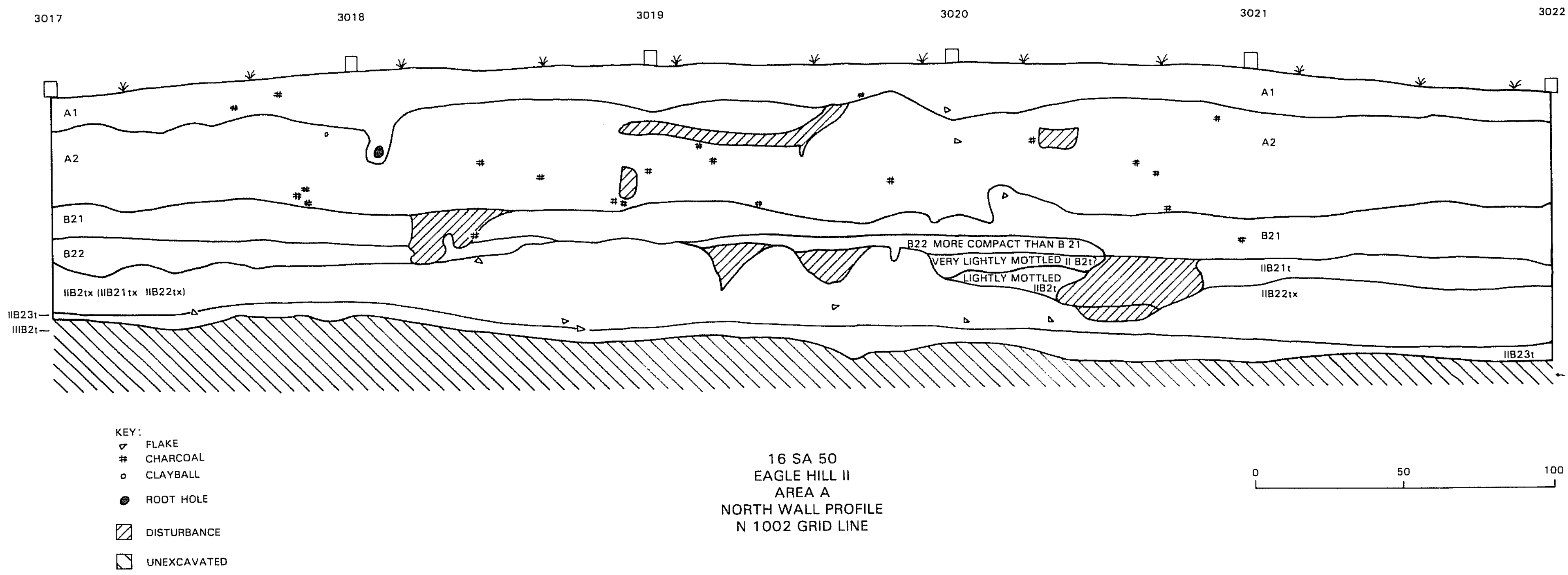


Figure 39. *North Wall Profile Along the N1002 Grid Line.*

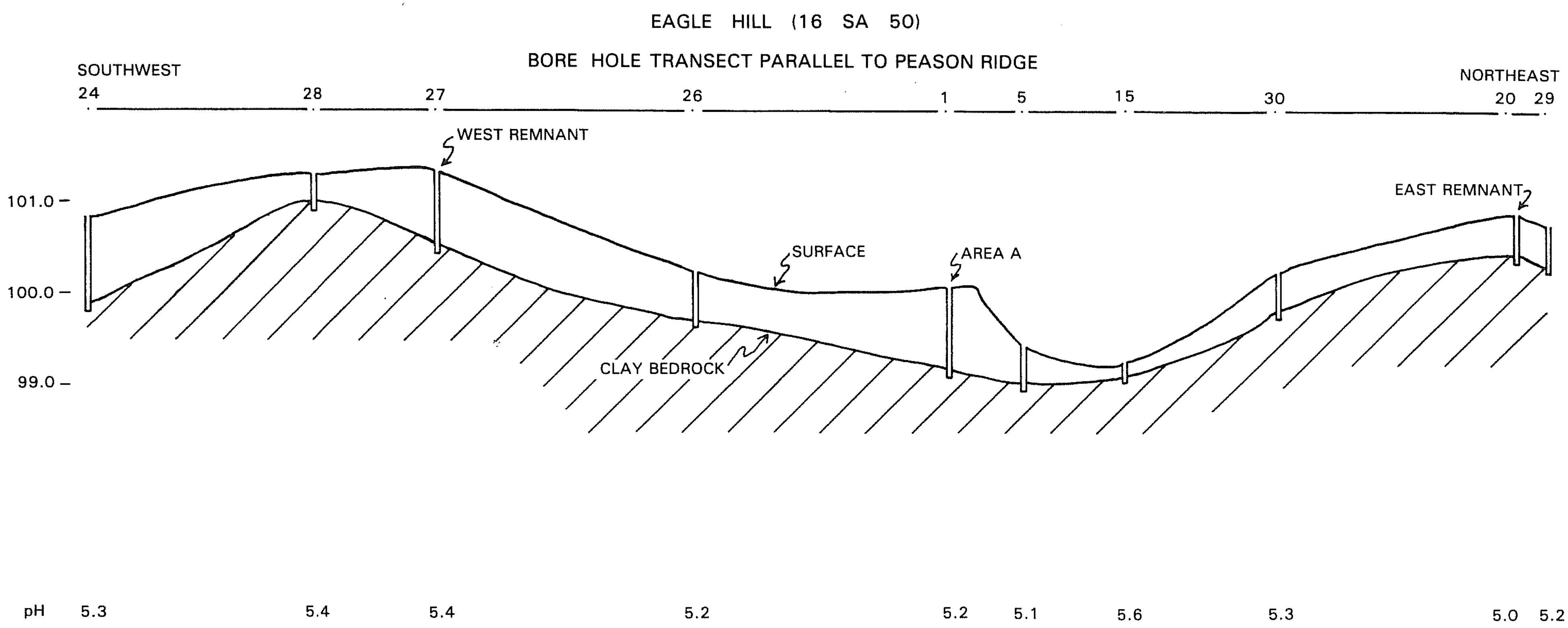


Figure 40. *Profile View of Clay Surface Transect.*

Movement of sediments appears to have been, at least in part, a product of fluvial processes, and the period is punctuated by erosional surfaces within the section. Such a change in the depositional regime was probably fostered by a change in the precipitation pattern. The exact nature of the change is indeterminant. A decrease in vegetational cover caused by a shift to wet winters and dry summers, or intense thunderstorms following periods of dryness are likely prospects for the cause.

Colluvial movement of materials down slopes is generally modeled as follows. A slope can be divided into an upper and lower segment. The ratio of upper to lower area is dependent on the degree and regularity of the slope, amount of precipitation, nature of the sediments, length of the slope, etc. Highly vegetated (Schumm 1965) and relatively flat slopes are inefficient at moving sediments downslope. Efficiency increases with less vegetation and as the slope is organized into systems of rills, gullies, and streams.

Holocene development of sediments at the Eagle Hill locality appear to be a classic case of development of efficiency (Fig. 41,a-e). At the end of the Pleistocene a planar clay surface with a thin soil (Fig. 41,a) began to be subjected to relatively rapid colluvial action (Fig. 41,b). The upper segment of the slopes to the northeast and to the southwest contributed sandy clay sediments toward the gentle swale or saddle at the locality. Our transect, Figure 40, confirms a decrease in surface sediment depth toward higher ground. Apparently the very slick condition of the air strip at the top of the hill to the southwest is attributable to the lack of surface sands to buffer the clays.

In addition to the colluvial dumping of sediments into the saddle, the drainage systems apparently began to organize to more efficiently evacuate sediments from the hill (Fig. 41). Gullies cut into the plain from the north and the south. Some erosional activity is evident in the profile in Figure 39. By our estimates, however, there does not appear to be decisive surface alterations as would be evidenced by the appearance of prominent rills or gullies in the section within Area A.

The reason for the lack of prominent erosional forms may be shown in the present-day geomorphic forms. To the southeast of the site is a resistant siltstone outcrop with a very old gully emptying onto it. It is about three to five meters below Area A in elevation. The age of the gully is attested by the oxidation of the clay bedrock in gentle swales visible in the cutbank. Apparently the relative flatness of the locality was maintained by an underlying caprock, until extreme disruptions such as logging, stump removal, and frequent firing characteristic of this century took place.

To the north of the locality about 100-150 m is a cutbank that contains a buried soil. It is about 60 cm above sandstone bedrock and is topped by another 60 cm of high energy fluvial deposits. We found a piece of sawn timber between the soil and the fluvial deposits, and therefore assume that it is an example of north slope soils before deforestation during the first quarter of this century. As was mentioned earlier, we have found evidence of pedogenesis on the south slopes in the clay. While it is too early to generalize from so few observations, the possibility needs to be examined that the

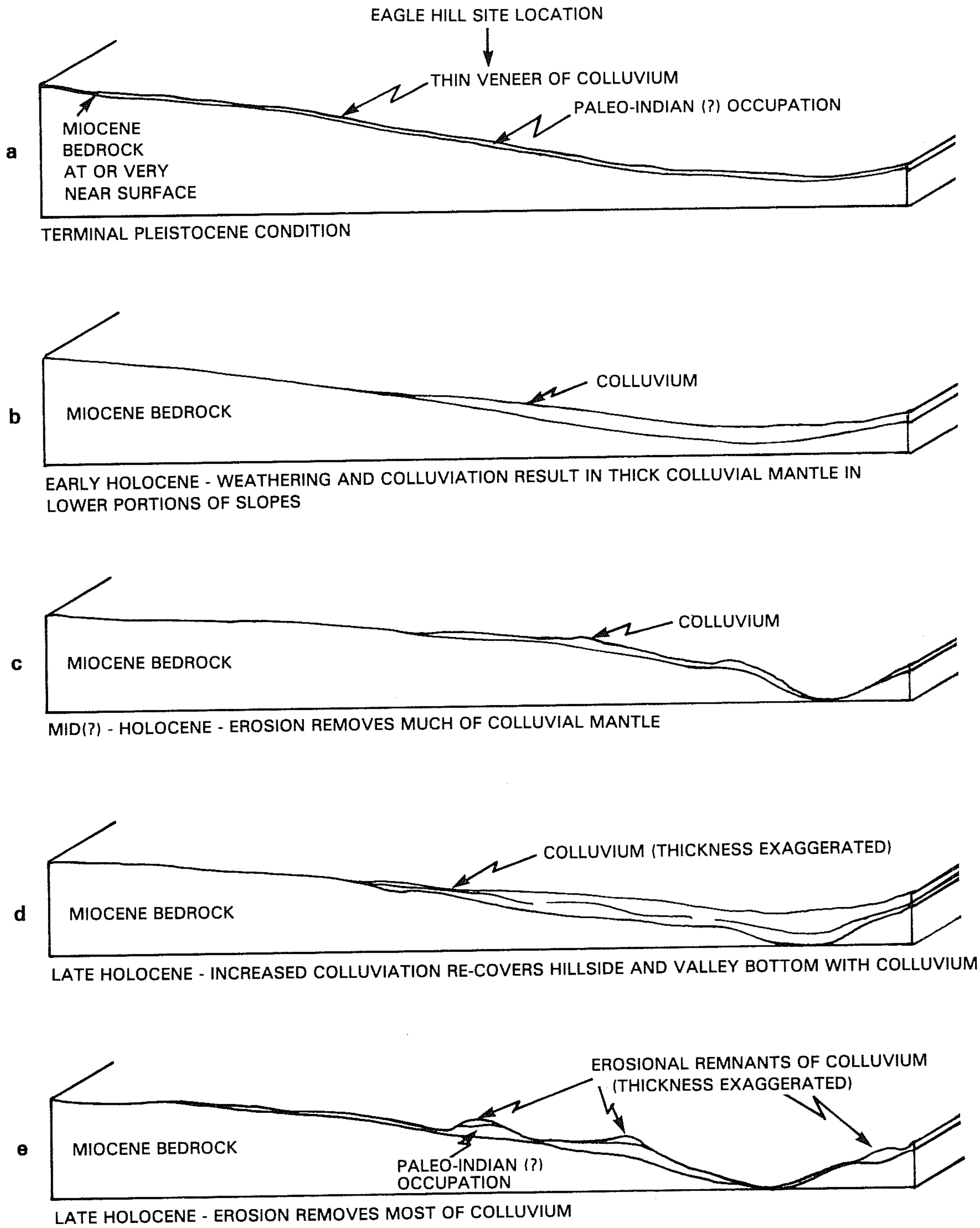


Figure 41. *Geologic History of the Eagle Hill Site.*

north slopes were supporting a robust soil development, while the south slope was more prone to periods of intensive erosion. It would also be of interest to examine the pollen and biosilica profiles of the north and south slopes to determine the characteristics of the pre-European vegetation. Such studies could well throw light on the erosional characteristics of the vegetation regimes extant during the Prehistoric period. It is the judgement of Nials that the soil is less than 2500 years old and is therefore probably post-Hypsithermal.

The Crayfish Problem

While we were on the site from April 16-21, 1980, we noticed that there were numerous crayfish (*Orconectes limosus*) castles on the site. Crayfish can cause considerable disruption to archaeological deposits, and Nials (personal communication) in another study of a site in southeastern Oklahoma found between five and 38 holes per square meter. A small biface was found to have been moved downward 45 to 60 cm in the section. While we were re-excavating Servello's test pits, we found one hole parallel to the wall all the way to the clay. When encountered, the crayfish was retreating into the clay bedrock.

The crayfish problem suggested an element of archaeological caution. For one, we should be cautious of far-reaching conclusions based on a few artifacts, since they could be vertically disturbed by crayfish. Since there are no flakes of any size on the surface, we might conclude that the crayfish do not create upward disturbance. We have some evidence that they move materials downward. Also, since the observed creature was moving presistently into the clay, there may be a reservoir of artifacts in the clay.

Sediments and Soils (Brown)

The soils at 16 SA 50 are indicative of a relatively complex pedologic development, one that is of critical importance to the archaeological remains buried at the site. The interaction of *in situ* pedogenic activity with cycles of erosion and deposition necessitated a preliminary evaluation of the archaeological significance of the strata recognized at the site. As pointed out in earlier sections, this consideration resulted in the development of an excavation technique, which combined natural, arbitrary, and cultural strata into a system that aided rapid and efficient data recovery from the site. The following section discusses soil development at 16 SA 50 and its relevance to aboriginal occupations at the site.

As noted in previous sections, the depositional history of the soils around the Eagle Hill II site centers around the movement of colluvial materials from higher positions on the ridge to more stable lower slopes, forming a surface layer of varying depth above the underlying Miocene clays and silt/sandstones. In addition to the fact that colluvial rates must have been quite variable through time, the soil picture is complicated by evidence that indicates major periods of erosion as well, when unknown amounts of material were removed from the surface of previously formed soils. At least three and possibly four or more erosional events have truncated the main area of the site since the late Pleistocene, leaving remnants of the lower portions of previously developed soils.

The main focus of this discussion is the soil found in the central portion of Area A, tentatively classified as a Typic Fragiudult. A brief physical description of the typical soil profile is below. This is followed by a general discussion of the significance of these horizons and their distribution.

Soil Horizon A1, 0-12 cm. Grayish brown (10 YR 5/2), very fine sandy loam. Dark grayish brown (10 YR 4/2) moist, massive, soft, very friable. Few fine grass roots. Lower boundary generally clear, wavy, marked by many fine and medium faint to distinct mottles of material from the zone below, apparently as a result of root activity. This zone is marked by a slight humic accumulation. The color of this zone becomes gradually lighter from top to bottom (ca. 10 YR 4.5/2 to 10 YR 5.5/2).

Soil Horizon A2, 12-44 cm. Very pale brown (10 YR 7/3), very fine sandy loam, (10 YR 7/4) moist, massive, slightly hard, very friable; common very fine and few fine roots. Moderate amount of small (1-5 cm) manganese concretions; few very small strong brown iron oxide stains; some small root and rodent burrows (2-10 cm). Lower boundary clear, smooth, marked by many distinct fine and medium mottles of material from stratum below. Because of its light color and otherwise apparently unaltered nature, this zone is regarded as an A2 or albic horizon, although there is no incontrovertible evidence that it has been leached; it could possibly have been formed by colluvial deposition so rapid as to inhibit the addition of humus. As with the stratum above, there is a slight tendency to lighten in color with depth.

Soil Horizon B2, 44-60 cm. Brownish yellow (10 YR 6/6) very fine sandy loam, yellowish brown (10 YR 5/6) moist; weak medium crumb structure; slightly hard, very friable, nonsticky, not plastic; few very fine roots; rare tiny manganese concretions and iron stains; lower boundary gradual, wavy. The lower few centimeters of this stratum are transitional in nature with some mottling from the lower zone and a slight tendency to brittleness of the peds. These fragipan-like characteristics are contrasted to a marked increase in fine roots at the bottom, where they have turned horizontally in response to the more developed fragipan of the stratum below. In Figure 39 this horizon is divided into two subunits, B21 and B22. The lower of these two subunits is discontinuous and is marked primarily by a slightly higher clay content than in B21.

Soil Horizon IIB21tx, 62-70 cm. Yellow (10 YR 7/6) very fine sandy loam, light yellowish brown (10 YR 6/4) moist; mottled with few, prominent fine red (2.5 YR 5/6) iron stain mottles (and many very fine [0.5-2 mm] iron stain mottles) as well as common distinct medium mottles of light gray (10 YR 7/2) sand; weak, medium subangular blocky structure; slightly hard, very friable, nonplastic, nonsticky; very clear sand skins on some ped faces and in some small vertical cracks; common, very fine roots following filled cracks; lower boundary clear, generally smooth. This stratum is not continuous across the area. Where it is recognized, it appears as transitional between Soil Horizon B2 and Soil Horizon IIB22tx below; where it does not occur, the transition between these two strata is more abrupt.

Soil Horizon IIB22tx, 70-80 cm. Yellowish brown (10 YR 5/8) and light gray (10 YR 7/2) very fine sandy loam, dark yellowish brown (10 YR 4/6) and brown (10 YR 5/3) moist, mottled with red iron oxide (2.5 YR 4/8); moderate, medium to coarse subangular blocky structure; slightly hard, friable, very brittle, nonplastic, nonsticky; sand skins on ped faces and cracks; mottling is generally vertically oriented suggesting cracking or vertical piping; coarse hexagonal patterning shown is horizontal section, with sandier material lining hexagon boundaries; lower boundary clear, smooth. This zone is noticeably clayier than those above. Fragipan characteristics are best developed in this stratum. Mottling is more intense in this stratum than any other.

Soil Horizon IIB23t, 80-90 cm. Light brownish gray (10 YR 6/2) sandy clay loam, same when moist, mottled with yellowish brown (10 YR 5/8) and red (2.5 YR 4/8); moderate coarse to very coarse subangular blocky structure; hard, firm, slightly plastic, slightly sticky; very few sand grains present on some ped faces, but no brittleness or other fragipan characteristics. Lower boundary clear to abrupt, slightly wavy, and marked by occasional small jasper pebbles present as lag gravels on the erosional surface.

Soil Horizon IIIB2t, 90-102 cm. Light brownish gray (10 YR 6/2) clay, loam grayish brown (10 YR 5/2) moist, mottled with red (2.5 YR 4/6) medium to coarse prominent iron oxide mottles; strong, very coarse subangular blocky structure; very hard, very firm, plastic, sticky; lower boundary gradual, smooth.

Soil Horizon IIIC, 102 cm and below. Light brownish gray (10 YR 6/2) sandy clay loam, grayish brown (10 YR 6/2) moist; moderate, very coarse subangular blocky structure; very hard, very firm, plastic, sticky.

The lowest recognizable depositional unit at 16 SA 50 is a grayish clayey sediment (which includes both IIIC and IIIB2t) thought to date to the Miocene. Technically, a sandy clay loam (cf. Table 10), this sediment has a very silty clay feel, because of the near absence of coarse sand and the predominance of very fine sand. The upper 15 to 20 cm of this sediment (IIIB2t) has been pedogenically altered by partial oxidation (resulting in a deep red mottling) and the introduction of translocated clays (cf. Table 10) and coarse sand into the original Miocene matrix. This stratum is considered a moderately developed argillic B horizon.

At the top of this stratum is an erosional surface marked by jasper lag gravels and a distinctive change in the nature of the sand fraction. While pedogenic alteration of this unit may still be occurring, the lack of a clear transition and quite distinctive patterns of mottling suggest that the IIIB2t alteration was initiated prior to the truncation, which resulted in the erosional surface. The depth of this original soil or the time of its development is unknown.

During excavation this stratum was quite moist and plastic (though not easy to dig), but upon exposure to the air, it rapidly dried and began to show large peds (ca. 10 cm) with moderate size cracks (up to 1 cm in width) between. This high shrink-swell potential could have potentially displaced artifacts under conditions of extreme drought, but little indication of such displacement was encountered during excavation.

TABLE 10. PARTICLE SIZE DISTRIBUTION IN AREA A

Sample No.	Depth-Horizon	Sand	Silt	Clay	Textural Class*	Sand Subfractions† vc	c	m	f	vf	VFS/FS Δ
			Percentage					Percentage			
1	4 cm-A1	70.9	22.5	6.6	VFSL	0.4	2.8	3.0	27.9	63.6	2.3
2	30 cm-A2	72.4	21.8	5.8	VFSL	0.6	2.7	4.2	25.7	64.7	2.5
3	40 cm-A2	69.1	24.0	6.9	VFSL	0.4	2.5	4.1	28.0	62.9	2.2
4	47 cm-B21	64.2	25.9	9.9	VFSL	0.8	2.7	2.2	28.0	64.4	2.3
5	57 cm-B22	60.0	26.0	14.0	VFSL	0.4	2.4	6.3	20.8	69.6	3.3
6	62 cm-IIB21	57.7	25.3	18.0	VFSL	0.6	2.3	3.9	25.3	65.1	2.6
7	72 cm-IIB22	56.8	25.2	18.0	VFSL	0.4	2.3	3.6	29.1	62.8	2.2
8	82 cm-IIB23	55.6	24.4	20.0	VFSL	0.4	2.2	4.1	25.8	64.7	2.5
9	94 cm-IIIB2	45.3	20.1	34.6	SCL	0.9	3.2	5.5	27.7	60.1	2.2
10	107 cm-IIIB2	41.1	19.1	39.8	CL	0.9	2.9	1.1	29.6	63.4	2.1
11	135 cm-IIIC (clay bedrock)	45.6	23.8	30.6	SCL	0	0.3	0.9	18.7	71.9	4.2

*VFSL=very fine sandy loam; SCL=sandy clay loam; CL=clay loam.
†vc=very coarse sand; c=coarse sand; m=medium sand; f=fine sand; vf=very fine sand.
ΔVFS/FS=very fine sand-fine sand ratio.

In addition to its vertic tendencies, this unit does have considerable cultural significance in that it probably was at or very close to the surface during the Paleo-Indian occupation of the site. This may have significantly altered groundwater hydrology during that time, causing relatively rapid runoff, but allowing some standing wet areas where depressions in the truncated clay held water at or just below the surface. As pointed out earlier, such a depression may have been responsible for the formation of the low rise that marks Area A.

Of some interest is the areal extent of the argillic modification of this Miocene clay. It is only found in the general area of the Area A mound. In other places Soil Horizon IIB2 directly overlies unaltered (or minimally altered) clay bedrock. This indicates either a localized soil development within the depression or extensive erosion of the surrounding areas. In either case, since the surface of the altered clay under the mound is lower than the surrounding unaltered clay, it suggests a slightly different drainage pattern at the time of Paleo-Indian occupation than at present.

While the Miocene sediments underlying the site probably resulted from a low energy fluvial or lacustrine depositional environment, all of the overlying depositional units seem to be of colluvial origin. The unit which immediately overlies the Miocene clay (which includes IIB23t, IIB22tx, and IIB21tx from bottom to top) shows the strongest pedogenic alteration of any unit, with intense multicolored mottling, translocated clay and sand, and fragipan development. As noted previously, the boundary between these two depositional units is an erosional surface.

Soil Horizon IIB2t(x) contains the oldest *in situ* cultural material found at the site and is divided into three subunits based on texture and structure. The differences between these units are primarily pedogenic rather than depositional. Taken as a whole the unit is regarded as argillic, with marked structural development and the apparent presence of translocated clay. The lowest unit (IIB23t) contains the clay maxima and exhibits no fragipan development. Both of the upper two units show some fragipan development and generally differ only in the pattern and color of mottling. The uppermost stratum (IIB21tx) shows transitional characteristics and is partially discontinuous.

One of the most important questions at the site is the history of postdepositional disturbances to this critical strata. The upper portion of this unit is marked by the horizontal polygonal network commonly seen in fragipans. It seems likely that these are vertic cracks filled at an early stage in the development of the fragipan. The possibility of vertical displacement of artifacts within these cracks was recognized and carefully watched for during the excavation. Artifactual materials from this stratum were recovered almost exclusively from within the prisms.

In contrast to this potential disturbance, the presence of the fragipan itself indicates very little soil disturbance, since its development. The structure of the fragipan inhibits vertic movement and limits root penetration, except along prism faces. In this case, the few penetrations of the fragipan by large taproots were quite distinct and easily separated from the intact soil.

The core series and soil tests conducted at the site indicate that this soil unit is more widely distributed at the site than the pedogenically altered bedrock. Despite this, its thickest and most highly developed segment is beneath the mound at Area A. In addition to its wider distribution, the erosional surface contours at its top more closely approach the modern surface contours, suggesting that microrelief began to approximate that of the present at some time prior to the end of the major erosional period, which resulted in its truncation.

The erosional surface that separates this unit from the overlying one is less distinct than the one above the Miocene clay, but is indicated by a number of lines of evidence, including both soils and cultural data. Soil evidence includes slight changes in the mineralogic composition of the sand fraction and a relatively high percentage of coarse sand and small pebbles near what is thought to be the erosional surface (cf. Lopez, page 150). Archaeological evidence includes the dense cultural substratum 3.12, which mixes apparent Archaic dart points with ceramic materials, and the wide ranging radiocarbon dates to either side of the surface.

Overlying the truncated argillic horizon (IIB2t[x]) is a relatively thick depositional unit that contains all of the ceramic remains at the site. Diagnostic soil horizons within this depositional unit include a thin, slightly humic Soil Horizon A1 (note there is no plow zone) overlying a bleached Soil Horizon A2 or albic horizon. Together these form an ochric epipedon that overlies an altered subsurface horizon (B2), which might be best termed as cambic rather than argillic. Although there is a slightly higher clay content within Soil Horizon B2, the most distinctive feature is its deep gold color. This color appears to be the result of the liberation of limonitic iron minerals that have stained the very fine sandy matrix. The relatively low clay content within this stratum has apparently precluded the development of any strong structure; the reported crumb structure is so ephemeral that it could almost be regarded as massive.

Although the thicknesses of the individual units vary considerably, all of the horizons within this upper unit are widely distributed in the area surrounding the site, and the pedogenic alterations of these units may be much later than their colluvial deposition. The loosely compacted nature of this soil horizon and the absence of a strong structure make it easily penetrable by roots and rodents, as was observed during the excavation of the site. Fortunately, the distinctive colors of these three upper horizons make such bioturbation highly visible. The amount of bioturbation may be even greater than that observed, however, due to the possible late development of the pedogenic horizons. In general, some artifactual mixing must be expected from the upper levels.

There are slight indications of a possible truncation surface between Soil Horizons A2 and A1, based again on sand grain composition and the nature of the boundary itself. This is not clear, however, and because of its thinness, the A1 zone has not been assigned to a different depositional unit even though it was treated separately during excavation. In any case, because of its nearness to the surface, care should be taken in the interpretation of artifactual materials from this zone.

Site Catchment and Settlement Pattern (Gunn, Sheehan, and Garner)

The overwhelming topographic fact about the location of the Eagle Hill II site is that it is located on a relatively flat segment of Peason Ridge, a distinctively upland habitat. Most of our inferences concerning the utility of the site must be drawn from reasonable assumptions about the purposes such a habitat can serve.

In spite of some severe difficulties, we thought that an effort should be made to familiarize ourselves with variation in the terrain and its possible implication toward resource availability. To do this, we chose to generate a photogammetric, geomorphical map (Fig. 36). Naturally the relative economy and speed of production were a factor, especially given the fact that no detailed Soil Conservation Service (SCS) soil maps were available. Also, the site is on the edge of a bombing and artillery impact range, and no access was permitted for ground observations. As can be seen in the map (Fig. 36), detail is quite precise, and we feel it provided a more than adequate analysis of exploitable microhabitats in the locale.

Thomas and Campbell (1978:66-95) conducted an extensive catchment analysis of the Whatley site (16 LA 37) about 100 km east of Eagle Hill. The following analysis generally conforms to the Whatley site design to provide comparable data on the two locations. Usually a site catchment analysis is conducted with the assumption that the site centered in the study area is a base from which resources are gathered. Given the remote location and apparent nonpermanent nature of the Eagle Hill II site, the site catchment analysis can be alternatively viewed as a search for base areas from which individuals were likely to come.

The geomorphic mapping identified four major surface sediments/features in a five kilometer radius around the site (Fig. 42). The highest locations are topped by Pleistocene sands (PS); sand bodies that are relatively erosion resistent and which act as aquifers for the occasional springs at surprisingly high elevations along the ridge. Military vegetation maps (*Fort Polk Terrain Analysis*, Map G) indicate that these areas are marked by short grasses and sparse stands of evergreens. Historically, they were covered by large longleaf pines. It is not unlikely that during periods of high regional aboriginal population density, the area may have been as burned-off and relatively treeless as it is now. During dry summers, fires start easily by natural and human causes. We were privileged to fight one such fire during the time of our excavations.

Below the sands are fields of colluvial sediments. Compositionally they are not unlike the Pleistocene sands, since the higher sandy areas are, in large part, their source. Soil development supplies some clays. The colluvia accumulate in locales that are prone to deposition, but are sedimentologically active. The Eagle Hill site exists due to such an accumulation. The varied Holocene record of deposition and erosion at the site bears ample evidence of this sedimentological restlessness.

Miocene lake bed clays (M) are exposed at the surface of steeper slopes and generally the active erosional surface facies. The modern vegetation appears

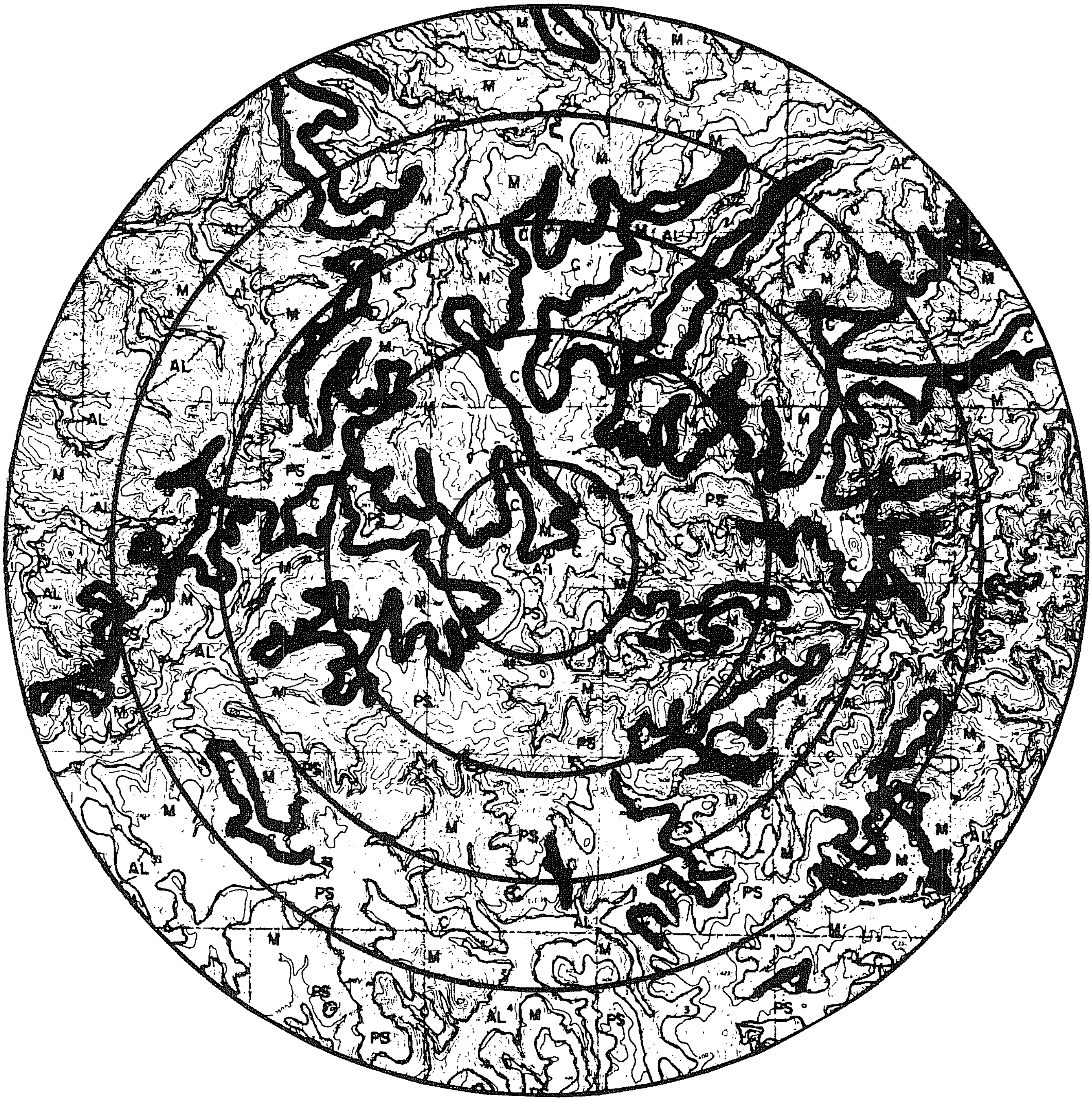


Figure 42. *Eagle Hill Catchment (1-5 km Rings) and Colluvium-Clay Interface (Heavy Lines).*

to be represented by sparse to medium densities of evergreens and open grasslands in well-drained areas. In less well-drained areas, a deciduous component asserts itself. Finally, the alluvium is dominated by deciduous varieties.

Table 11 summarizes the surface sediment regime within five kilometers of the site. Little of the catchment is in Pleistocene sands (14%) or alluvium (13%). There is no alluvium in the immediate one kilometer of the site and what is there only reaches 20% of the landscape in the most distant concentric circle. Colluvium represents over half the land surface near the site, while Miocene clays appear a distant second at 26%. The bottom totals for the row percentages are the expected values for the outward progression from ring to ring. Colluvium and sands are clearly overrepresented near the site. Clays occupy half of the catchment as a whole.

TABLE 11. SURFACE SEDIMENT TYPES IN THE EAGLE HILL CATCHMENT BY ONE KILOMETER CONCENTRIC RINGS

Sediment Type	Catchment Rings (km)					
	1	2	3	4	5	Total
Area (millions of square meters)						
PS	.62	2.27	2.84	2.36	2.83	10.91
C	1.69	2.88	4.85	4.69	2.84	16.95
M	.83	4.15	7.09	11.56	16.79	40.42
AL	.00	.13	.97	3.38	5.83	10.31
Totals	3.14	9.43	15.75	21.99	28.28	78.59
Row percentages						
PS	.06	.21	.26	.22	.26	1.00
C	.10	.17	.29	.28	.17	1.00
M	.02	.10	.18	.29	.42	1.00
AL	.00	.01	.09	.33	.57	1.00
Totals	.04	.12	.20	.28	.36	1.00
Column percentages						
PS	.20	.24	.18	.11	.10	.14
C	.54	.31	.31	.21	.10	.22
M	.26	.44	.45	.53	.59	.51
AL	.00	.01	.06	.15	.21	.13
Totals	1.00	1.00	1.00	1.00	1.00	1.00

Without archaeological information, the attraction of prehistoric peoples to Peason Ridge remains a matter of conjecture. However, the specific microhabitat of the site offers some possible explanations. The site is located midway between two large Pleistocene sand bodies and on the margin of the colluvium next to the Miocene clays. From the perspective of arboreal food sources, this location has several potential advantages.

The location between the sands is probably relevant to the nonproductive nature of the sandy areas. They would have been vegetated by longleaf pine, slash pine, shortleaf pine, turkey oak, and blackjack oak. The pines provide no foodstuffs, and the two oaks are of the black oak family, which has small, bitter acorns. Leaching their acorns for consumption would require quantities of running water.

The colluvium, however, probably provided a more interesting dietary selection. Although the upper reaches of the colluvium would have differed little from the sands at the lower edge of the colluvium, water would have seeped along the clays and surfaced at the colluvium-clay interface. We were able to observe this process in the early phase of the project during the spring rains. The colluvium-clay interface would have provided, in addition to moisture, the higher nutrient content of the clays. This ideal situation would have fostered post oak, which bear small, but very good acorns, hickories, and hickory nuts, and probably a rich understory of berries. Conditions of the clays would have been less favorable, because they do not act as an aquifer. The land would have been susceptible to extreme seasonal drying.

The Eagle Hill site, therefore, offers the optimal location for harvesting along the colluvium-clay interface between the sands. The vegetation-colluvium-clay system also provides a ready explanation for the apparent limiting of occupation activity to moist sedimentation periods. During long dry summers, the sand and colluvial aquifers would dry up and restrain the productivity of the colluvium-clay interface.

This hypothesis could best be tested by determining if sites located on Peason Ridge are frequently associated with similar situations. The highest potential areas are marked by a heavy line in Figure 42.

F. HIGH RESOLUTION ENVIRONMENTAL COLUMN (Gunn)

Constant volume sediment samples (2000 cc taken from the southwest corner of each one-meter square in each occupation plane) were designed to sample the horizontal distribution of phenomena on occupation floors. However, since our excavation design called for removal of only selected occupation floors at one-centimeter precision, the constant volume samples do not constitute a continuous vertical sample of soils from top to bottom of the site.

In order to insure a column of samples from top to bottom, we collected what we call a High Resolution Environmental Column (HREC). The HREC column was collected in arbitrary one-centimeter levels from the surface down to the Miocene clay (Plate 7). On occasion when arbitrary levels crosscut obvious natural levels, the sediments from the two levels were bagged separately. The HREC column was collected from the south half, 50 x 100 cm, of excavation unit E3019 N1002 and, therefore, consisted of about 5000 cc per sample. This figure is reduced somewhat by the removal of a 1 x 10 x 10 cm sample from the southwest corner of each unit for pollen/biosilica analysis. Since the site is about one meter deep, the HREC column produced 94 such samples.

Plate 7. *Excavation of the High Resolution Environmental Column (HREC).*

The HREC provided a sample large enough for the study of microfaunal remains, grain size analysis, geochemical analysis, pollen analysis, biosilica analysis, etc. The logic behind collecting the samples in one centimeter arbitrary levels was to collect samples at such a refined level that once in the laboratory, data from the samples could be combined at whatever level of resolution desired.

Fine-Grained (Sand) Sediment Analysis (Van Note)

Examination of HREC column sediments in the Eagle Hill site was undertaken to discover information about depositional environment (soil composition, types and possible sources of parent materials, and distance and means of transportation to the site). The geological situation of the site indicates that sediments may have been eroded from hills to the southwest and northeast of the site, or deposited by wind. These sediments have been subsequently altered by plant, animal, human, and pedogenic activity. Analysis consisted of studies of size, material type, and angularity.

Particle Size Analysis

Seven sediment samples from the HREC column corresponding to substrata 1.13, 2.13, 3.11 4.12, 4.15, 4.16, and 4.17 were processed through three screens to separate particles according to size and to facilitate material type and angularity studies of the fraction most likely to provide specified environmental evidence.

Procedure--Each sample was weighed, put into 500 ml of water, and poured through a stack of three screens (1.70 mm mesh, 0.50 mm mesh, and 0.15 mm mesh). An additional 500 ml of water was added. The material in each screen was then washed by recycling the water until clean, tapped off the screen, dried, and bagged. Particles remaining in the water were allowed to settle ten to fifteen minutes and placed in an evaporating dish. Each fraction was subsequently weighed.

Results--No information on level 1.13 is available, because the original weight of the sample was not recorded. However, there appears to be only slight variance with substratum in the percentage of the original weight of the sample which accumulated in each fraction (Fig. 43). The large fraction (all materials larger than 1.7 mm in diameter) occupies only 0.1% to 0.2% of the original weight, with the exception of substratum 4.16 where a pebble was noted. The 0.50 fraction (particles between 0.50 mm and 1.70 mm in diameter) remains fairly constant, varying from 1% in levels 4.12 and 4.15 to 1.6% in level 2.13. There is less than 5% difference in weights with respect to the 0.15 fraction (particles between 0.15 mm and 0.50 mm) with the largest percentages found in the two lowest levels. The percentage of weight that accumulated in the evaporating dishes, the small fraction, is fairly constant in the three uppermost levels, occupying between 74% and 76% of the total weight, but decreases in the three lower levels where only 56% to 63% of the total weight appears.

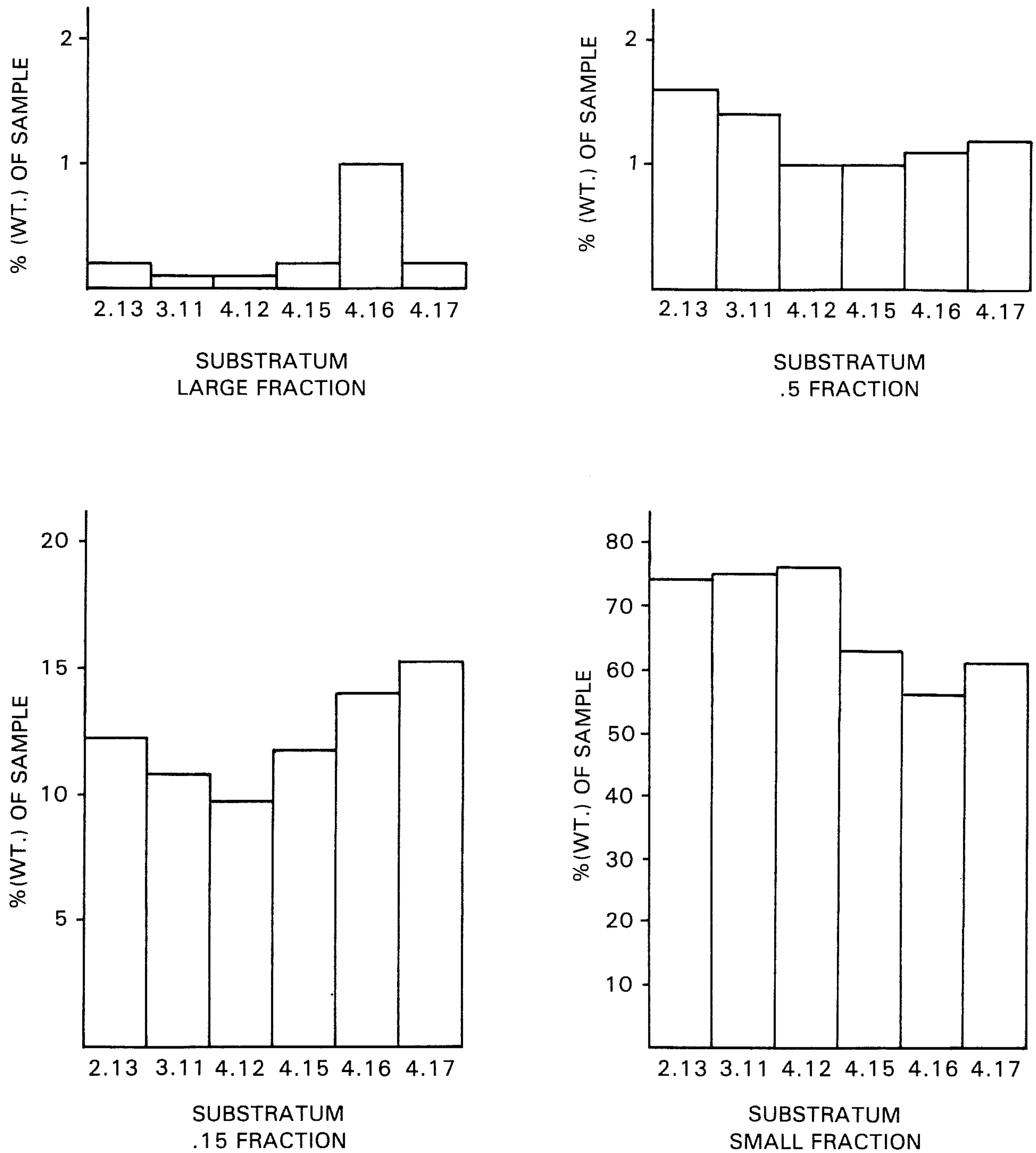


Figure 43. *Percentage of Original Weight According to Fraction.*

Observations--The most significant differences appear in the small fraction. A comparison of Krumbein and Sloss' (1963) scale of particle sizes with the screen sizes used shows which types of particles accumulated in each fraction (Table 12). The large fraction is composed of very coarse sands and very small pebbles. The 0.50 fraction is made up of medium to coarse sands while the 0.15 fraction encompasses the very fine to fine sand particles. The small fraction would contain some very fine sand as well as medium- to coarse-sized silts. The clay-sized particles were discarded with the water since the time was short (Table 13). The settling time that was allowed during the screening process would have allowed most of the silts to settle, but the finer silts were lost as well as the coarse clay that would have required several hours of settling time.

The variance between upper and lower substrata of weights of the small or silt-sized fraction may be an important environmental indicator. Cornwall (1958) indicates that sediments composed of wind-blown dust are made up largely of silt particles (he suggests 70% as typical) between 0.002 mm and 0.06 mm in diameter. Cornwall further indicates that clay-sized particles (less than 0.002 mm in diameter) are widely dispersed by winds and lost as an entity, but silts are heavy enough to settle fairly rapidly and thus are important as a wind-blown sediment. This rapid settling would be important to the deposition-vegetation mechanism which is suggested to be the cause of the Area A mound. The fact that the fourth fraction of the three upper levels is composed of 10% to 20% more of the total weight may indicate that wind-blown sediments were a more important factor in deposition in the uppermost levels than in the lower substrata. The rapid deposition rates during the OP 3.11-OP 2.13 interval were no doubt assisted by an open forest parkland (see section H), which allowed aeolian movement of silt-sized particles during certain seasons of the year.

Material Type and Angularity

Particles from the 0.50 fraction (0.50 mm to 1.70 mm in diameter) were examined microscopically in order to study material types and angularity. This particular particle size was chosen for study, because it might yield further environmental indicators, such as rodent teeth.

Procedure--The second fraction of each sample was subjected to a 100-grain count analysis. Each grain was classified by material type and angularity. Quartz was classified as clear, white, yellow, rose or smoky. Other classifications include charcoal, hematite concretions, limonite concretions, quartzite, conglomerates of calcite and quartz, chalcedony, burned resin, seeds, snails, and teeth. Angle types were recorded as angular or subangular. Data were recorded and subjected to principal components analysis.

Results and Observations--Quartz was the dominant material type (Fig. 44) with the clear and yellow varieties most common. Rose quartz was more common in the lower levels, possibly indicating that the source rocks were greatly eroded by the time of occupation of stratum 2.13. This might be confirmed by examination

TABLE 12. PARTICLE SIZE SCALE

Screen size	diam. in mm	Particle Types	
	4.00 - 64.00	Pebbles	
	2.00 - 4.00	Granules	
1.70 mm	1.41	Sand	coarse
	1.00		
	0.70		medium
	0.50		
	0.35		fine
	0.25		
	0.17		very fine
	0.12		
0.50 mm	0.08	Silt	very coarse
	0.06		
	0.04		coarse
	0.031		
	0.022		fine
	0.015		
	0.011		very fine
	0.007		
0.15 mm	0.005	Clay	very coarse
	0.003		
	0.0028		coarse
	0.0020		
	0.0014		fine

NOTE: A comparison of screen sizes used and Krumbein's scales as presented in Shackley (1975).

TABLE 13. PARTICLE SETTLING TIMES

Particle size (microns)	Withdrawal depth (cm)	Time hours	Time minutes	Time seconds
62.5	20			58
44.2	20		1	56
31.2	10		1	56
22.1	10		3	52
15.6	10		7	42
11.0	10		15	0
7.8	10		31	0
5.5	10	1	1	0
3.9	10	2	3	0
2.8	10	4	5	0
1.95	10	8	10	0
1.40	10	16	21	0
0.98	10	32	42	0

SOURCE: Shackley 1975

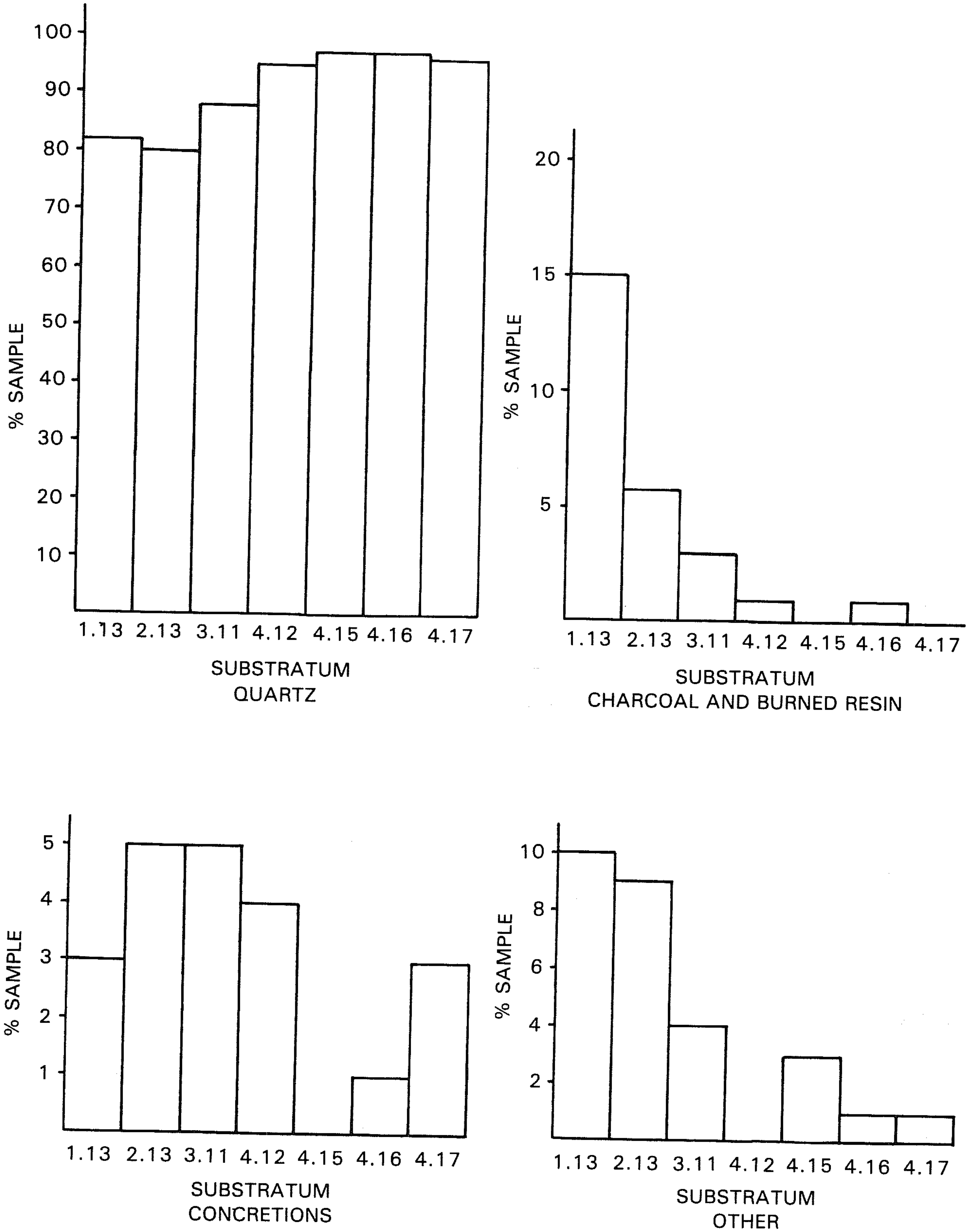


Figure 44. *Percentage of Material Type According to Level.*

of the hillside cores taken near the site. Charcoal is quite common in the uppermost levels, but becomes almost nonexistent in the lower levels. This is probably due to destruction by soil action and by highly acid water percolating through the soil. Concretions were present throughout the column, but hematite concretions disappear in the lower levels. In fact, the lower the substratum, the stronger the tendency for the fraction to be composed entirely of quartz. Seeds, although not always present in the grain count, were found in all but the lowest levels and were separated from the matrix. One snail was found in OP 1.13. There was a possible tooth fragment in OP 3.11.

Particles were found to be predominantly subangular (Fig. 45), but certain levels, notably OP 2.13 and 4.12, showed a marked increase in instances of angularity. It may indicate the close proximity of certain source rocks or more rapid burial of sediments, thus allowing a shorter time span for transportation and/or weathering of particles.

Principal components analysis confirmed some of these observations. An examination of correlation coefficients by substratum reveals a strong positive correlation with subangular clear quartz, subangular yellow quartz, and both angular and subangular rose quartz, indicating the tendency of these components to increase toward the bottom of the column. On the other hand, a tendency to decrease in number toward the bottom of the column is shown by the strong negative correlations of angular clear quartz, both types of white quartz, smoky quartz, charcoal, hematite, quartzite, conglomerates, chalcedony, burned resin, and seeds. The hardness of quartz and its tendency to weather extremely slowly, compared to the other components of the fraction, would explain this market decrease in all components other than quartz.

<u>Coarse-Grained (Pebble) Sediments</u> (Lopez)

Coarse-grained sediments generally in the pebble range (4.0 mm to 64 mm in diameter) were recovered from 1/8-inch screens. Determinations were made of material types, angularity, and size frequency of pebbles from Occupation Planes 1.13, 2.13, 3.11, 4.12, 4.15, 4.16, and 4.17. The analysis was intended to discover changes in source area from stratum to stratum, locate deflation surfaces, and discover stones that may have been brought to the site by human occupants.

Two analyses were performed. In the first, a column of squares was taken from E3017 N999 and analyzed in detail. The second analysis consists of weighing pebbles from all units of occupation.

Table 14 shows the frequencies of pebbles from the column. An increase in size and range of sizes is evident in OP 3.11 and below. The predominant sizes range from 5 mm to 8 or 10 mm in all levels. However, there is a marked increase in the number of sizes in the 6 to 10 mm range in levels 3.11 through 4.17. This supports the presumption that materials were transported to the site from different source areas and by different means. These are geomorphical (i.e., sheet erosion, gully erosion, etc.,) and by animals (especially birds, gizzard stones). The consistent presence of sizes 5 to 8 m argues for land movements, soil accretion, and hydrolic activities being the responsible agents. Inconsistencies

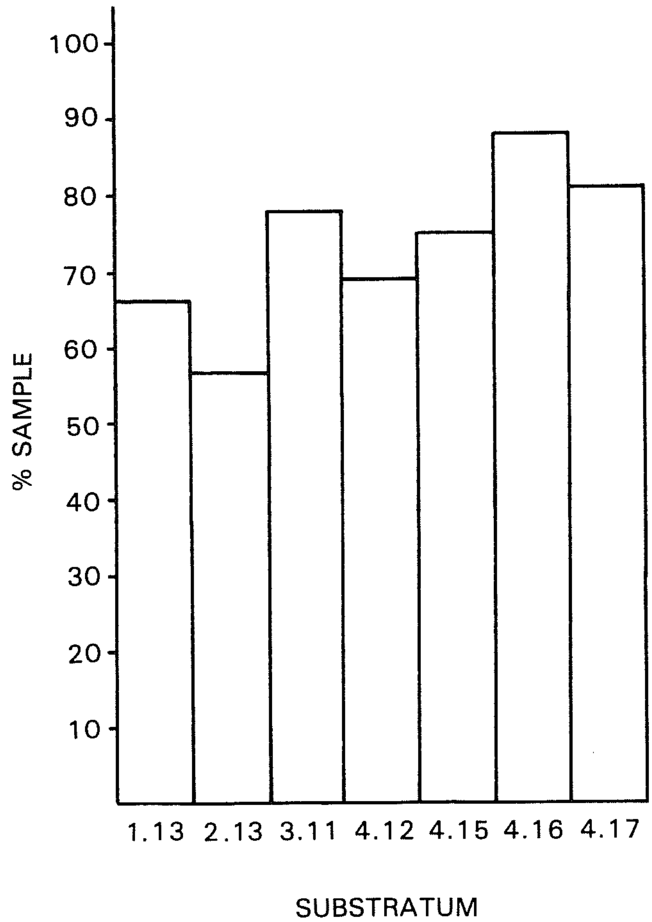


Figure 45. *Percentage of Subangular Particles.*

in other categories suggested other native agents of transport from upslope. The fact that Eagle Hill is in a saddle allows colluvial deposition from either direction upslope. Pedological evidence suggests that the site was originally located at or near the bottom of the slope on the east side of the saddle. Eventually, colluvium from the other slope overrode the lower levels. Consequently, pebbles larger than 5-8 m in the lower levels may have had their source to the east. Unfortunately, the source sediments by which this hypothesis could be tested have since been eroded.

TABLE 14. PEBBLE COUNTS BY OCCUPATION PLANE

	Occupation Plane							
Size (m)	4.17	4.16	4.15	4.12	3.11	2.13	1.13	Totals
4.0- 4.9	5	20	7	10	18	5	0	65
5.0- 5.9	54	53*	47*	18*	44	20*	14	250
6.0- 7.9	74*	36	48*	17*	51*	19*	26*	271
8.0- 9.9	27	29	5	6	13	4	9	93
10.0-11.9	19	19	9*	9*	23*	5	11	95
12.0-13.9	10	9	4	6	7	3	3	42
14.0-17.9	7	5	3	6	10	4	0	35
18.0-21.9	2	1	0	1	13*	0	0	17
22.0-25.9	1	0	1	0	1	0	0	3
26.0	0	0	0	0	3*	0	0	3
Totals	199	172	124	73	183	60	63	874

* Mode

Note that pebble sizes greater than 18 microns are nearly absent from all levels except OP 3.11, possibly indicating human transport to the site. OP 3.11 has the greatest frequency of cultural material in the strata except OP 2.13.

There are differences in the frequency of pebbles from level to level (Fig. 46). By far, level 4.17 has the most pebbles per unit area. OP 3.11 ranks a notable second, especially given the trend throughout the section. Both of these levels were identified in the field as being on or near erosion surfaces. Increased frequency of pebbles may well be due to deflation.

Figure 47 summarizes pebble weights for each occupation plane by one meter squares. Weight ranges are approximate and reflect the average occupation area per level. The weights are recorded in grams, and ranges are set at 0-10, 10-25, 25-50, and over 50 grams. The weights recorded show a remarkable differentiation in weight distribution over each occupation plane. Pebble weight is indicative of at least two factors: those pebbles brought in by humans and the different natural source areas. In theory, a careful study of weight distributions may also indicate how far source areas were from the site.

Table 15 describes the pebble materials in each level. These materials include rose quartz, smoky quartz, clear quartz, white quartz, yellow quartz,

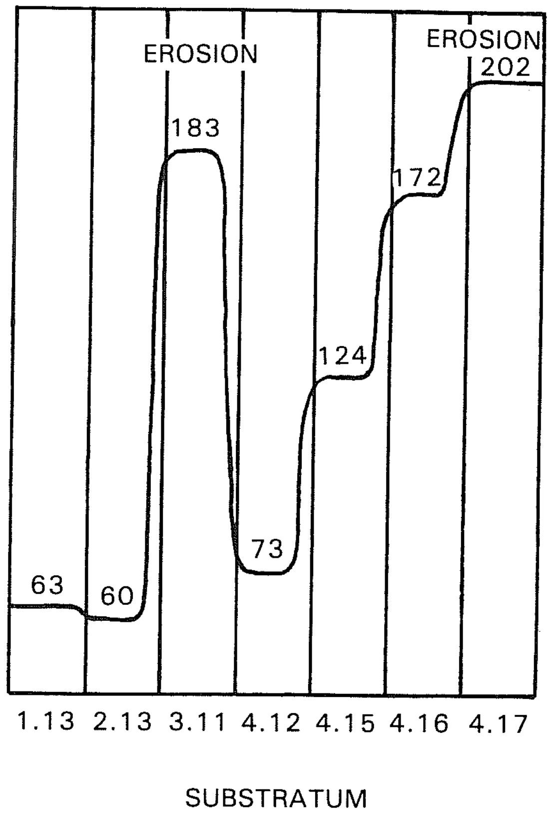


Figure 46. *Concentrations of Pebbles by Count.*

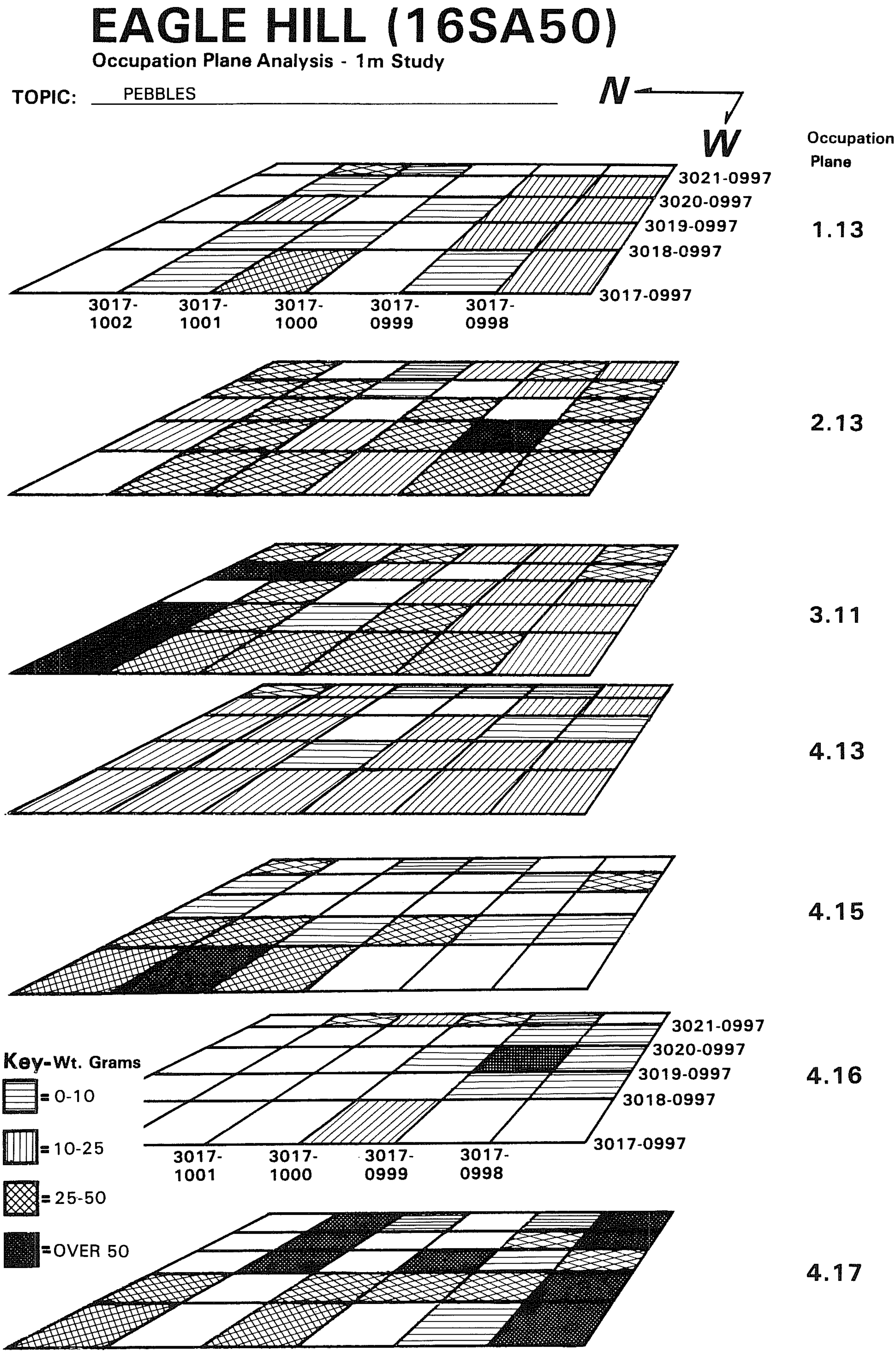


Figure 47. *Horizontal Distribution of Pebbles in Excavation.*