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TEXAS ARCHEOLOGICAL SOCIETY

The Society was organized and chartered in pursuit of a literary and scientific undertaking: the study of man's past in Texas and contiguous areas. The *Bulletin* offers an outlet for the publication of serious research on history, prehistory, and archeological theory. In line with the goals of the Society, it encourages scientific collection, study, and publication of archeological data.

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Jimmy L. Mitchell, Editor
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Cover Photographs

Reconstructions made by Betty Pat Gatliff, SKULLpture Lab, Norman, Oklahoma. For information on these reconstructions, see Glassman, Gatliff, and McGregor, *Plains Anthropologist* 34(125):223-231, August 1989. Photographs courtesy of Roberta McGregor, Associate Curator of Anthropology, the Witte Museum, San Antonio, Texas.

Front Cover: Archaic period mother and child from skeletal material recovered from the Shumla Caves, Lower Pecos Region.

Back Cover: Archaic period male from skeletal material recovered from the Shumla Caves, Lower Pecos Region.

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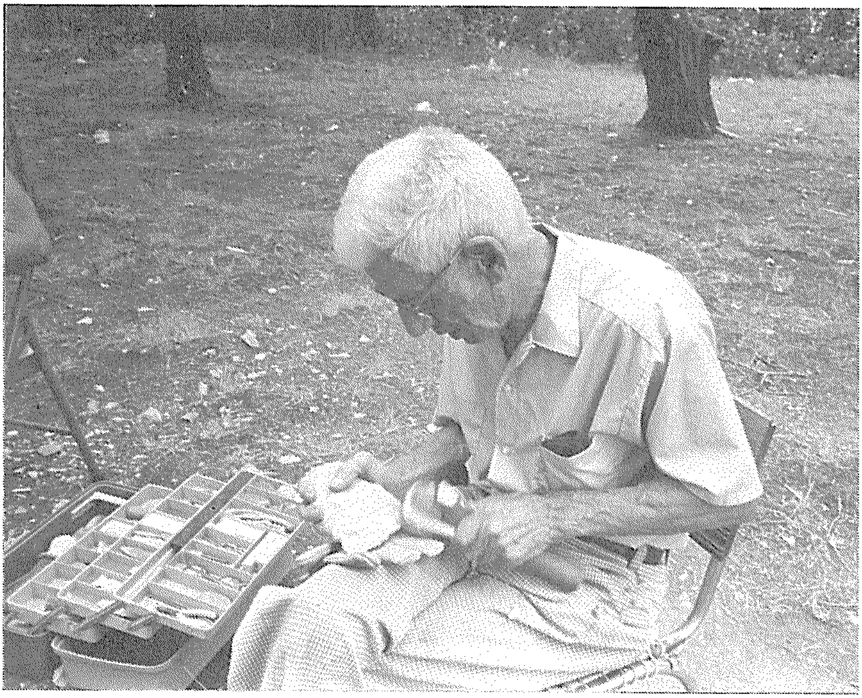


Dedication

This volume is dedicated to J. B. Sollberger of Dallas, Texas, a 28-year member of the Society who has achieved a both national and international reputation as a flintknapper ***par excellence,*** has acquired exceptional skill in the experimental replication of Paleo-Indian lithics, and has delved beyond replication to the serious study of the technology of how prehistoric American Indians controlled the manufacture of lithic tools. He has been author and coauthor of several significant archeological reports in local, regional, state, and national publications. He is fearless in his expression of his faith in the results of his systematic examination of the materials, tools, and results of prehistoric lithic processes, and is not hesitant to confront controversy. Appropriately, this volume begins with a report by "Solly" on his analysis of the techniques for producing fluted Folsom projectile points.

On Replicating Fluted Projectile Points

J. B. Sollberger

ABSTRACT

This paper is an invitation to others in experimental archeology to publish explicit details and data on the subject of how and why fluted points were made. The author believes that fluting methods evolved over time from simple to complex as Paleo-Indians filled a need for longer and longer flute scar channels. It is demonstrated that lever-controlled pressure replicates the complex, evolved form of Folsom fluting with precision and efficiency. Advocates of punch percussion fluting should support their beliefs on how full-length flutes were made with specific comparative data and examples of high-quality replications (i.e.; put up or shut up).

INTRODUCTION

For the new world, Crabtree (cf., 1966, 1968) set the American archeological community on fire by demonstrating outstanding ability to replicate stone age tools, projectile points, and blades. He described a lithic tool kit, flaking methods, and techniques. These and other contributions made Crabtree the father of modern lithic technological studies, and deservedly so. His disciples now number in the thousands; one can now even obtain college credit by attending a flintknapping course. But such courses are, by their very nature, elementary. One graduates with neither great skill nor any profound insights in lithic analysis. Such skills are developed only later, after long and diligent experience in actual flintknapping.

For accurate replication of a prehistoric artifact, much more than a basic shape is required. Errett Callahan reported that his first several hundred attempts to replicate eastern Clovis points were actually not "replications because they were too thick (1979:170)." In his early work, Crabtree (1966) maintained that he could replicate Folsom by two different methods of fluting; however, one has simply to check his published data to find that only one of his points is thin enough to qualify as an average Folsom. Average thickness of Folsom points is between 3.7 and 3.8 mm (Sollberger 1985); this implies that 50 percent of the total documented Folsoms are thinner than that standard.

Folsom Flute Scar Length

In the early (pre-Crabtree) days, the Folsom type was characterized as having two flutes that snap-terminate at about two-thirds of the point's length (I have been asked many times how one makes the flutes snap off at that percise length). All older point-type books illustrate and describe a single blunt-pointed form, widest above mid-length, as the typical Folsom point.

This stereotype ignored the fact that many Folsoms are widest across the basal corners (Suhm et al. 1954:Plate 92 and others). But, by precedent, the first to publish often sets an unalterable consensus. It is difficult subsequently to modify such stereotyping.

However, Crabtree (1966) later described the Lindenmeier Folsom as having both flutes intersect the distal end (the tip), thus forming a knife-sharp point or penetrator. Today, much of the archeological community believes that Folsom man always intended full length fluting. Judge, for example, believes that Folsom preforms were snapped off at the end of the shortest flute scar and then completed (Judge 1977). Such action would certainly require a thick distal end, and the shaping retouch would leave obvious scars within the channel faces.

In contrast, Wilmsen and Roberts (1978) provide a photograph of acute-angled distal ends of finished points that were broken off (in use?) above the fluted part. Therefore, I feel justified in asking, how long are flute scars supposed to be? To answer this we must first determine the purposes fluting served.

Why Flute?

The discovery of the association of fluted points with Ice Age animals at Folsom, New Mexico, was denied before eventually being accepted. The channel scars from fluting were first called grooves; it was widely supposed that these were "blood grooves" that were ground out to enhance bleeding to make the animal die more quickly. No one seemed to realize that to function as a "blood groove" the grooves must necessarily be in the spear shaft itself, external to the binding, and not on the stone point. Analysis of the mechanics of this weapons system made this obvious. By accurately replicating the artifacts and using them experimentally, we can begin to understand their very functional design characteristics.

After some years of replicating fluted points, I have come to believe that fluting was done for one major reason: fluting reduces the diameter of the spear shaft needed at the opening of the mounting slot for point attachment. This extends the amount of cutting edge that slices into the animal, widening the entry wound, before the full thickness of the spear shaft is encountered, increasing the depth that can be penetrated with a hand-thrust spear. On the supersized, thick-hided megafauna, repeated deep penetrations were very necessary in order to kill the animal. Men have limited strength, and their tools are designed to help overcome their limitations.

Fluting technology did not develop overnight. It takes a long time to learn the properties of the materials being used and develop the techniques for proper control of the patterns of flaking. We would expect such technology to improve over time, as long as the need for such technology remained.

Fluting Versus Basal Thinning

When archeologists discuss point technology, a common question is, "is it fluted or is it basal thinning?" I don't think we have a published rule, so I will provide one.

> When basal flaking thins the proximal end longer than the length of the hafting notch (typically with one or two, or, rarely, with three or more flakes), the point is fluted. When the hafting slot is longer than the basal thinning flake or flakes, the point is not fluted.

Pre-Folsom Fluting

We do not know how long it took the Clovis people to recognize a need for fluting and to learn how to make a flutable biface..

Could it be that as Paleo-Indians' technology progressed, they improved their methods eventually to obtain full length fluting? The channel scars on Clovis points—at least those on a majority of them—range between little longer than basal pressure-thinning flakes and half the length of the points. The evidence from mammoth-kill sites west of the Mississippi River tends to support this generalization.

East of the Mississippi, however, there are more varieties of Clovis and Clovis-like points. Eastern points with full-length flutes are not uncommon (but note that no Folsoms have been found in the eastern states).

Some authors have proposed that Clovis fluting originated in the East but I do not believe there is sufficient dating or other evidence to support the theory that fluting is earliest east of the Mississippi. However, fluting in the East probably persisted to a later date and became more diverse in the East. The shorter flutes of the western United States are probably the earlier technology.

Bonnichsen and others illustrate and describe a Moosehorn Clovis variety from Maine (Bonnichsen et al. 1983:36-48). The lengths of their specimens range between 75 and 136 mm (their Table 1), and their illustrations clearly suggest that full-length fluting was intentional.

Storck (1984:6, Figure 2) describes and illustrates a Parkhill Clovis complex in Ontario that produced Barnes type Clovis points; flute scars measuring as much as 85 mm long are reported. Cambron and Hulse (1964) describe the Cumberland Clovis points of the eastern United States as about three inches long, many of them fluted right to their tips.

In the light of such evidence, my judgement on eastern Fluting (the Cumberland, Moosehorn, and eastern Clovis varieties) is that full-length flutes were highly desired and are the most well developed form. These point types are, therefore, probably more recent than western Clovis fluting by at least a few hundred years. They could have been produced only after technological advances that made full-length fluting consistently achievable.

The technological advantage of full-length fluting is simply this: fluting right to the tip thins the projectile tip to a razorlike edge. Such tip-thinning reduces the resistance to entry by reducing the bifacial friction encountered while cutting the slot of entry wide enough for the attached spearshaft to enter. This results in greater hunting efficiency and, therefore, is a constructive adaptive change.

Paleo-Indian Versus Archaic and Late Prehistoric Technology

At the end of the ice age, as the large, slow megafauna gave way to smaller, quicker game animals, fluted lanceolate points evolved first into points with stem constrictions, then shouldered points, then quite wide corner-notched and basal-notched projectile points. These were probably adaptive changes, not just stylistic ones. Megafauna such as mastodons required more than six inches of penetration to reach vital organs; they were hunted less and less as their numbers diminished until they became extinct. Smaller game such as deer and antelope move too fast for repeated thrusting. The two-man thrust spear gave way to the atlatl and thrown darts. Darts lengthened the hit range but, being longer, had to be of lighter weight. Hunters learned to get penetration to vital organ depth by cutting a wider slot at the point of entry. The wider wound, that is, the wider slot-cut at entry, opened easily for the shaft entry following .

A simple analogy would be to take a steel needle and a thick hide or canvas. Push the needle through half or more of its thickness, then try to pull it through from the other side. The friction of the round, tight hole makes it very difficult to pull the needle through. Now, take a sharp edge and cut a slot at the point of entry; the needle goes through with very little force, since the slot lets it almost fall through. Such a slot, cut by a wide-shouldered or corner-notched Archaic projectile point hitting with some force, allows deep penetration of the projectile point and its attached foreshaft, resulting in more efficient hunting of fast-moving wild game.

Eventually, the bow and arrow came along as another major technological innovation. The high-velocity arrow, with its flatter trajectory, is much more accurate than a thrown spear, and, with higher velocity and smaller shafts, hunters could get substantial penetration. Again, the weight of the point was substantially reduced in a tradeoff for greater hunting efficiency; a hunter could carry many more arrows than he could the heavier atlatl darts with their fore- and mainshafts. He could shoot from ambush before the game or enemy saw him.

PRESSURE VERSUS PERCUSSION FLUTING

The challenge for modern flintknappers to replicate examples of aboriginal fluted points has motivated a great deal of experimentation and generated a great deal of literature. Efforts have been centered on finding *the* method by which aboriginals fluted their points. Many of the published reports claim success, but illustrate only mediocre results. Most agree that some form of percussion is required for true replication. The words *true replication* have become a subterfuge to forestall constructive criticism.

The process of replication has two inherent, inseparable parts:

1. The tools and manufacturing processes should be like those of the aboriginals.

2. The product must equal in every respect the quality of the original.

Part 1 has been adhered to by hardly anyone working in the field of lithic technology, so part 2 is all that is left. The proof of a pudding is in the eating, so, if part 2 is obviously a failure, the replicated tool should be rejected, and there is no need to invoke part one.

In lieu of the more popular percussion fluting, I have used fork-and-lever pressure fluting since about 1966. Every reaction I have had from professional and avocational archeologists (other than Bruce Bradley and Errett Callahan) has been, "I prefer percussion" or "Indians would not have used such a device."

Many percussion fluting advocates have chipped flint as long as I have. Where are their Folsom, Cumberland, and Barnes Clovis points of acceptable thinness and length, with each flute extending right to or nearly to the tip? The longitudinal section between the channel scars at the very tip should be straight, thin, and centered. The thinness of the tip proves that overshot or end-snipping corrections were not needed to complete the point. The better examples of Cumberland, Folsom, and some specialized Clovis have converging channel scars (Crabtree 1966). With pressure fluting, I have made dozens of all these types, in all of which the channel scars do converge exactly as Crabtree suggests.

Why is pressure fluting held in disdain? It is generally accepted by most lithic technologists that in the beginning there was only percussion flaking. Flint is a tough stone, and most strong men can consistently produce only flakes of less than 2.5 cm by pressure flaking. The first people to publish work on lithic technology shared this belief; they are cited and quoted, so a general consensus has been created that, unfortunately, is treated as proof.

One of several possible examples is the work of H. Holmes Ellis (1965), who attempted experimental lever flaking and came to the conclusion that "this procedure is unsuitable and awkward to use (Ellis 1965:22)." In a later section "Lever and Fulcrum," Ellis finds that the method "has many limitations" and "only small flakes can be removed (Ellis 1965:39-41)." I find, however, that Ellis is wrong on lever flaking and misleading on other techniques (such as those illustrated in his figures V, VI, XI, XII, XVIII, and XX). No knapper can trap the dorsal face of his flakes against a solid stone anvil and be successful.

There is a moral to the Ellis work and similar reports. It is, don't necessarily believe what you read or hear. Believe what you can see and do for yourself. Do not join the concensus blindly; open your eyes and demand proof.

In the 1960s, I devised the fork-and-lever flaking method for bifacing and fluting (Sollberger 1978). The late Joel Shiner observed my work and remarked that "your use of the copper lever invalidates your work," so I then switched to antler levers and found not only that my fluted points were acceptably thin (by aboriginal standards) but also that my success-failure ratio was greatly improved (Sollberger 1985). This outcome was the opposite of what Shiner predicted.

It can be neither proven nor disproven that lever fluting was used in the past. The unwavering support of a consensus that lacks good empirical evidence is, however, simply insisting that subjective voting can produce correct results.

We moderns are surely at least equal to people of 10,000 years ago in cognitive abilities and flintknapping skills. It follows then that the quality of our replications should be equal to or exceed the quality of their best work. Judging from most efforts, however, I can find only poor and mediocre replications when the force to obtain long flutes was compression fluting by a punch.

However, by using lever pressure fluting I can match some of the better works of Paleo-Indian era flintknappers (Figure 1). Flute flakes in excess of 130mm long and 9.0 mm wide offer no problem to pressure fluting when a lever is employed to control the flaking.

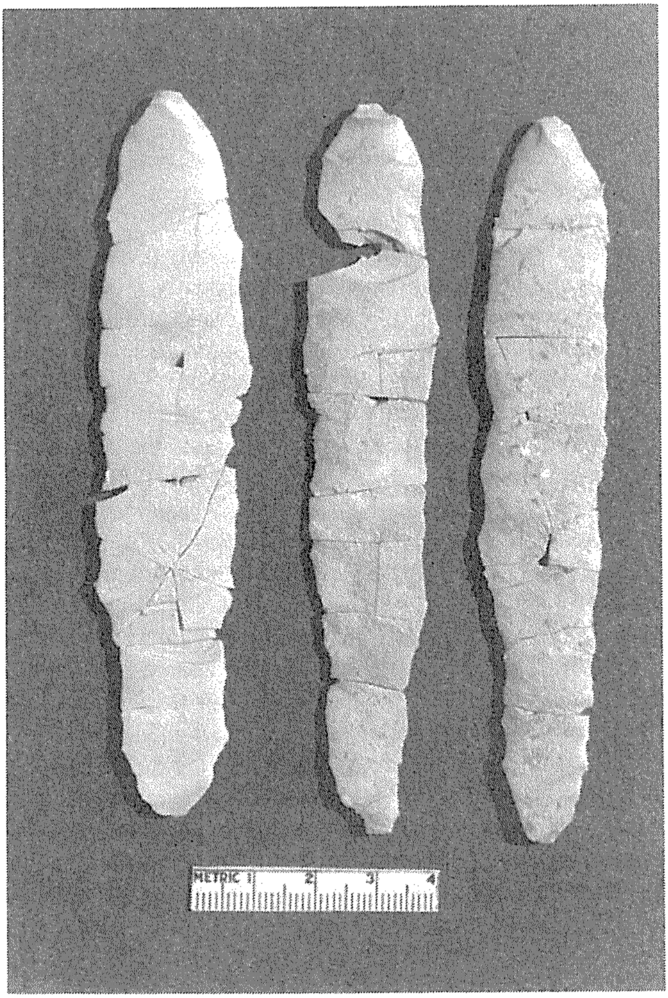


Figure 1. Three pressure flutes from the author's replications; long, wide, full preform-length channel flakes. The wide one is 114.55 mm long. Note that the long flutes always detach in three or more pieces.

Length Versus Thickness

Experimental archeologists searching for replicative methods and techniques often claim (or imply) success while ignoring comparative data (i.e., aboriginal points) on thickness and length. For an example, see Boldurian, Fitzgibbons, and Shelly (1985:293-303 their Tables 1 and 2). To consider that their one finished point (their Figure 5) replicates a freshly completed Folsom-man projectile product requires a great stretch of the imagination. The Boldurian report wrongly stresses the inherent ineptness of clamp-and-lever pressure fluting. Their Table 1 provides a mean length of 55.5 mm, maximum thickness of 11.0 mm, and weight of 18.9 g, giving a length-to-thickness ratio of 5.045.

For comparison, I recently weighed the first five points from a tray of my clamp-held, lever-fluted replications to find that the five totaled no more than 19.0 g, and averaged about 3.8 g. The ten flute scars at mid-length averaged 13.57 mm wide. Each of the ten flutes terminated at the tip. The average maximum width was 20.35 mm, mean length was 45.32 mm, and average maximum thickness was 3.0 mm, giving a length-to-thickness ratio of 15.10:6. The Folsom length-to-thickness ratio for aboriginal specimens is about 11.29:1 (Sollberger 1985:47), demonstrating that, at this time, pressure fluting appears to be producing results closer than percussion to the attributes of aboriginal specimens.

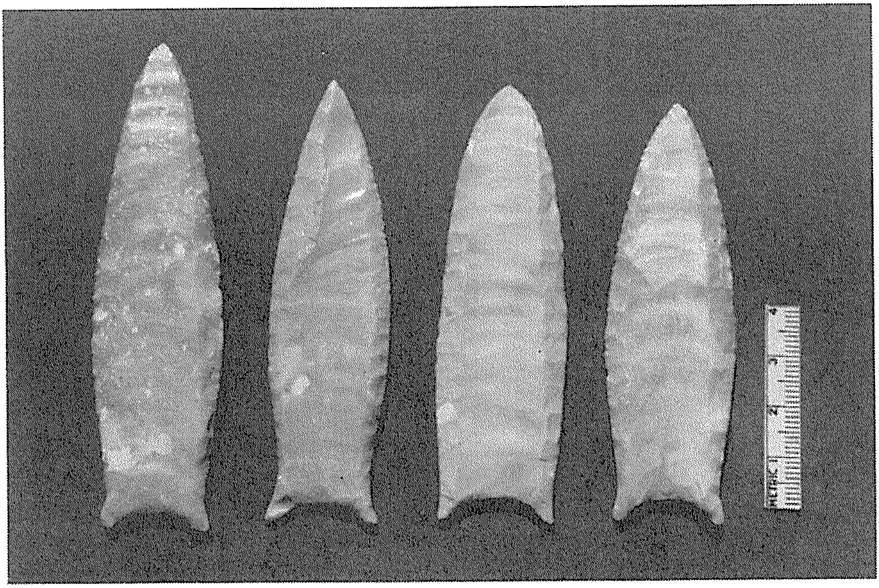
Sharp, Centered Distal End Tips

The full-length fluting of eastern Paleo-Indian projectile types (such as Cumberland), suggests a highly developed fluting technology. In fact, such full-length fluting may be by itself a sufficient indicator of more recent dates for such specimens (radiocarbon dating may not be needed, except as an independent verification of this hypothesis). It is my view that such point types have been produced only since the advent of technological developments that included vertical preform clamping with lever-assisted pressure flaking (on this point, see E. L. Davis [1978] on the evolution of fluting at China Lake, California).

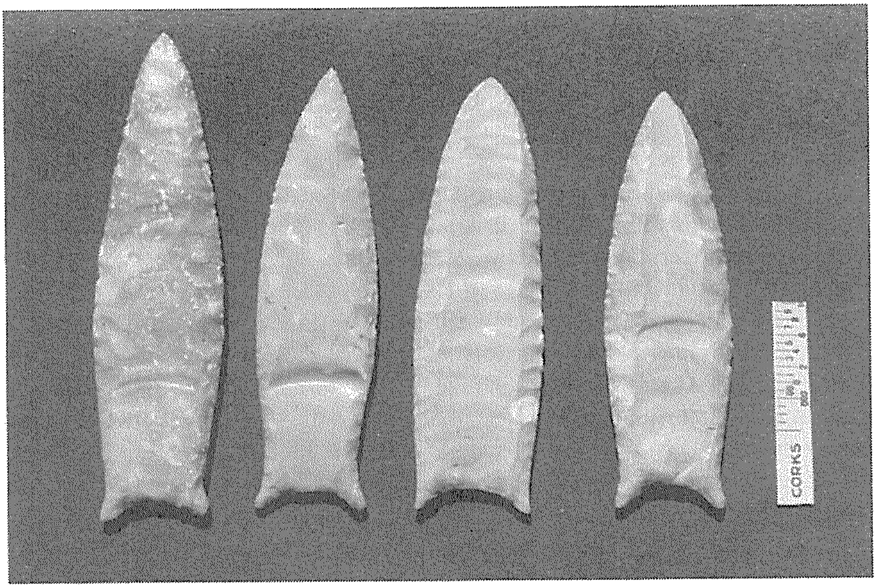
A basic intuitive understanding of fracture mechanics (which we today know as Hooks Law) is all that is required. With that, any competent knapper can produce both flutes with constant, even thinning, without *outrepasse,* to a sharp, centered, distal end tip. Heat treatment is not required (Figure 2).

The maximum thickness of any projectile point is the width of the slot it will pass through. For percussion fluting advocates, if a point will not drop through a 4.0 mm slot, the replication does not qualify as a Folsom.

Clovis points of the northeastern United States and Ontario, Canada have deeply concave basal configurations compared to the shallow-base western Clovis (Figure 3). The very short distal end flake scars outside the channel faces show that the fluting made these ends very thin. None of the preform faces were chipped to have strong flute-guiding ridges.

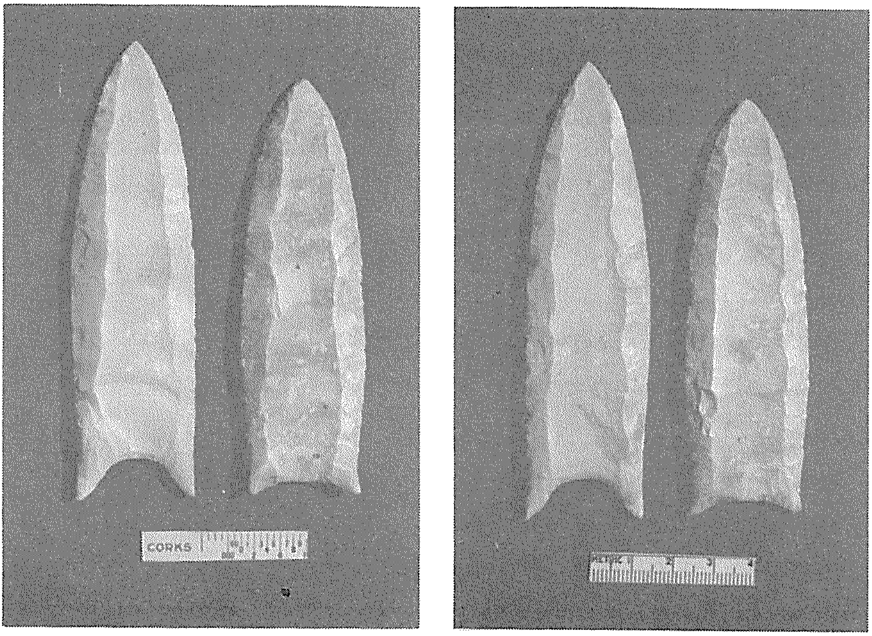


Obverse



Reverse

Figure 2, Obverse (above) and reverse (below) photographs of replicated Cumberland Clovis points, on which the flutes on both sides intersect the light grinding to the sharp-edged distal ends of the preforms. All of these specimens were made by lever pressure fluting. The longest one is 97 mm long, the widest, 24.0 mm wide, and the maximum thickness is 5.9 mm. The third from the left is 87 mm long, 25.7 mm wide, and has a maximum thickness of 5.0 mm.



Obverse Reverse

Figure 3. Photographs of replicated Clovis points showing the difference between eastern Clovis (deep basal concavity at left in each photograph) and western Clovis (shallow basal concavity, at right in each photograph). The western style illustrated the shortening of basal corners in setting up the second fluting platform.

Well-developed guiding ridges, as are found on Eden points, are not safe to use except for long, narrow points, such as Cumberland. Note that on the longer point (Figure 3, reverse face, left edge), the preform volume is abruptly increased at a snapped-off bifacing flake. This suggests that the small volume increase added sufficient resistence to the leading edge of compression to slow it down while the then-freed length of fracture was still being opened to widen the flute flake crack above. The widening of the crack formed a secondary compression (Sollberger 1986:101-105) within the flute flake at and along the fracture front. The combined load of the flaking tool and secondary compression required that a new and deeper tension formation direction (to support further fracture propagation) must come from the flute flake side of the fracture front.

The result was certainly the undulation trough you see extending across the channel flake scar. The depth of that trough was limited by the fact that when the compression front passed through the volume increase noted (the snap-break) it accelerated, in that the volume reduction concomitantly speeded up the closely following fracture front, which was as the trough deepened. Had the volume beyond not reduced, an *outrepasse* (or reverse hinge fracture) would have divided the preform into two pieces. The shallow and deep basal concavities (Figure 3) will be discussed later.

We must try to recover the traditions of stone age flintknappers through carefull documented experimentation. The full-size shop drawings I make (Figure 4) can be extremely valuable in that search, for they reveal many facts about the reaction of lithic materials to the flaking forces the flintknapper uses, eventually telling us what the correct longitudinal and cross sectional contours must be relative to flute length, width, and fluting platform strength.

Sept 26, 87. Barnes type Clovis. Contour configuration.

Pedernales flint: 580^0 F. Held- 2 hours.

Preform: 135.0 x 32.0 x 10.70 mm max thk.

First flute: 130.0 x 19.25mm wide. 5.mm short of tip.

Second flute: 126. mm lg, exactly to tip.

Completed lght: 130.0 x 31.5 x 7.5 mm between flute ridges.

Final retouch: basel concavty and distal tip.

lght/thk ratio 17.34: wd/thk 4.20

Remarks: First channel face is featureless. Second has force line marking onset of secondary compression at bulbar end. Accept template as-is.

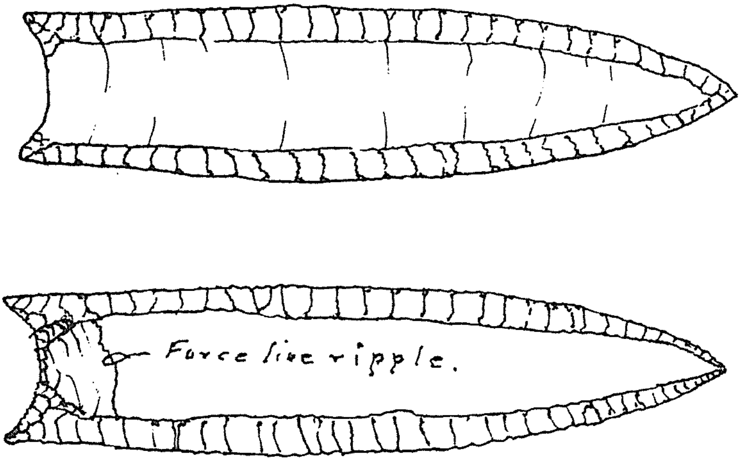


Figure 4. A shop drawing entitled "Fluting results from preestablished preform contours," made by the author for an individual replication specimen

BASIS FOR FLUTING TECHNIQUES

Fluting projectile points is the art of blade-making on specialized cores. Fluting platforms are necessarily more delicate than platforms for blades. It takes about the same interval of time for the fracture of either to travel because the contouring flakes that size the flute for width and thickness originate from lineal edges. The Levallois percussion technique was refined by New World Paleo-Indian craftsmen who fluted points by the addition of pressure flaking to reduce the prominence of the percussion flake scar ridges. This was done to straighten the flute's lineal edges, which, in turn, straightened the swells and lows of the fracture down the length of the ventral face.

Percussion-blade success rises with the addition of weight to the core, because weight adds thickness and reduces the core rotation and deflection caused by the impact. Increased thickness of the core relative to blade thickness reduces distortion of the core mass by the percussive instrument in proportion to the cross sectional area of the blade being struck.

The core for fluting is a biface that is much thinner and lighter than a blade core. Percussion fluting distorts and literally bends the biface core because the amount of flaking force cannot be reduced. so light-weight blade cores and bifaces must be held in a vice or clamp to prevent rotation and deflection in order to have a success ratio sufficient to sustain an industry. Deflection of the core reduces or eliminates the flaking force. Rotation, from its very onset, constantly changes the correct angle of applied flaking force to excessive and more so, resulting in more and greater failures. The human hand cannot hold a preform against deflection and rotation nearly as well as can a simple leather-padded clamp applied to the preform's lineal edges.

The need for fluting was predicated on the premise that the deeper the penetration, the faster an animal was immobilized. Deeper penetration was first accomplished by basal thinning, which reduced the hafting diameter restriction. With some apparent success came further modifications; basal thinning gave way to short flutes and, eventually, to full-length flutes. Each modification resulted in increased penetration and stronger hafting, while reducing the thrust energy requirements. Each gain, however, also increased manufacturing constraints. The longer flutes increased the losses to manufacturing failure. The introduction of pressure fluting eventually must have replaced percussion, since lever pressure allowed the use of minimal force with its superior advantages.

We have an analogy with modern weaponry. Shotguns and rifles at first had very large calibers. Big-bore weapons gave way to smaller calibers, flatter trajectories, and increased velocities as technology developed As stone age man learned and developed his technology, so modern man has also progressed.

From the onset of fluting until the development of classic Archaic dart point types, the hallmark of the Paleo-Indian projectile point flaking patterns is extensive pressure-flaking laid over percussion. Paleo-Indian points have a smooth, molded feel to them. On less well made pieces, the channel scar lineal edges weave in and out, and the channel scar faces wave up and down according to preform thickness changes in length, width, or surface. A minor volume change in the flute flake as it lengthens causes ripples, a larger change causes undulations, and an excessive change results in a manufacturing failure. If the flaking force is reduced in time over the fracture length, the fracture deceleration produces ripples at distal ends. Lever pressure fluting provides a constant force throughout, whereas percussion provides a faster fracture in addition to the greater distortions produced by the force required for fracture length. That is why, for example, pressure blades can be much more uniformly flaked than can percussion blades (Crabtree 1978; Sollberger 1983).

MANUFACTURING TECHNIQUES

Fluting is a specialized type of blade making. A more precise fluting platform is needed because the more fragile biface core is used.

Fluting Procedures

It is necessary to isolate a nipple to serve as the fluting platform. First, one must bevel-shorten the base so the desired flute will not become thicker below the nipple; if it thickens, it will result in an overshot. A low spot less than straight below the nipple will snap-break the flute short.

To form the nipple, start small flakes at the beveled edge of each basal corner, with the force directed toward the lineal edges (not towards the distal end). As the midwidth is approached, make the flakes longer, so a parallel-sided column is achieved. Next, turn the preform over and thin the backside to a sharp edge, which must be carefully ground to the proper thickness—this thickness determines the thickness of the resulting flute flake.

You now have your first fluting platform, but it needs to be very critically examined. The backside should be flat, and this flat side should be parallel to the preform width center plane. The fracture should instigate well above the center plane of thickness. Even for a very long flute, the arc of instigation should be no wider than 3 mm and its thickness no greater than about 2.5 mm; for small points like Folsom, these measurements should be even smaller. Lastly, the longitudinal face below the nipple face must be only lightly convex for about two-thirds of the desired flute length. If such conditions are not present, the preform will have to be remodelled. If it passes inspection, then the flute can be made.

The second platform is much the same. Reverse the bevel by flaking into the first channel face. Then reverse that bevel to leave a centered, exposed column, the backside of which is the channel scar face of the first flute. It is important to form an offset to separate the fluting column from the prior flute face in order to locate the second flute instigation. This thinning of the column is done by pressing off a flake from each lateral margin of the fluting column. The direction of force for each thinning flake should be toward the opposite lateral margin of the preform. Grind the second nipple and subject the preform to the same critical examination as you did for the first flute. If it does not conform, remodel by shortening the preform; the result will be a very deep basal concavity after making the flute.

Following the second flute, only minor retouch at the tip and within the basal cavity is required. It is pure nonsense to suggest that preform distal tips have to be left thick and wide and that they were heavily ground to support the fluting force. In fact, in my opinion, the Cumberland type in particular and other types where the objective is full-length fluting to thin the tip cannot be so fluted from preforms left wide or thick at the distal end. Convincing proof is lacking for this hypothesis, but if you believe otherwise, please publish your proof.

Some Observations

Bifacing is a reduction system. A "bad" flake cannot be replaced. A quickly made point usually is nothing to be proud of. A five-hour fluted point usually is more than satisfactory. A fraction of a millimeter becomes important, and is an important tolerance in fluting. Later "Plano"-Indian point makers gave up fluting for thicker, heavier lanceolate and stemmed forms more suitable for atlatl dart points. No stone age or modern man always uses perfect stone, always has the right tool kit, or always experiences reduction success. Therefore, we often take what we can get.

In order to reconstruct Paleo-Indian lifeways involving the making of stone tools, logical analysis alone is not enough. We must have and use a common knowledge of the reaction of lithic materials to flaking forces. Only then can archeologists agree and raise lithic analysis to its greatest possible potential (see Sollberger 1986:101-105).

With such knowledge and experience, you can look at fracture ventral faces and interpret fracture feature formations such as radius of the ring arc, the extent of lipping, the angle and depth of bulbar flare, the onset of acting secondary compression, causes for undulations and ripples, tear lines, fracture most advanced centrally or lateraly or shifting between the margins, the cause for thickening or thinning wave planes, snap breaks, diving flakes, and the various kinds of hinge fractures as opposed to lengthwise or crosswise overshots.

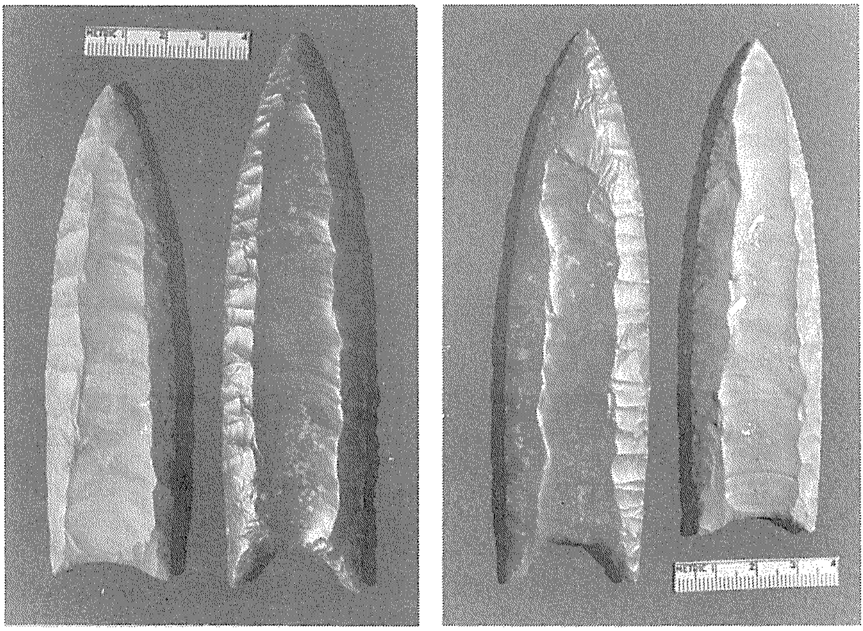
If fracture feature formations cannot be explained under a noncontradictory fracture theory, the hypothesis is wrong, and the analysis is probably also wrong.

In fluting industries, preforms were made to conform to the standard of tradition and were given critical analysis. If the preform was too thin to flute, the knapper did not try. If only one face was flutable, he took one flute. When the eye of the knapper predicted failure with a single flute, he made two or more thin, narrow flutes from the same face lateral to each other. The term for that is *multiple fluting*.

Boldurian and his co-workers extended that terminology to include the taking of a second flute from directly below the first attempt (which certainly must have aborted in order to make a need for the second). The term multiple fluting should not be used unless the flutes are side by side and overlapping; where the knapper took this approach to completing the piece.

Examples

Following are some illustrations of the kinds of results that can be achieved with preform clamping and controlled lever pressure fluting. In the first (Figure 5, obverse and reverse), only one of the four faces has the flute right to the tip; this is a function of combined platform strength and longitudinal convexity of the preform.



Obverse

Reverse

Figure 5. Obverse (left) and reverse (right) views of replication, showing how early flute snap breaks from buckling shorten the flutes. Uneven faces cause lateral turns.

Another point (Figure 6, left) is a good example of a channel scar forming free of ripples, undulations, and other problems. Such a specimen is the result of good preforming of facial surfaces, plus the benefits of preform clamping and controlled lever pressure flaking.

CONCLUSIONS

I have researched fluted point cultures from Clovis times onward; groups who produced full-length channel scars on their points that are directly comparable to the channel scars on the replications illustrated in this report. All of these experimental examples are the result of lever pressure fluting with the preforms held vertically in split-limb grooved clamps. Several ethnographic reports suggest such a technique, but modern practitioners and most of the archeological community have rejected it. Most modern replication experiments

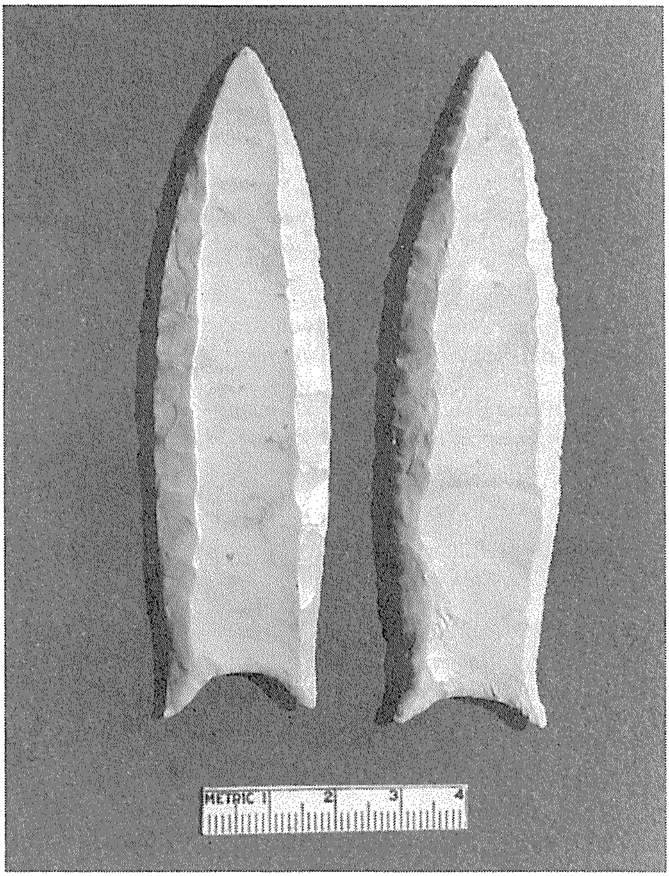


Figure 6. Two replications. The specimen on the left shows how near-perfect contours plus pressure force result in an undulation-free, ripple-free flute, with channel scars right to the tip of the point.

have been done with indirect percussion. I fail to find in the archeological literature any proof that such percussion fluting is equal to or better than the "better" work of Paleo-Indians.

If the prevailing hypothesis for indirect percussion fluting is correct, it should be demonstrated with empirical evidence that equals the "better" specimens left by stone age flintknappers. Where is the evidence? Only when such evidence is published will we be in a position to say that the Indians would or would not have used pressure by lever-assist to gain the necessary force for controlled fluting. My own experimental work has convinced me in this case, but I am open to examining the work of others. One last caveat however—a rebuttal to be valid must be accompanied by evidence. Flutes must have the overall thinness of aboriginal specimens—right to the tip.

REFERENCES CITED

Boldurain, A. T., P.T. Fitzgibbons, and P. H. Shelly

1985 Fluting Devices in the Folsom Tradition: Patterning in Debitage Formation and Projectile Point Basal Configuration. *Plains Anthropologist* 30:293-303.

1986 A Reply to Sollberger and Patterson on experimental Folsom Biface Manufacture. *Plains Anthropologist* 31:245-248.

Boldurain, A. T., G. A. Agogino, P. H. Shelley, and Mark Slaughter

1987 Folsom Biface Manufacture, Retooling, and Site Function at the Mitchell Locality of Blackwater Draw. *Plains Anthropologist* 32:299-310.

Bonnichsen, Robson, Bruce Bourque, and D. E. Young

1983 The Moosehorn Fluted Point Discovery, Northern Maine. *Archeology of Eastern North America* 11:37-48.

Callahan, Erret

1979 The Basics of Bifacing Knapping in the Eastern Fluted Point Tradition. *Archeology of Eastern North America* 7(1).

Cambron, J. W., and D. C. Hulse

1964 *Handbook of Alabama Archeology* Part I, edited by David L. Dejarnette, The Archeological Research Association of Alabama.

Crabtree, D. E.

1966 A Stoneworkers Approach to Analyzing and Replicating the Lindenmeier Folsom. *Tebiwa* 9(1):3-39.

1968 Mesoamerican Polyhedral Cores and Prismatic Blades. *American Antiquity* 33(4):446-478.

Davis, E. L.

1978 Associations of People and Rancholabrean Fauna of China Lake, California. *Early Man in America from a Circum-Pacific Perspective.* Edited by Alan Lyle Bryan. Occasional Papers No 1 of the Department of Anthropology, University of Alberta, Edmonton.

Ellis, H. H.

1965 *Flint-Working Techniques of the American Indians.* Ohio Historical Society, Columbus.

Judge, J. W.

1973 *Paleoindian Occupation of the Central Rio Grande Valley in New Mexico.* University of New Mexico Press, Albuquerque.

Suhm, D. A., A. D. Krieger, and E. B. Jelks

1954 An Introductory Handbook of Texas Archeology. *Bulletin of the Texas Archeological Society* 25.

Sollberger, J. B.

1978 Lever Flaking As a Credible Alternative to Hand-Held Pressure Flaking. *Flintknappers Exchange* 1(1) 6-7 and 1(2) 25.

1985 A Technique for Fluting Folsom. *Lithic Technology* 14(1)41-50.

1986 Lithic Fracture Analysis: A Better Way. *Lithic Technology* 15(3) 101-105.

Sollberger, J. B., and L. W. Patterson

1983 A Pressure Method for Microblade Manufacture. *Lithic Technology* 12(2)25-31.

1986 Comments on Folsom Fluting Experiments by Boldurian et al. *Plains Anthropologist* 31(113):241-244.

Storck, P. L.

1984 Research into the Paleo-Indian Occupations of Ontario: A Review. *Ontario Archaeology* 41:6.

Wilmsen, E. N., and F. H. H. Roberts, Jr.

1978 Lindenmeier 1934-1974. *Smithsonian Contributions to Anthropology* No. 24.

J. B. Sollberger, Archeologist and Flintknapper

Leland W. Patterson

The work of J. B. Sollberger, known to his many friends and associates simple as "Solly," has been familiar for many years to people engaged in archeology in Texas. His career as an avocational archeologist spans several decades. Solly is known for work in Texas prehistoric archeology and for research in experimental flintknapping. His work has been published in several journals, including *American Antiquity, Plains Anthropologist, Lithic Technology, La Tierra* (Journal of the Southern Texas Archaeological Association), *The Record* (publication of the Dallas Archeological Society), and the *Bulletin of the Texas Archeological Society.*

Solly was born in 1914 in Dallas, Texas, where he graduated from high school in 1932. He became a plumber in Big Spring, Texas and, in 1935, married Anna Stohacker, of Kerrville, Texas. In the 1930s he explored several sites in South Central Texas, and his earlier archeological publications focus on this region. During World War II, from 1942 to 1945, he served in the Army Air Corps. Subsequently, he has been a long-time resident of Dallas, as his backyard lithic workshop attests. He retired in 1977 after having been involved in the construction of steam-generated electric power plants, primarily in the Dallas region. Solly has been a long-time member of the Texas Archeological Society, the Dallas Archeological Society, and is a founding member of the Southern Texas Archaeological Association.

One thing that most distinguishes Sollberger is his ability to share his expertise with others. He has taught several generations of Texas flintknappers and has given many lectures and demonstrations on lithic technology. He also has been author or coauthor of more than 50 publications and has provided technical advice on lithic technology for projects of other individuals.

Solly has been engaged in archeological activities in South Central Texas since 1934. He has surveyed and studied the prehistory of this region and has shared his ideas in both published and verbal form. Typical of his publications are site reports (Sollberger 1948, 1949, 1950), naming of the Edwards arrowpoint type, initial postulation of the Turtle Creek phase of South Central Texas (Sollberger 1967; see also *La Tierra,* Volume 4, No. 4, October 1978), and thoughts on the Late Paleo-Indian/Early Archaic transition in South Central Texas (Sollberger and Hester 1972).

Some of his other publications on the archeology of Texas are a study of an animal effigy (Sollberger 1978), comments on the possible functions of Guadalupe tools (Sollberger and Carroll 1985), and general reflections on the science of archeology (Sollberger 1982, 1987).

Sollberger is well known and respected for his general archeological activities, but he has also earned fame as an experimental flintknapper. He is recognized as a Master Knapper in both North America and Europe and was recently honored as a recipient of the annual Don Crabtree Award of the Society for American Archaeology. Solly once said he got started in flintknapping after watching someone make a simple unifacial scraper, and once he had the "bug," there was no stopping his drive to become one of the best flintknappers of this era.

One of Solly's strong points is that he is a very astute observer of fracture patterns in knapped material. This has allowed him not only to perfect his knapping techniques, but also to make contributions to fracture theory (Sollberger 1986). He is also an innovator of knapping techniques, seen in his development of unique pressure methods for controlling the fluting of Folsom point replicates (Sollberger 1985: Figure 1; Sollberger and Patterson 1980: Figures 2 and 3; Sollberger, elsewhere in this volume).

Solly constantly works to improve his flintknapping techniques. I once gave him a cast of a Lindenmeier site Folsom point with a thickness of 3.1 mm. At the time, Solly's Folsom replicates averaged about 3.9 mm in thickness. The extreme thinness of the Lindenmeier site point became Solly's new goal, and shortly afterwards the average thickness of his Folsom replicates was no more than about 3.2 mm.

Sollberger has taught many individuals the science and art of flintknapping and has given many demonstrations of his knapping skill to university groups, regional and local archeological groups, and the public. He is one of the founders of the Texas Knap-Ins, which serves as a focal point for experimental flintknappers in this state. Solly is never too busy to give advice to someone who wants to learn more about flintknapping. He has served as a reviewer for the journal *Lithic Technology* and has done replicate experiments in flintknapping for several professional archeologists, one of which involved replicating methods of Maya tranchet tool production (Shafer 1983:60).

Sollberger's publications on flintknapping cover subjects such as prismatic blade manufacture (Sollberger and Patterson 1976), thermal alteration of siliceous stone (Sollberger and Hester 1973), and lithic tool kits (Sollberger 1969). His report on the technology of Plains Indian beveled knives (sometimes called Harahey knives) is a classic reference (Sollberger 1971).

J. B. Sollberger is well known for his contributions to Texas archeology and to lithic technology. Even more, however, he is known to his many associates as a good friend and advisor. His work typifies what the best serious avocational archeologists are contributing to the science of archeology.

REFERENCES CITED

Shafer, H. J.

1983 The Tranchet Technique in Lowland Maya Lithic Tool Production. *Lithic Technology* 12(3):57-68.

Sollberger, J. B.

1948 Lamb's Creek Mound. *The Record,* Dallas Archeological Society 8(1).

1949 A Prehistoric Rockshelter in Kerr County, Texas. *The Record* 8(3).

1951 Three Sites in Atascosa County, Texas. *The Record* 9(3).

1967 A New Type of Arrow Point with Speculations as to Its Origin. *The Record* 23(3).

1969 The Basic Tool Kit Required to Make and Notch Arrow Shafts for Stone Points. *Bulletin of the Texas Archeological Society* 40:231-240.

1971 A Technological Study of Beveled Knives. *Plains Anthropologist* 16(53):209-218.

1978 An Animal Effigy from Kerr County, Texas. *La Tierra,* quarterly journal of the Southern Texas Archaeological Association, 5(3):20-21.

1982 Reflections. *La Tierra* 9(2):43.

1985 A Technique for Folsom Fluting. *Lithic Technology* 14(1):41-50.

1986 Lithic Fracture Analysis: A Better Way. *Lithic Technology* 15(3):101-105.

1987 Archaeology: A Definition. *La Tierra* 14(4):38-39.

Sollberger, J. B., and W. B. Carroll

1985 Guadalupe Tools: Were They Used for Defleshing Hides. *La Tierra* 12(1):18-22.

Sollberger, J. B., and T. R. Hester

1972 The Strohacker Site: A Review of Pre-Archaic Manifestations in Texas. *Plains Anthropologist* 17(58):326-344.

1973 Some Additional Data on the Thermal Alterations of Siliceous Stone. *Bulletin of the Oklahoma Anthropological Society* 43:33-65.

Sollberger, J. B., and L. W. Patterson

1976 Prismatic Blade Replication. *American Antiquity* 41(4): 517-531.

1980 Attributes of Experimental Folsom Points and Channel Flakes. *Bulletin of the Texas Archeological Society* 51:289-299.

The Prehistoric Legacy of the Lower Pecos Region of Texas

Harry J. Shafer

ABSTRACT

The Lower Pecos River region of Texas stands out as an archeological district because of its arid environment, deeply incised canyons, many overhangs suitable for human occupation, preserved perishable materials in the dry archeological deposits, preserved rock art, and long culture history. These factors have provided an extraordinary opportunity for archeologists to define an ancient cultural system with a precision rarely possible in archeology. Progress has been made toward defining and modeling the ancient ways of life and explaining the functions of specific kinds of sites within the system. Combined interdisciplinary studies have provided insight into the ancient Lower Pecos cultures to a degree unmatched in southern North America.

INTRODUCTION

This paper provides an overview of the archeology of the Lower Pecos Region, a brief description of the environment and a model of the cultural system (the prehistoric chronology of the region is described elsewhere in this volume by Thomas R. Hester).

The Lower Pecos Region of Texas and northern Coahuila, Mexico, is where the Pecos and Devils rivers join the Rio Grande (Figure 1). The region includes all of Val Verde County and extends about 160 km (100 miles) westward to the Marathon uplift; it incorporates Sanderson and Dryden canyons, all of Terrell County, the eastern part of Brewster County, northern Pecos, Crockett, and Sutton counties, and is bordered on the northeast and east by the Devils River watershed. The region also encompases the adjacent part of northern Coahuila, Mexico, for a distance of about 50 km.

The major types of prehistoric sites are rockshelters, caves, and open-air sites. The uses of these sites often differed, but there was some functional overlap. For example, people lived in both rockshelters and open-air sites; open-air habitation sites include alluvial terraces along the streams as well as upland surfaces subjected to erosion. Burial sites include caves and rockshelters, and rock art is protected by the overhangs of rockshelters. Most burned rock middens are in open-air localities, but some are in rockshelters.

There is also a strong overlap in the kinds of material remains recovered from the various kinds of sites. The greatest difference among the sites in kinds of material remains recovered is in the perishable inventory from dry rockshelters. When the region's unusual preservation capacity is considered, one can see why it is possible in the region to examine the ancient ways of life in greater

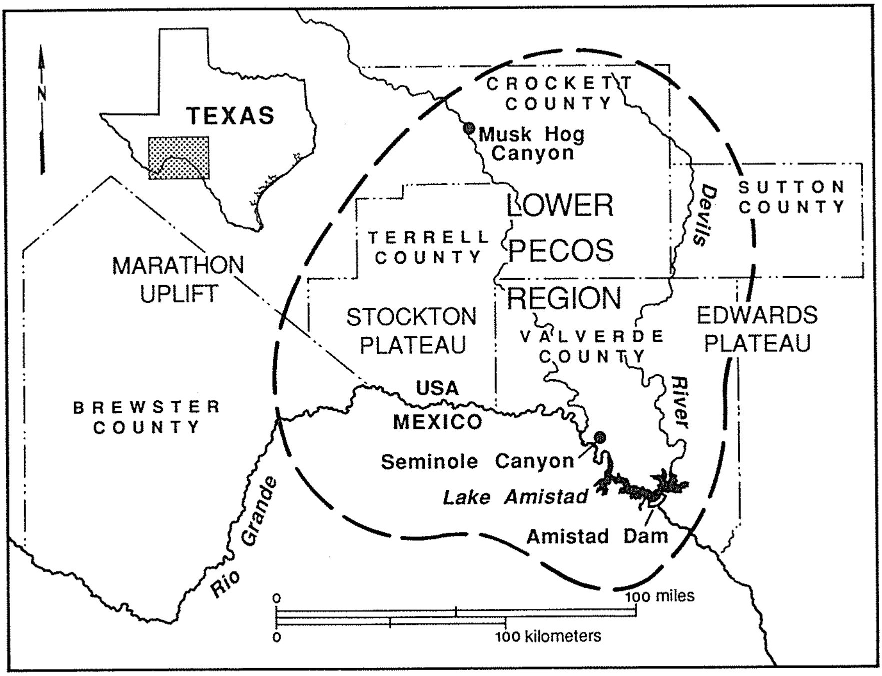


Figure 1. Map showing the approximate extent of the Lower Pecos region.

detail than in moister regions and to venture beyond the more basic questions of technology and subsistence.

ENVIRONMENT

The surface geology in the region is dominated by outcrops of Cretaceous limestone, eroded and dissected during millions of years of solution activity. The downcutting of the three major rivers—Rio Grande, Pecos, and Devils—and their tributary systems resulted in the formation of many deep narrow canyons in which, because of the variable density of the limestone strata, countless solution cavities, overhangs, and rockshelters were formed (Figure 2).

Permanent water sources are provided by the Rio Grande and the Pecos and Devils rivers and by solution potholes *(tinajas)* and springs. Despite the semiarid climate, the people were never beyond relatively easy access to water.

The local topography is dominated by a gently eroded limestone plateau (called the Edwards Plateau east of the Pecos River and the Stockton Plateau west of the Pecos River) interrupted by deeply incised narrow canyons that drain into the major rivers. The general north-to-south gradient of the plateau, together with the sometimes marked relief of the lower canyons, produces elevation contrasts of about 380 meters in the area.

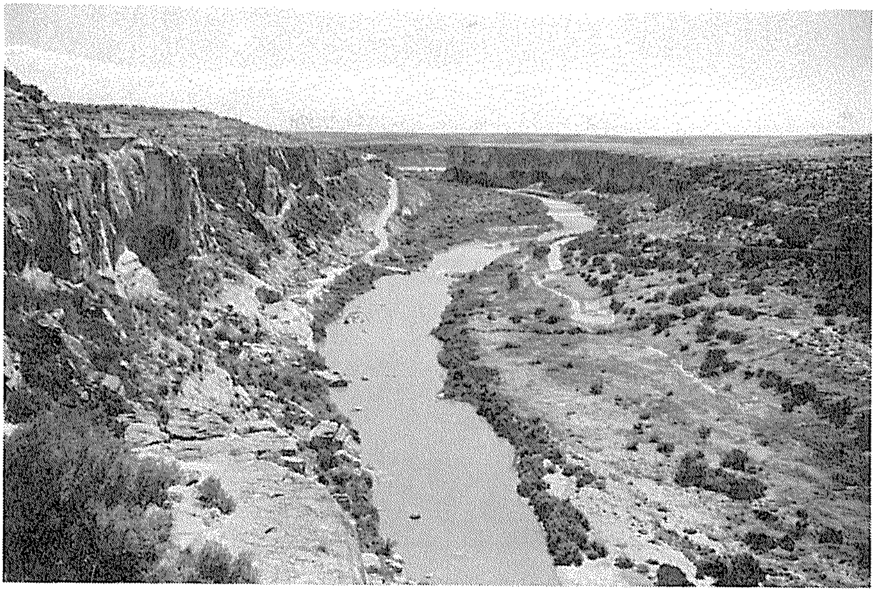


Figure 2. The deeply incised canyon of the Pecos River near its confluence with the Rio Grande, before the filling of the Amistad Reservoir. Moorehead Cave can be seen in the bluff on the left. Photo courtesy of Texas Archeological Research Laboratory, The University of Texas at Austin.

The landscape is typified by much bare rock (Figure 3) which, coupled with the thin upland soils common over much of the region, leads to rapid runoff of heavy rainfall and results in frequent flash floods and continued scouring of the canyons (Patton and Dibble 1982). The three river canyons have narrow, mostly Holocene, alluvial terraces, and on the more stable of these deposits almost invariably are traces of prehistoric human activity.

The climate is semiarid, with mild winters and hot summers. The average annual rainfall for the region varies from 30.5 to 56 cm (12 to 22 inches) annually, which increases to the east. The climate favors a plant cover dominated by xeric, or dry, land species. The deep shaded and moist canyons, springs, and the riverine belts sometimes supported stands of more luxuriant vegetation. The plant diversity for the region as a whole is high, but, since more than 90 percent of the land is upland, canyon slope, and bluffside, most of the vegetation is xeric (Dering 1979).

Elevation differences and general decrease in the soil depth from north to south, together with the east-west decrease in rainfall across the region, produce a gradual shift in the dominant plant communities. These environmental conditions also cause a slight maturation cline in plants from south to north that was probably very important to the ancient hunters and gatherers. The effect of such a cline would be for populations to prolong the harvesting of such foods as prickly pear fruits by shifting gathering locations northward as the fruits ripened.

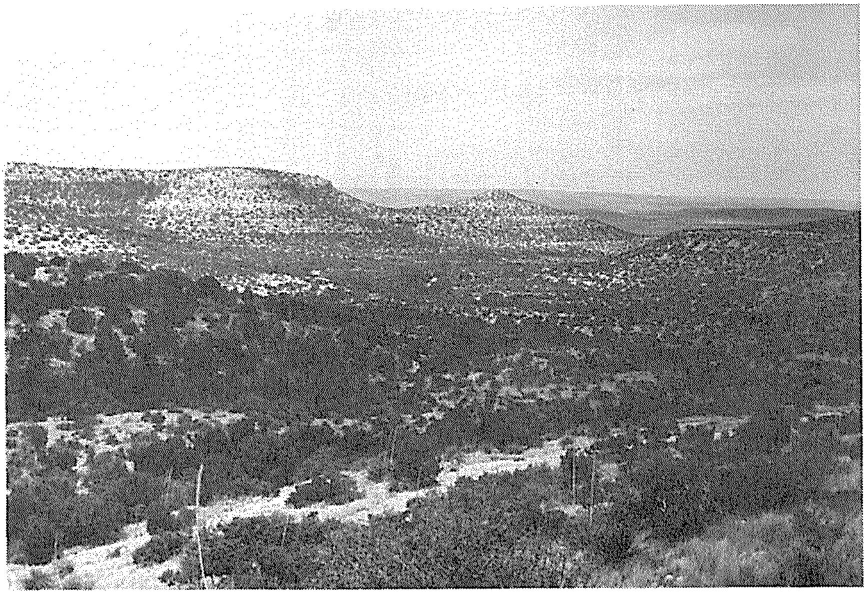


Figure 3. Looking into the dissected landscape of Musk Hog Canyon in Crockett County.

PALEOENVIRONMENT

Archeologists and botanists working with the deeply stratified terrace deposits along the Rio Grande and the Pecos River have collected sequences of fossil pollen samples from the sediments. Additional pollen samples, often in association with preserved plant parts, have been taken from stratified deposits in rockshelters. Analysis of these micro- and macroscopic plant remains, together with sedimentological histories and comparative data from adjacent areas, have led to a remarkably sensitive paleoenvironmental model for the Lower Pecos Region (Bryant and Shafer 1977, Patton and Dibble 1982). This model traces rather rapid desiccation in the region at the end of the Pleistocene; a gradual warming and drying trend began about 10,000 years ago and has continued to recent times. Within this time at least one reversal occurred, about 2,500 to 2,800 years ago, which evidently had a significant impact on the archeology of the region (Dibble and Lorrain 1968).

Paleoenvironmental models are extremely important tools for understanding patterning in prehistory; they provide a means of testing for anomalies in cultural patterns in order to determine if such anomalies could be due to some form of environmental stress or response.

THE CULTURAL SYSTEM

We do not know the ethnic identity of the prehistoric Indians of the lower Pecos River. However, reliable inferences about their general culture and way of life can be drawn from Spanish descriptions of hunters and gatherers of northern

Mexico and southern and southwestern Texas recorded in the sixteenth, seventeenth, and eighteenth centuries (Krieger 1956, Covey 1961, Griffen 1969, Newcomb 1961).

Throughout the culture history of the Lower Pecos Region, the people were hunters and gatherers. The only possible evidence of the use of domestic plants is a rare bottle gourd sherd from Conejo shelter (Alexander 1974).

The nature and quantity of the resources available in the environment and their nomadic or seminomadic way of life strongly influenced the size and social organization of the groups. The dominant social unit, as is found generally in hunting and gathering societies with low population densities (Service 1966), was the band (Griffen 1969, Newcomb 1961). Bands are the simplest form of human social organization. Bands vary considerably in size from single family-sized groups to groups of as many as 150 to 200 people. The number of people in a particular band depends on several factors, including population density and the availability of food and water.

In hunting and gathering societies, views about existence and the world tend to be strongly supernaturalistic. Everything in their world has supernatural explanations. Healing rituals and life-crisis rites such as birth, puberty, marriage, and death usually are supervised by a shaman, who may be male or female. Healing is typically individualistic, whereas group healing is more typical of formative (simple agricultural) societies.

One of the more outstanding features of the Lower Pecos Region is the preservation of the ancient art (Kirkland and Newcomb 1967, Shafer 1986). The variability and patterning in the art are like those found generally in hunting and gathering societies. Art in primitive societies is an indirect form of communication. Its purpose is to evoke emotion, and its context is religious ritual. The art forms are simple and highly traditional. The aim is to control (Service 1966:77).

Hunting and gathering societies also are described as egalitarian; no one person or group of people outranked anyone else. All people were of essentially equal status, although differences in age and sex certainly were acknowledged. Egalitarian societies characteristically do not have designated leaders or chiefs, as it were; decision making usually is done by consensus. The egalitarian label does not preclude the viewing of certain individuals as exceptional, in their magic, their ability to cure illness (as in the case of shamans), or for their skills as hunters or knowledgeable gatherers. Such individuals may have significant influence on others in their band, but there is no ranking in status on the basis of birth (Service 1966).

The mobile lifeway made it necessary for the people to carry with them all their worldly possessions, which affected both the technology and what was left at abandoned sites (Shafer 1981). Under these circumstances, it also can be expected that the people had multiple uses for many of the tools they carried.

Most of the settlements probably were open air; sheltered locations were reserved for needed shade and for refuge from inclement weather. Consequently, several different kinds of archeological sites could have been created by a single band's settlement in a canyon. Both open-air and sheltered locations could have been used simultaneously. One band, in a single occupational episode, could produce rock art, add to a growing pile of burned rock fragments in a midden, use bedrock mortars, and deposit a lens of fibrous residue in one or more rockshelters. Larger bands may have split into family groups, occupying several nearby sheltered areas simultaneously.

Living areas within the rockshelters also give a general indication of the size of the social groups who occupied them. Little attention has been paid to understanding the social aggregates of the Lower Pecos Archaic peoples, but, considering the space available in rockshelters, it is doubtful that occupying groups numbered more than about 25 to 30 individuals; smaller family-sized bands of 10 to 15 may have been more economic for winter or lean seasons.

ARCHEOLOGICAL SITES

Archeological sites in the region consist of rockshelters, caves, and open-air localities. Sites with specific functions are burial locations, bedrock mortar holes, and burned rock middens.

Rockshelters

Rockshelter sites have received the most attention because of the remarkably well preserved perishable artifacts found in the deposits of larger, better-protected examples (McGregor 1985).

Examples of excavated rockshelters include Eagle Cave (Ross 1965), Fate Bell shelter (Parsons 1965), Coontail Spin, and Mosquito Cave (Nunley, Duffield, and Jelks 1965), Centipede and Damp caves (Epstein 1962), 41VV88 (Dibble and Prewitt 1967), Baker Cave (Word and Douglas 1970, Hester 1983, Chadderdon 1983), Hinds Cave (Figure 4) (Shafer and Bryant 1977, Saunders 1986), Conejo shelter (Alexander 1974), and Parida Cave (Alexander 1970).

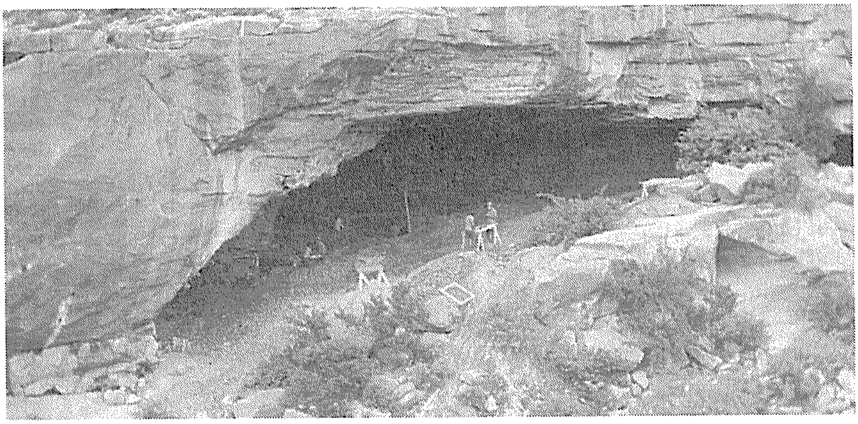


Figure 4. Hinds Cave (41VV456), Val Verde County, during excavation by Texas A&M University.

These sites are invaluable archives for the study of human ecology of prehistoric hunters and gatherers and their adaptations to the arid lands of southern North America. The deposits in such sites are enormously complex and demand methods of excavation and analysis that go far beyond the expertise of the casual excavator. Unfortunately, nearly all of the larger shelters, which are multidisciplinary archives of data because of the unusual preservation conditions, have been badly damaged—or, in some cases, totally destroyed—by relic hunters.

Rockshelters served as habitation sites for task units of one or more family groups, depending on the number of people in the residential groups and the amount of space available. The rockshelters vary in size from the huge Fate Bell Shelter in Seminole Canyon State Park (Pearce and Jackson 1933, Parsons 1965) to small overhangs that are hardly large enough to accommodate more than one person, to slight overhangs that, although floorless, are adequate for the protection of prehistoric paintings (Graham and Davis 1958).

Deposits in the rockshelters generally consist of ashy fill mixed with fragments of burned limestone, lithic artifacts, and animal bone. In the drier sites, perishable plant materials and fibrous artifacts are preserved. In some rockshelters, matted thin lenses or thick layers of fibrous materials are made up mostly of the residue from processing desert succulents such as sotol *(Dasylirion* sp.), lechuguilla *(Agave lechuguilla),* and prickly pear cactus *(Opuntia* sp.), and the remains of grass beds and flooring materials. Mixed with the matted remains of food and flooring residue are discarded remnants of textiles and other items of material culture.

Fiber lenses or layers of organic material may have been purposefully scattered over the living floors of the shelters in order to improve living conditions. This situation was noted at Gobbler shelter (Dering and Shafer 1976) and Hinds Cave (Shafer and Bryant 1977), where two floors of prickly pear pads (with spines removed) were found (Figure 5) together with indications that other floors may have been covered with dry grass and oak leaves collected during the early spring leaf fall.

Among the fiber lenses are found not only the usual array of stone and bone cultural items, but also materials—artifacts and other items directly related to human activities—that usually are not preserved in the archeological record (Figure 6 A, 6 B). It is this inventory of perishable materials that is so important, not only to archeologists, but also to botanists, zooarchaeologists, and other specialists who are often called upon to aid in the analysis of archeological materials. Items of food and debris from food processing, and desiccated remains of digested food in coprolites recovered from deeply stratified deposits, have provided an extraordinarily detailed understanding of the subsistence of the people. Technological items used to harvest, hunt, make fire, and process foods, together with items of clothing, play items, ritual paraphenalia (painted pebbles, painted sticks, pictographs), and, occasionally, burials, have provided a remarkably complete record of the material culture (Shafer 1986:58-131).

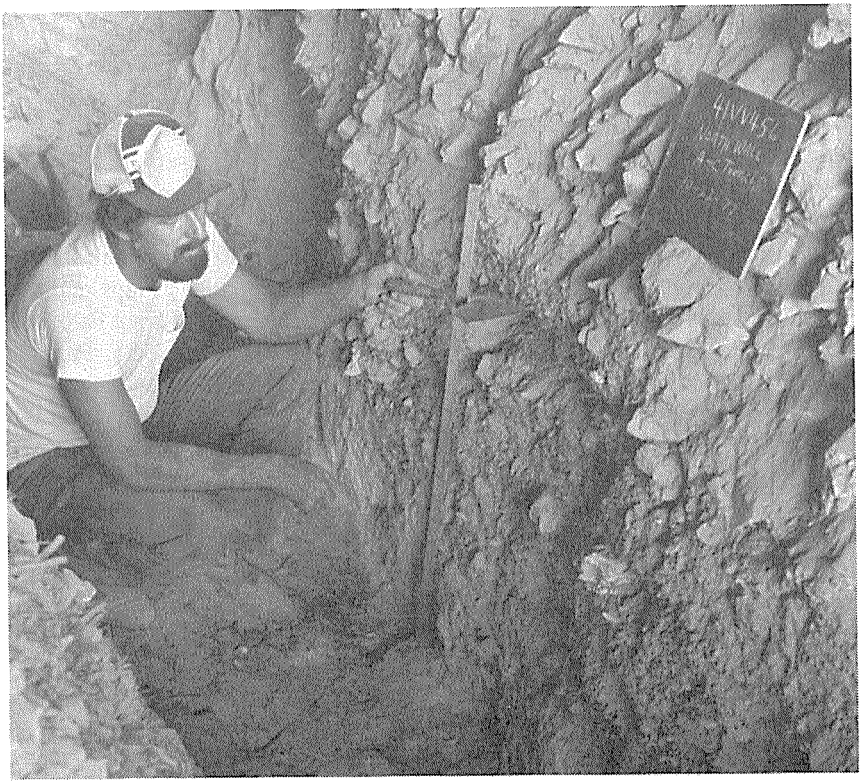


Figure 5. Prickly pear floor showing in A-C Trench profile in Hinds Cave, excavated by Texas A&M University.

When rockshelters were occupied by family groups, floor space predictably was divided by households. Evidence for cultural patterning during certain episodes of occupation has been found at Hinds Cave (Shafer 1986:97) and can be inferred from reports of other sites such as Damp Cave (Epstein 1962) and Conejo Shelter (Alexander 1974).

The living areas in the better-preserved caves often have shallow, grass-lined pits, usually near the back wall, which presumably served as sleeping areas (Shafer and Bryant 1977, Epstein 1962, Dibble and Prewitt 1967). These pits sometimes have a rather complex structure; they are oval, scooped out of the cave floor, and layered with green twigs and branches that are in turn covered with thick layers of grass. A layer of flat objects—prickly pear pads (with spines removed), fragments of matting, or discarded sandals—was placed on top of the grasses (Figure 6 A), and over this apparently was placed a *petate* (rectangular checker-weave mat).

Fire hearths are generally either ash lenses from *in situ* burning or shallow ash-filled basins. It is the author's impression that at Hinds Cave these kinds of

Figure 6 A. Grass-lined pit covered with prickly pear pads and discarded sandal. These pit features probably represent ancient bedding areas.

Figure 6 B. Excavation of an ancient latrine area in Area B at Hinds Cave by Texas A&M University. Note stratification of the perishable deposits.

hearths were found in the sleeping area of the shelter near the back wall and may have been more for warming-fires than for cooking. The shallow ash-filled basins measure from less than 1 meter to 2 meters across and are lined with slabs of burned limestone. These features also are found in the living areas, but are sometimes nearer the fronts of the shelters.

Wooden stakes forming semicircular patterns that have been found in several professionally explored sites such as Baker Cave (Word and Douglas 1970) and Coontail Spin (Nunley, Duffield, and Jelks 1965) indicate that partitions may have been built beneath some overhangs. Living areas occasionally were floored with organic materials, presumably to improve the living conditions. If Hinds Cave can be used as an example (Shafer and Bryant 1977, Shafer 1986:99), latrines were evidently at the edges of the living areas.

Caves

Both vertical shaft and horizontal shaft caves are found in the region, but few have been investigated systematically (Turpin 1985). Horizontal shaft caves primarily served mortuary functions (Greer and Benfer 1963, Collins 1969). Vertical shaft caves are usually sinkholes that lead into large subterranean solution caverns (Prewitt 1981, Steele et al. 1984, Turpin 1985). Prehistoric activity usually is confined to the entrance area, often in the form of burned rock middens, but burials are sometimes encountered at the bottom of vertical drops near cave entrances (Turpin 1985). Vertical shaft caves were used for burial places from Central Texas into northern Mexico (Del Rio 1953). These sites may help solve the nagging mystery of where the ancient people in Central and southwestern Texas deposited their dead in early and middle Archaic times.

Open-Air Sites

Several types of open-air sites are found in the Lower Pecos Region (Graham and Davis 1958, Moore 1983). Together, these sites have provided highly significant data on the chronology of the region and on the manner in which upland resources were used by the hunters and gatherers.

Alluvial Terrace Sites

Alluvial terrace sites, such as the Devils Mouth site (Figure 7) (Johnson 1964, Sorrow 1968a), Arenosa shelter (Figure 8) (Dibble 1967), and Nopal Terrace (Sorrow 1968b) have deeply stratified deposits. Scouring from overbank flooding of the Rio Grande or Pecos or Devils rivers undoubtedly caused the loss of many terrace remnants at the same time that others were being formed, resulting in frequent interruptions in the cultural sequence (Patton and Dibble 1982).

Holocene terraces were developed by the deposition of sequential layers of silts, each layer sealing and so preserving cultural materials left on the surface of the previous layer, resulting in a relatively unmixed stratified sequence. Since

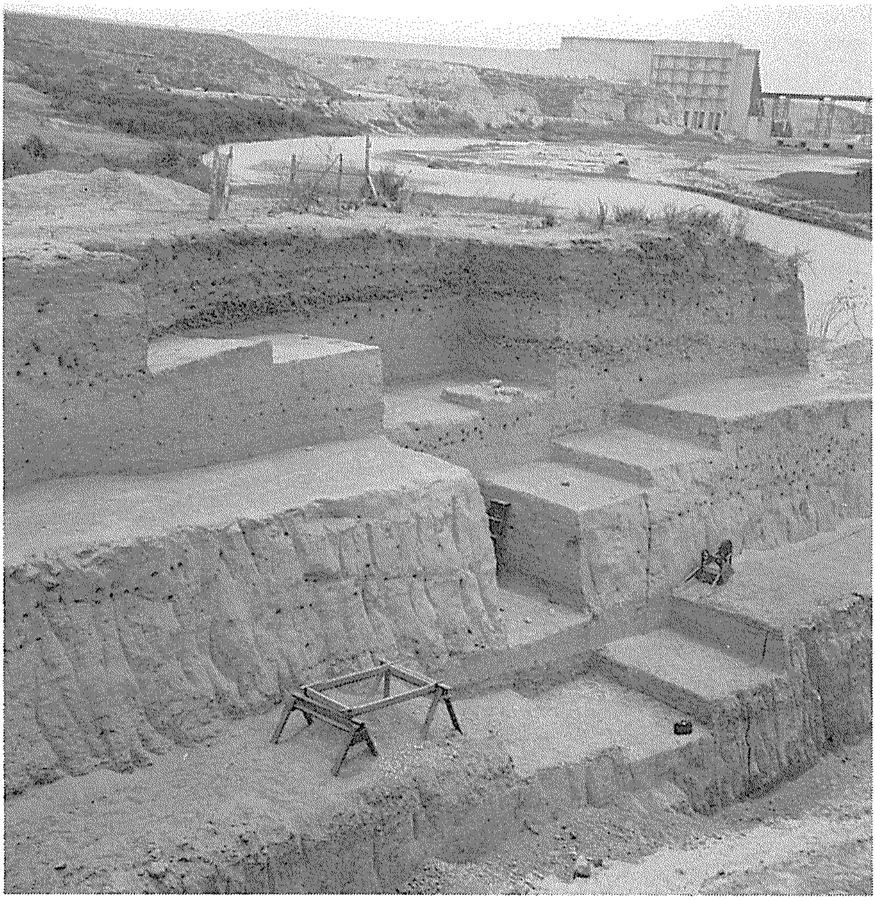


Figure 7. Devils Mouth Site at the confluence of the Devils and Rio Grande rivers prior to the completion of Amistad Dam. The site was excavated by The University of Texas at Austin. Photo courtesy of Texas Archeological Research Laboratory, The University of Texas at Austin.

decay removes most perishable materials from the archeological record in terrace sites, analytical emphasis has to be focused on the features, the functional and stylistic patterns of the lithic artifacts, and on faunal remains. There is a potential, where scouring was not a factor, for such deposits to have botanical data in the form of charred plant remains and pollen. Although rockshelter sites are intricately stratified, they often do not have sequences of sealed deposits that can be correlated easily with the lithic and perishable sequence. Instead of depending on only one type of site, a more complete chronological record was developed in the Lower Pecos Region by excavating both stratified terrace sites and deep rockshelters.

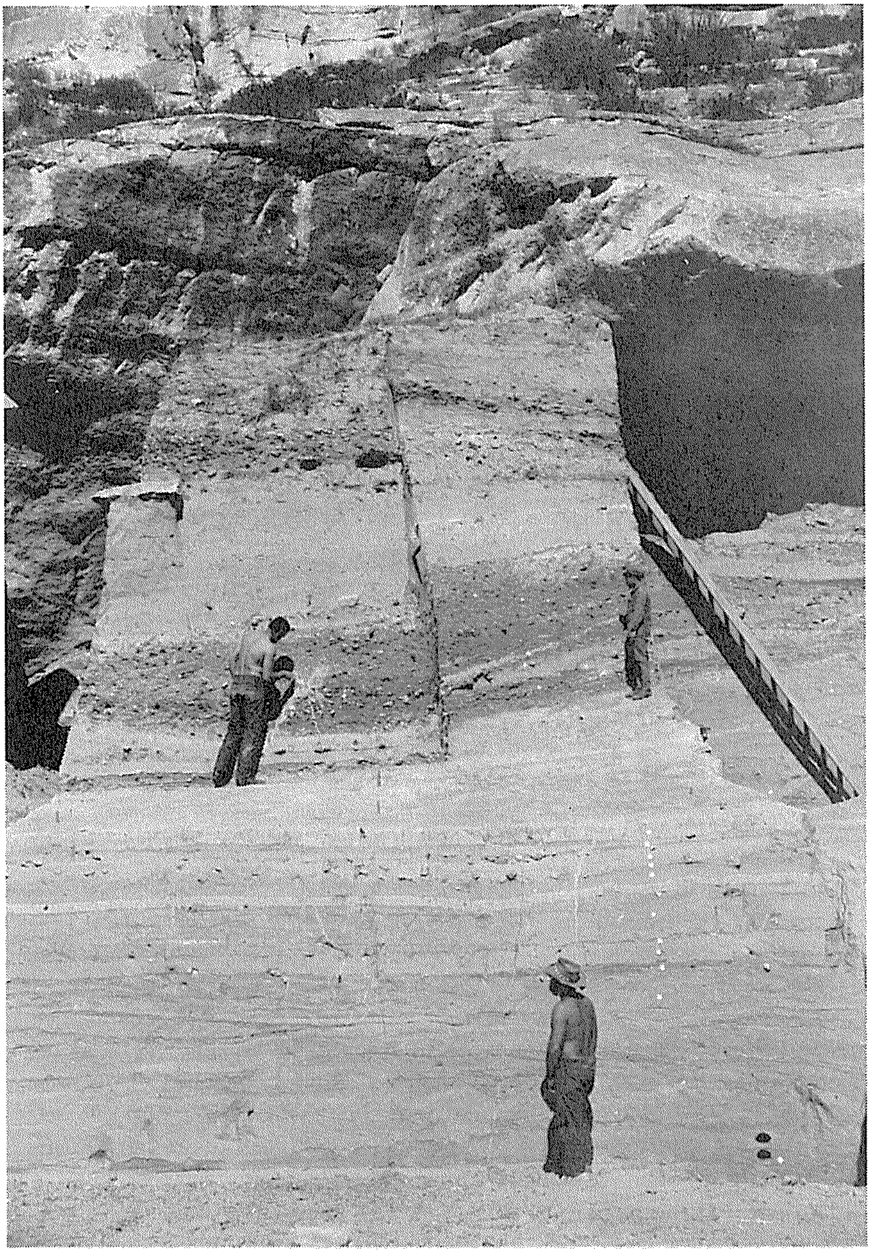


Figure 8. Arenosa shelter in the Pecos River canyon near its confluence with the Rio Grande. The site was excavated by The University of Texas at Austin. Photo courtesy of Texas Archeological Research Laboratory, The University of Texas at Austin.

Burned Rock Middens

Perhaps the most visible open-air sites are the burned rock middens. These interesting sites are mounded accumulations of fire-cracked limestone fragments resulting from repeated use of the stones as heat conductors for preparing food in a single or series of overlapping pits. Reuse of the oven requires replacing the cobbles or slabs. Single hearths are found far more frequently than the middens, but investigations at Musk Hog Canyon (Moore 1983) demonstrate that the middens result from repeated use of the ovens. The forms of the burned rock middens have temporal and, possibly, functional significance. Dome-shaped middens are the earliest, dating at least to the middle Archaic period if not earlier; an example is the Doss site (Nunley, Duffield, and Jelks 1965), which dates to the middle period of the Archaic sequence in the region. A thick burned rock midden deposit was encountered in the early Archaic deposits at Hinds Cave (Shafer and Bryant 1977:43) dating from 7,000 to 4,000 B.C., and burned rock fragments are found in talus deposits of even the earliest rockshelters in the region.

The dome-shaped middens are more common in the eastern part of the region and beyond into Central Texas. These sites probably result from repeated processing of acorns at traditional locations (Creel 1986; see Bean and Saubel 1972 for a description of acorn processing among southern Californian Indians).

Many burned rock middens relate to the processing of desert succulents, which were used by the first Archaic peoples who settled in the lower canyons (Dering 1979). Earth ovens were used for baking desert succulents throughout the cultural sequence; however, one form of midden accumulation—the ring- or crescent-shaped midden with a distinct central depression or pit (Figure 9 A)—is particularly distinctive and indeed is the most common midden form (Dibble and Prewitt 1967, Greer 1965, Moore 1983, Shafer 1971). These accumulations of burned limestone rock fragments result from multiple use of a single pit or of a series of overlapping pits (Figure 9 B), which are rock-lined depressions in the soil or bedrock. Use of the oven causes fire-fracturing of the limestone cobbles or slabs used for heat conducting. The crest of the crescent or ring midden is usually on the north or northwest side (Figures 9 A, 10 A, 10 B). This midden form is late in the archeological sequence, usually dating after A.D. 600 (Greer 1968), and is seen more frequently in western Val Verde and Crockett counties and throughout the Trans Pecos Region. Their function is convincingly tied to the baking of sotol and lechuguilla bulbs. The manner of processing these desert plants has been amply documented in the ethnographic literature (see Moore 1983).

The most thoroughly investigated crescent midden sites are in Crockett and Pecos counties (Moore 1983). Middens yield very few formal tools, so they are generally safe from artifact collectors (the greatest danger to middens is root plowing), but they yield an interesting assemblage of lithic and other artifacts, consisting most commonly of chert debitage, discarded artifacts such as unifacial tools, burin-struck cores, burin spalls, and, rarely, projectile points. Ashy fill

Figure 9 A. Site 41CX218, a crescent-shaped burned rock midden near the Pecos River in Crockett County, during excavation by the 1976 Texas Archeological Society Field School.

Figure 9 B. Central pit feature at site 41CX218, a crescent-shaped burned rock midden near the Pecos River in Crockett County.

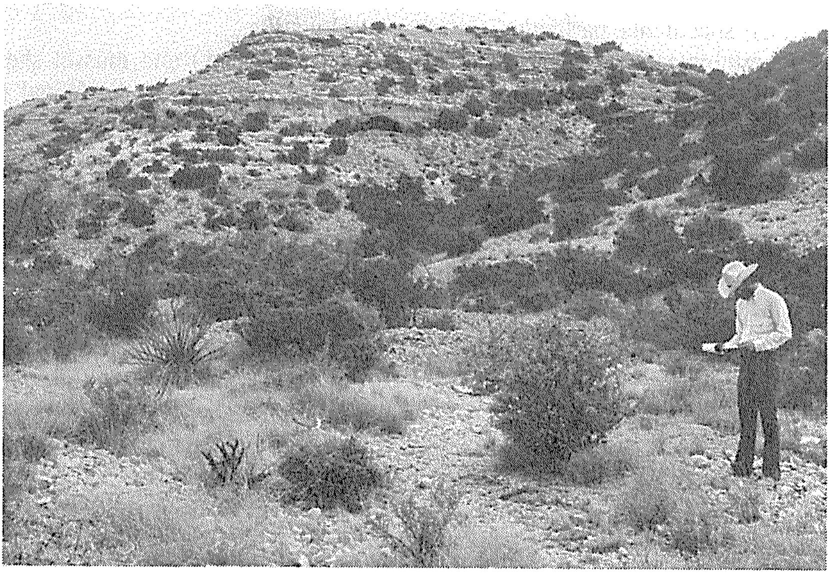


Figure 10 A. A crescent-shaped burned rock midden in Musk Hog Canyon, Crockett County, recorded by the 1976 Texas Archeological Society Field School.

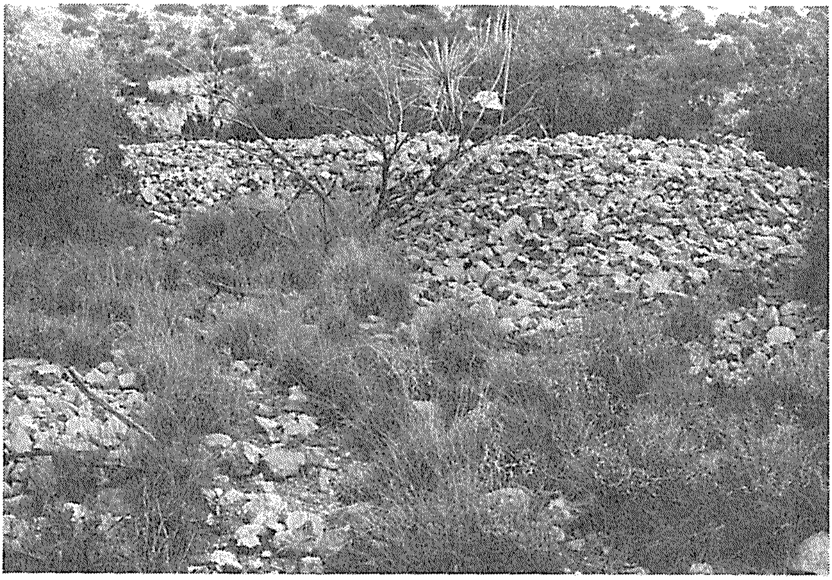


Figure 10 B. Mounded accumulation of burned rock on north side of a crescent-shaped burned rock midden in Musk Hog Canyon, Crockett County, recorded by the 1976 Texas Archeological Society Field School.

in and adjacent to the pits often yields woody charcoal and charred leaf bases of the desert succulents, particularly sotol and lechuguilla.

Invertebrates such as large land snails *(Rabdotus* sp.) and mussel shells (even in the middens several miles from permanent water) are the faunal remains most frequently encountered in the crescent and ring midden sites. Some of these sites have additional adjacent middens made up of habitation refuse, in which vertebrate faunal remains may be quite common.

Scattered burned rock fragments, lithic artifacts, and snail and mussel shells are found at most sites near potential sources of water—along bluffs overlooking streams, and at the heads of tributary canyons—where they are accompanied often by burned rock middens. Limestone-paved hearths, or small concentrations of burned rock that presumably are the disarticulated remains of rock-lined hearth ovens that were used only once, can be found almost anywhere in the region where soil conditions permit. In addition, artifacts marking locations where the ancient gatherers exploited the landscape by harvesting the economic plants and animals are scattered over the upland and canyon slopes (Saunders 1986). Many of these sites, because they are unrewarding to collectors, remain largely intact for future investigation by archeologists.

Mortar Holes

Bedrock mortar holes—conical holes pecked and pounded out of bedrock surfaces—are found in many locations throughout the region. Their presence can be predicted in bedrock exposures near permanent water, but they can occur wherever human activities were concentrated. Usually, several are found at a single location, but, in some locations such as Live Oak Creek in Crockett County, there are more than a hundred. Bedrock mortar holes are assumed to be associated with the processing of baked bulbs of sotol, lechuguilla, and, possibly, acorns. Because they hold water for a long time, tinajas may have been used secondarily in making a fermented drink (Griffen 1969).

Rock Circles

Clusters of rock circles were discovered first by David S. Dibble on an upland flat near Infierno Canyon (now in Seminole Canyon State Park; see Turpin 1982). Since Dibble's discovery, several similar sites have been documented in the Lower Pecos and Trans-Pecos areas (Mallouf 1985). These rock features, which probably represent the stone outlines for wickiup-type structures, are associated consistently with a distinctive lithic and ceramic assemblage that sets them apart from rockshelters and other open sites. The rock circle sites are associated with brownware and orangeware pottery, scrapers, and Perdiz and other small arrowpoints. The rock circle sites are probably protohistoric and may be the sites of intrusive groups who were attracted to the area because of the bison herds that were in the region in protohistoric times.

Burial Sites

Burials are seldom found in the Lower Pecos region, but those that are are in rockshelters (Collins 1969, Dibble and Prewitt 1967), or horizontal (Collins 1969, Greer and Benfer 1963) or vertical shaft caves (Turpin 1985). Most of the burials from rockshelter deposits date from late in the prehistoric sequence. Most are primary burials, both males and females of all ages, flexed or semi-flexed in shallow pits, often covered with a layer of cobbles. About 11 percent of the burials tabulated by Turpin, Henneberg, and Riskind (1986) were cremated remains wrapped in mats or skins. The burials in horizontal shaft caves apparently were wrapped in flexed positions and dropped into the openings of sinkholes (Del Rio 1953).

Both primary burials and cremations often were wrapped in checkerweave mats and rabbit fur blankets (Alexander 1974, Shafer 1986:119, 122, Turpin et al. 1986). Personal possessions such as broken (or "killed") carrying baskets, other baskets, bags, and various other paraphenalia, are found with some of the burials, but there is apparently no evidence for status-marking in burial ritual.

No special facilities or formal tombs were built. Turpin (1985) refers to Seminole Sink as a tomb, but the use of the term tomb for this sinkhole burial site is unfortunate, since it implies a formally constructed facility such as the rock cut tombs of the southern Maya Lowlands (Hall 1986). Turpin acknowledges that the sinkhole is a natural formation.

Rock Art Sites

One of the most outstanding characteristics of the Lower Pecos region is the degree of preservation of the rock art (Jackson 1938, Kirkland and Newcomb 1967, Shafer 1986:138-159). The sheltered recesses and overhangs have provided a protective shield for some of the most impressive Archaic rock art galleries in the New World. Monochrome, bichrome, and polychrome paintings are concentrated in the vicinity of the mouth of the Pecos River, but they extend throughout much of Val Verde County and well into adjacent counties.

Several distinctive styles of rock art have been defined in the region (Shafer 1986:138-159), the dominant and most impressive being the Pecos River Style (Kirkland and Newcomb 1967:37-80) (Figure 11), which is also clearly the earliest of the major styles, based on superposition of images (it may have been preceded by monochrome red paintings at site 41VV75 in Seminole Canyon). Pecos River Style paintings are entirely prehistoric, and their anthropomorphic figures using the atlatl and spear place this style before the introduction of the bow and arrow. There is debate among archeologists as to the antiquity of the Pecos River Style; guesses as to its beginning range between 1,000 years and 6,000 years ago.

Later styles are the Red Monochrome Style (Kirkland and Newcomb 1967:81-110, Turpin 1986) and a perplexing Red Linear style (Turpin 1984).

Figure 11. Pecos River Style pictograph from Panther Cave (41VV83) in Seminole Canyon. Photo courtesy of the Texas Archeological Research Laboratory, The University of Texas at Austin.

The Red Monochrome Style undoubtedly extends back into prehistoric times, after the introduction of the bow and arrow, or about A.D. 1000, but some clearly historic motifs also are executed in red monochrome (Kirkland and Newcomb 1967:pl. 64 and 65). The depiction of bison in the Red Monochrome Style may help to place the dates of some examples more precisely, since the bison range extended this far south only at certain times (Dillehay 1974, Turpin 1987).

The Red Linear Style is difficult to date because of its abstract motifs and the uncertainty of superposition (see Turpin 1984 for an opinion on the antiquity of the Red Linear Style).

Discussion

The history of archeological research in the Lower Pecos Region follows a pattern, seen in other parts of the world, of bias toward excavating the more productive and impressive sites. Archeological attention was focused on the rockshelters as early as the 1930s (McGregor 1985), whereas no attention was paid to excavating or even documenting open-air localities until the start of the Amistad Reservoir project in the late 1950s and early 1960s (Graham and Davis 1958, Dibble and Prewitt 1967). Even then the emphasis continued to be on investigating rockshelters and deeply stratified terrace sites. The density and nature of upland sites is poorly known, even with the recent survey by Joe Saunders (1986) of the area between Lewis and Still canyons in Val Verde County, which provided the first comprehensive and unbiased study of an upland area. Also, an intensive survey has been carried out at Musk Hog Canyon (Shafer and Moore 1976) on the Pecos River in Crockett County, and, when the data are published, the distribution and variability of upland sites will be known much better

The high degree of preservation provided by the climate and selection of habitation sites, however, has given us an excellent opportunity to examine the human ecology of the area in a far more detailed way than is usually possible in archeology. The remarkable preservation of botanical materials has yielded parallel sequences of data on ancient climate variation and the economic use of plants and animal resources. These paleoenvironmental reconstructions provide a unique opportunity to measure cultural responses to environmental change over a 9,000-year span (Bryant and Shafer 1977, Dering 1979, Shafer and Bryant 1977).

The region underwent a rather marked desiccation at the end of the Pleistocene to the extent that marginal desert conditions were established there by about 9,000 years ago. The earliest hunters and gatherers in the region adjusted quickly to these conditions and established a seasonal pattern and evidently an equilibrium adequate to sustain descendent populations for some 8,500 to 9,000 years. We cannot be sure whether the chronological sequence represents the remains of many separate groups who occupied the region over time and exploited the environment in similar ways or documents the historical continuity of one tradition. The real situation probably was a combination of these possibilities. Although long-term climatic changes may have affected the seasonal rainfall pattern and amount of available moisture, these changes did not have an adverse affect on the xeric vegetation pattern or, concomitantly, on the patterns of human exploitation of this vegetation. In other words, although some climatic changes may have occurred, no major adaptive adjustments by the Archaic groups are indicated. Consistent use of bison is not indicated in the archeological record, suggesting that bison were not in the area during most of the prehistory of the region (Dillehay 1974). Opportunistic exploitation of bison is documented by a massive kill at Bonfire shelter (Dibble and Lorrain 1968), which correlates with a mesic interval about 2,500 to 2,800 years ago (Bryant and Shafer 1977). Bison retreated from the area after the mesic interval and returned again just before the coming of the white man (Turpin 1987). There is no indication that the brief mesic period had a lasting impact on subsistence patterns in the area.

Chronology

Temporal controls on the cultural-historical reconstruction were made possible by the focus on deeply stratified alluvial terrace sites, ample numbers of radiocarbon dates, and a generally sensitive stylistic sequence of projectile points (Dibble 1967). By dating deposits that yielded specific projectile point styles, it has been possible to build a well-dated stylistic sequence that can be used as a general index for correlating deposits from different sites. Stylistic changes also have been recognized in sandals (Shafer 1986:131), other textiles (Andrews and Adovasio 1980), pictographs (Kirkland and Newcomb 1967), and painted pebbles (Parsons 1986). A review by T. R. Hester of the prehistoric sequence based on these evidences is presented elsewhere in this volume.

Spatial Analysis

Much less attention has been given to establishing spatial dimensions for the prehistoric archeological assemblages. Early attempts to establish regional limits were based on the geographic ranges of specific projectile point styles. This approach has some merit, but there is no easy way of correlating such a distribution with that of any specific ethnic group. Some point types have much broader ranges than others, or the ranges are indistinguishable when ancient boundaries are crossed (for example, compare the Lower Pecos Region in Turner and Hester 1985, Figure 21, and the distribution of Montell points, page 126, whose distribution extends far into Central Texas). In the early studies, arbitrary cultural areas were established, using the Midwestern Taxonomic System (Suhm, Krieger, and Jelks 1954), and the Pecos River focus was the Archaic cultural unit imposed in this region; but later work showed that it had little utility as a culture-historical concept. More recently, the author has attempted to define meaningful territorial margins for the Lower Pecos Archaic populations by examining the geographic extent of the Lower Pecos Style rock art (Shafer 1977). The assumption was that the rock art represents ideographic symbols that could relate most closely to the language of one specific group. Since group or band affiliation of historic Texas Indian groups has depended more on linguistic traits than on subsistence or material culture, it was deemed that the distribution of the Lower Pecos Style would give a better approximation of the territorial extent of the ancient populations than would traditional diagnostic units.

In retrospect, the projected extent of the "home range" applied only to the time period during which the Pecos River Style rock art was produced (which could be anywhere from 1,000 to 6,000 years ago). However, because of the "oasis" formed by the Rio Grande and the Pecos and Devils rivers, the lower canyons probably were the focal point of territorial claims throughout most of human prehistory. The only times when this may not have been the case were when the distribution of primary resources, such as bison, may have been different from the territorial range indicated by the Pecos River Style, necessitating a violation or compromise of range boundaries. This may have happened in later times, when the appearance of bison in the region and their exploitation by intrusive groups is documented in seventeenth and eighteenth century Spanish accounts (Turpin 1987).

In this study, once information was available on the approximate geographic range of the Pecos River Style hunters and gatherers, the plant, animal, and mineral resources in the region could be identified, and species variability, distribution, density, and behavior could be noted. These ecological data provided a background essential for the study of economic patterns in the archeological record. This approach raises questions about time control and the basis for assuming that the pictorial symbolism is directly related to the linguistic symbolism, but the author believes it was a fruitful start toward factoring out patterns in the prehistoric human ecological situation.

Very little spatial analysis has been done on the site or household level, either to define households specifically or to ascertain patterns in the distribution of features to define patterns of space use in settlements. The research at Hinds Cave, where features such as beds, hearths, and latrines associated with the living area were defined within the context of the site as a habitation area, serves as a model for beginning such studies (Shafer and Bryant 1977, Shafer 1986:97).

Dietary Studies

No area of study has produced more details on cultures and lifeways than have the dietary studies based on analysis of human coprolites (desiccated human feces) from the dry caves in the Lower Pecos Region. These dietary studies were undertaken on coprolites from Parida Cave (Riskind 1970), Conejo shelter (Bryant 1974), Hinds Cave (Williams-Dean 1978, Stock 1983, Reinhard et al. 1988) and Baker Cave (Sobolik 1988). Specimens have been examined from sites in the Pecos and Devils River canyons, and from early, middle, and late phases of the Archaic sequence. The specific information on the dietary patterns reconstructed from these coprolite studies, coupled with studies of the economic plants from Baker Cave (Sobolik 1988), Hinds Cave (Dering 1979), and Gobbler shelters (Dering and Shafer 1976) and faunal remains from the same deposits (Word and Douglas 1970, Hester 1983, Lord 1984), has made possible the construction of an unusually complete profile of the hunting and gathering patterns through time. More recently, preliminary parasitological and nutritional studies of the people, based on coprolite analysis (Reinhard et al. 1988) and skeletal analysis (Steele and Olive 1988) show that the ancient people of the lower Pecos were generally healthy, although the rough fibrous diet did lead to some nutritional stress.

Major economic plants consumed include the desert succulents such as prickly pear stems and fruit, sotol and lechuguilla bulbs, wild onions, persimmons, mesquite, and a variety of perennial plants. The diet was heavily vegetarian, but, in addition, hunting, trapping, and foraging were directed mostly at rabbits and small rodents, fish, deer, river mussels, land snails, lizards, snakes, turtles, and insects.

Seasonality

Despite the seemingly ideal conditions in the Lower Pecos Region for studies in seasonality, efforts to define seasonal movements and occupations have been met with only limited success (Dering and Shafer 1976, Sobolik 1988, Williams-Dean 1978). Seasonal changes and clinal shifts in ripening times of wild plant foods undoubtedly necessitated a significant degree of seasonal emphasis on resource exploitation. However, due to the variability in the environment brought about by such factors as amount and timing of rainfall, temperature, and sunlight, which bear directly on the germination and maturation of plants, it is doubtful that archeologists ever will be able to compile an almanac for the ancient Lower Pecos Region.

The real stresses on the populations came during the winter and early spring months. Bulbs of sotol and lechuguilla and prickly pear stems were available the year round (Brown 1988), but little information is available on the actual winter foods. Perennial plants grow in protected recesses most of the year, but it is not known to what degree these weedy plants were consumed. Hunting may have been emphasized more in the winter to offset meager supplies of fruits and vegetables in that season.

Pecans (found only along the Devils River) and acorns were available from late spring to early fall in most years, together with a variety of lesser fruits and vegetables. The importance of pecans and acorns in the fall and winter diets cannot be measured by coprolite studies, since these nuts leave no recognizable trace (except for identifiable shell fragments) undigested. Undoubtedly these nuts were exploited, since cracked pecan hulls and acorns are found in some deposits at Baker Cave (Kenneth M. Brown, personal communication), and acorn fragments are found throughout the dry deposits of Hinds Cave. Although no storage facilities have been found to indicate that these nuts were in fact stored, they may have been extremely important, and we may have interpreted the winter diet as being leaner than it actually was.

Technology

The dry caves also have given us a rare opportunity to examine specific aspects of the technology of their occupants. Such technological items as hafted tools, perishable parts of weapons, fragments of snares, baskets, and other textiles, bone awls, fire drills and hearth sticks, digging sticks, and organic residue on stone tools all provide a rather complete view of the day-to-day technology.

An item usually found in the kit of a band was a knife made of a large oval flake hafted in the center of a wooden handle, making it resemble an Eskimo *ulu*. These artifacts are similar to but date much earlier than the mescal knives found in the American Southwest (Heizer 1970). Hafted examples are in the collections of the Witte Museum (Shafer 1986:111), and discarded blades comprise the most common chipped stone artifacts, except for projectile points, found in archeological deposits in the region. They have been misclassified as scrapers (Epstein 1962, Dibble and Prewitt 1967), but analysis of organic residue and use-wear on these oval unifaced tools from Hinds Cave showed that at that site they were hafted knives used to slice leaves from the bulbs of desert succulents (Shafer and Holloway 1979). Animal hair in the residue matrix also indicated that the tools were used to cut almost anything. Plant residue in the form of sotol epidermis recovered from the use-worn tip of a persimmon wood digging stick from Hinds Cave confirmed its suspected use.

Overall, the environment provided the materials necessary for making the tools needed for harvesting resources or for accomplishing all necessary tasks. This was a simple, highly efficient technology that fitted the mobile way of life of the people. Few tools were curated; a mobile group would carry only essential possessions such as weapons, digging sticks, carrying baskets, tool bags with accoutrements, cradles, and, probably, petates. Other items simply were left at the habitation sites, since they could be replaced quickly at the next campsite.

SUMMARY

Archeologists who have worked in past years in the region have established an important point of departure for their present-day colleagues by establishing a sensitive cultural sequence that is keyed to artifact style change and radiocarbon dates. Research efforts of the Amistad Reservoir salvage program and continued research stimulated by that project have provided a large body of data on the kinds of sites and their distribution. Early studies focused on the ancient technology and artifacts; more recently, analysts have shifted attention to the perishable and inferential aspects of these ancient cultural systems such as the economic uses of plants and animals, dietary patterns, seasonality, resource scheduling, and systems of belief. With the help of excellent chronological control, models of environmental variability, and ecological studies, understanding of the lower Pecos Archaic world has been developed to a degree rarely experienced by archeologists for any area. Indeed, in tribute to the archeologists who have worked in the region, it can be said that the current model of the lower Pecos hunters and gatherers is the most comprehensive Archaic culture model in North America.

With a more nearly complete view of the lower Pecos River paleoenvironment, archeologists can continue to explore the ancient world with a better understanding of what the people faced and how they coped with the realities of day-to-day living. But in coping they went beyond the basic technology and subsistence aspects of their culture. They had psychological needs to meet, and, presumably, they met them in part by arriving at a satisfactory neutrality with uncertainty. Magic, religion, and witchcraft are among the ways primitive societies customarily guard against the unexpected and, at the same time, allow individuals to achieve inner strength and confidence.

The rock art of the Lower Pecos Region presumably functioned in this realm as a means of communicating ritual symbolism. Each art medium, however,, probably was created in its own specific context. Interestingly, few, if any, of the end products of the art forms were regarded as sacred, since overpainting of pictographs in the Lower Pecos Style is common, and both painted pebbles and clay figurines, discarded after use, are found in midden deposits (Shafer 1975).

The Lower Pecos Region was occupied for about 9,000 years by populations that followed essentially the same way of life. One cannot help but be impressed by the simplicity and durability of these ancient people. Indeed, their resourcefulness wins the admiration of all who become familiar with the area. What to us appears to be a marginal desert was, perhaps, to them a veritable garden.

ACKNOWLEDGMENTS

The original draft of this paper was presented at a workshop informally labeled the "Lower Pecos Think Tank" at the Witte Museum in May 1984. The "Think Tank," a concept of the museum's director Mark Lane, was a retreat attended by a group of invited scholars for the purpose of establishing a foundation for the book, *Ancient Texans*, and a permanent exhibit depicting the lifeway of the ancient lower Pecos River people. The exhibit was to use materials gathered during expeditions in the 1930s to the Lower Pecos Region sponsored by the Witte Museum (McGregor 1985). The Think Tank was the most intellectually stimulating (if not exhausting) meeting the author ever has experienced. In addition to Mark Lane, participants who shared their knowledge of hunters and gatherers or of the Lower Pecos Region are: Megan Biesele, Vaughn M. Bryant, Juan Chavira, Richard Gould, Terence Grieder, Thomas R. Hester, Roberta McGregor, Fred Valdez, George Zappler, and Jimmy Zintgraff. Others

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REFERENCES CITED

Alexander, R. K.

1970 Archeological Investigations at Parida Cave, Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* 19. The University of Texas. Austin.

1974 The Archeology of Conejo Shelter: A Study of Cultural Stability at an Archaic Rockshelter Site in Southwestern Texas. Ph.D. dissertation, Department of Anthropology, The University of Texas at Austin.

Andrews, R. L., and J. M. Adovasio

1980 Perishable Industries from Hinds Cave, Val Verde County, Texas. *Ethnology Monographs* 5, Department of Anthropology, University of Pittsburgh.

Bean, L. J., and K. S. Saubel

1972 *Temalpakh: Cahuilla Indian Knowledge and Usage of Plants.* Malki Museum Press. Morongo Indian Reservation. Banning.

Brown, K. M.

1988 Some Annotated Excerpts from Alonzo De Leon's History of Nuevo Leon. *La Tierra* 15(2):5-20.

Bryant, V. M., Jr.

1974 Prehistoric Diet in Southwest Texas: The Coprolite Evidence. *American Antiquity* 39(3):407-420.

Bryant, V. M., Jr., and H. J. Shafer

1977 The Late Quaternary Paleoenvironment of Texas: A Model for the Archeologist. *Bulletin of the Texas Archeological Society* 48:1-26.

Chaddedon, M. F.

1983 Baker Cave, Val Verde County, Texas: The 1976 Excavations. *Center for Archaeological Research Special Report* 13. The University of Texas at San Antonio.

Collins, M. B.

1969 Test Excavations at Amistad International Reservoir, Fall, 1967. *Papers of the Texas Archeological Salvage Project* 16. The University of Texas. Austin.

Covey, Cyclone

1961 *Cabeza de Vaca's Adventures in the Unknown Interior of America.* University of New Mexico Press. Albuquerque.

Creel, D. G.

1986 A Study of Prehistoric Burned Rock Middens in West Central Texas. Ph.D. dissertation, University of Arizona. Tucson.

Del Rio, P. M.

1953 A Preliminary Report on the Mortuary Cave of Candelaria, Coahuila, Mexico. *Bulletin of the Texas Archeological Society* 24:208-256.

Dering, J. P.

1979 Pollen and Plant Macrofossil Vegetation Record Recovered from Hinds Cave, Val Verde County, Texas. M.A. thesis, Texas A&M University. College Station.

Dering, J. P. and H. J. Shafer

1976 Analysis of Matrix Samples from a Crockett County Shelter: A Test for Seasonality. *Bulletin of the Texas Archeological Society* 47:209-229.

Dibble, D. S.

1967 Excavations at Arenosa Shelter, 1965-66. Mimeographed report submitted to the National Park Service by the Texas Archeological Salvage Project, The University of Texas. Austin.

Dibble, D. S., and Dessamae Lorrain

1968 Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas. *Texas Memorial Museum Miscellaneous Papers* 1. Austin.

Dibble, D. S., and E. R. Prewitt

1967 Survey and Test Excavations at Amistad Reservoir, 1964-65. *Texas Archeological Salvage Project Survey Reports 3*. The University of Texas. Austin.

Dillehay, T. D.

1974 Late Quaternary Bison Population Changes on the Southern Plains. *Plains Anthropologist* 19-65, 180-196.

Epstein, J. F.

1962 Centepede and Damp Caves: Excavations in Val Verde County, Texas, 1958. *Bulletin of the Texas Archeological Society* 33:1-130.

Graham, J. A., and William Davis

1958 Appraisal of the Archeological Resources of Diablo Reservoir, Val Verde County, Texas. Report to the National Park Service by the Archeological Salvage Program Field Office, The University of Texas. Austin.

Greer, J. W.

1965 A Typology of Midden Circles and Mescal Pits. *Southwestern Lore* 31(3):41-55.

1968 Notes on Excavated Ring Midden Sites, 1963-1968. *Bulletin of the Texas Archeological Society* 38:39-44.

Greer, J. A., and R.A. Benfer

1963 Langtry Creek Burial Cave, Val Verde County, Texas. *Bulletin of the Texas Archeological Society* 33:229-252.

Griffen, W. B.

1969 Culture Change and Shifting Populations in Central Northern Mexico. *Anthropological papers of the University of Arizona* 13. University of Arizona. Tucson.

Hall, G. D.

1986 Results of Tomb Investigations at Rio Azul, Season of 1984. In *Rio Azul Reports Number 2. The 1984 Season,* edited by R. E. W. Adams, pp. 69-110. Center for Archaeological Research, The University of Texas at San Antonio.

Heizer, R. F.

1970 A Mescal Knife from Near Overton, Moapa Valley, Southern Nevada. *Papers on the Anthropology of the Great Basin, Contributions of the University of California Archeological Research Facility* 7:28-38.

Hester, T. R.

1983 Late Paleo-Indian Occupations at Baker Cave, Southwestern Texas. *Bulletin of the Texas Archeological Society* 53:101-120.

1989 A Chronological Framework for Lower Pecos Prehistory. *Bulletin of the Texas Archeological Society* 59: 53-64.

Jackson, A. T.

1938 Picture Writing of Texas Indians. Anthropological Papers Vol. II. *The University of Texas Publication No. 3809.* Austin.

Johnson, LeRoy, Jr.

1964 The Devil's Mouth Site: A Stratified Campsite at Amistad Reservoir, Val Verde County, Texas. *Department of Anthropology Archeology Series,* 6.The University of Texas. Austin.

Kirkland, Forrest and W. W. Newcomb, Jr.

1967 *Rock Art of Texas Indians.* The University of Texas Press. Austin.

Krieger, A. D.

1956 Food Habits of Texas Coastal Indians in the Early Sixteenth Century. *Bulletin of the Texas Archeological Society* 27:57-58.

Lord, K. J.

1984 Zooarcheology of Hinds Cave (41VV456). Ph.D. dissertation, The University of Texas at Austin.

McGregor, Roberta

1985 Episodes in the History of Texas Archeology: Excavations at Shumla and Eagle Caves, Witte Museum. *Bulletin of the Texas Archeological Society* 56:127-142.

Mallouf, R. J.

1985 A Synthesis of Eastern Trans-Pecos Prehistory. M.A. thesis, The University of Texas at Austin.

Moore, W. E.

1983 Archeological Investigations at Musk Hog Canyon, Crockett County, Texas: A Report of the 1976 Texas Archeological Society Field School. *Bulletin of the Texas Archeological Society* 53:13-82.

Newcomb, W. W., Jr.

1961 *The Indians of Texas.* The University of Texas Press. Austin.

Nunley, J. P., L. F. Duffield, and E. B. Jelks

1965 Excavations at Amistad Reservoir, 1962 season. *Texas Archeological Salvage Project Miscellaneous Papers* 3. The University of Texas. Austin.

Parsons, M. L.

1965 1963 Test Excavations at Fate Bell Shelter, Amistad Reservoir, Val Verde County, Texas. *Texas Archeological Salvage Project Miscellaneous Papers* 4, The University of Texas. Austin.

1986 Painted Pebbles: Styles and Chronology. In: *Ancient Texans*, pp. 180-185. Texas Monthly Press. Austin.

Patton, Peter, and D. S. Dibble

1982 Archeologic and Geomorphic Evidence for the Paleohydrological Record of the Pecos River in West Texas. *American Journal of Science* 282:97-121.

Pearce, J. E., and A. T. Jackson

1933 A Prehistoric Rock Shelter in Val Verde County, Texas. *The University of Texas Bulletin* No. 3327. Austin.

Prewitt, E. R.

1981 Wooden Mortar from the Stockton Plateau of Texas. *Journal of Field Archaeology* 8(1):111-117.

Reinhard, K. J., J. G. Jones, and R. P. Barros

1988 Biocultural Overview of the Lower Pecos Region, Texas. In: *Health and Disease in the Prehistoric Southwest II*, edited by Stan Rhine and R. Ted Steinbock (in press). Maxwell Museum, University of New Mexico. Albuquerque.

Riskind, D. H.

1970 Pollen Analysis of Human Coprolites from Parida Cave. In Archeological Investigations at Parida Cave, Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* 19. The University of Texas. Austin.

Ross, R. E.

1965 The Archeology of Eagle Cave. *Papers of the Texas Archeological Salvage Project* 7. The University of Texas at Austin.

Saunders, J. W.

1986 The Economy of Hinds Cave. Ph.D. dissertation, Southern Methodist University. Dallas.

Service, E. R.
1966 *The Hunters* . Prentice Hall. New Jersey.

Shafer, H.J.
1975 Clay Figurines from the Lower Pecos Region, Texas. *American Antiquity* 40(2):148-157.
1977 Art and Territoriality in the Lower Pecos Archaic. *Plains Anthropologist* 22-75, 13-22.
1971 An Archeological Reconnaissance of the Sanderson Canyon Watershed, Texas. *Texas Archeological Salvage Project Survey Report* 7. The University of Texas. Austin.
1981 The Adaptive Technology of the Prehistoric Inhabitants of Southwest Texas. *Plains Anthropologist* 26-92, 129-138.
1986 *Ancient Texans*. Texas Monthly Press. Austin.

Shafer, H. J., and V. M. Bryant, Jr.
1977 Archeological and Botanical Studies at Hinds Cave, Val Verde County, Texas. Annual report to the National Science Foundation by the Department of Anthropology, Texas A&M University, pp. 1-66. College Station.

Shafer, H. J., and Richard Holloway
1979 Organic Residue Analysis in Determining Stone Tool Function. In *Lithic Use-Wear Analysis*, edited by Brian Hayden, pp. 385-400. Academic Press.

Shafer, H. J., and G. L. Moore
1976 Texas Archeological Society Field School Archeologists' Report. *Texas Archeology* 20(4):5-10.

Sobolik, K. D.
1988 The Prehistoric Diet and Subsistence of the Lower Pecos Region, as Reflected in Coprolites from Baker Cave, Val Verde County, Texas. M.A. thesis, Texas A&M University. College Station.

Sorrow, W. M.
1968a The Devil's Mouth Site: Third Season, 1967. *Papers of the Texas Archeological Salvage Project* 14. The University of Texas. Austin.
1968b Test Excavations at the Nopal Terrace Site: Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* 15. The University of Texas. Austin.

Steele, D. G., and Ben Olive
1988 Bioarcheology of Region 3 Study Area. Manuscript on file at the Department of Anthropology, Texas A&M University. College Station.

Steele, D. G., K. E. Byrd, Al McNatt, and G. Veni
1984 Human and Non-human Skeletal Remains Recovered from Sorcerer's Cave, Terrell County, Texas. *Texas Journal of Science* 36(2-3):169-184.

Stock, J. A.

1983 The Prehistoric Diet of Hinds Cave (41VV456), Val Verde County, Texas: The Coprolite Evidence. M.A. thesis, Texas A&M University. College Station.

Suhm, D. A., A. D. Krieger, and E. B. Jelks

1954 An Introductory Handbook to Texas Archeology. *Bulletin of the Texas Archeological Society* 25.

Turner, E. S., and T. R. Hester

1985 *A Field Guide to Stone Artifacts of Texas Indians.* Texas Monthly Press. Austin.

Turpin, Solveig

1982 Seminole Canyon: The Art and Archeology. *Texas Archeological Survey Research Report* 83. The University of Texas at Austin.

1984 The Red Linear Style Pictographs of the Lower Pecos River Region. *Plains Anthropologist* 29:181-198.

1985 Seminole Sink: Excavation of a Vertical Shaft Tomb, Val Verde County, Texas. *Texas Archeological Survey Research Report* 93. The University of Texas at Austin.

1986 The Red Monochrome Style: Pictographs of the Lower Pecos River Region, Texas. *Bulletin of the Texas Archeological Society* 55:123-144.

1987 Ethnohistoric Observations of Bison in the Lower Pecos River Region: Implications for Environmental Change. *Plains Anthropologist* 32(118):424-430.

Turpin, S. A., Maciej Henneberg, and D. H. Riskind

1986 Late Archaic Mortuary Practices of the Lower Pecos River Region, Southwest Texas. *Plains Anthropologist* 31(114):295-316.

Williams-Dean, Glenna

1978 Ethnobotany and Cultural Ecology of Prehistoric Man in Southwest Texas. Ph.D. dissertation, Texas A&M University. College Station.

Word, J. H., and C. L. Douglas

1970 Excavations at Baker Cave, Val Verde County, Texas. *Texas Memorial Museum Bulletin* 16. Austin.

A Chronological Framework for Lower Pecos Prehistory

Thomas R. Hester

ABSTRACT

This very brief review of the culture history of the Lower Pecos Region of Texas identifies and describes major trends and patterns during 11,000 years of prehistory. The paper provides a chronological perspective for the papers on the Lower Pecos in this issue of the *Texas Archeology Society Bulletin.*

INTRODUCTION

The Lower Pecos archeological region is one of the few areas in Texas for which there is a detailed chronological record. The preservation of organic materials suitable for radiocarbon analysis, coupled with the excellent stratigraphy in open site and rockshelter deposits, provides a remarkably precise culture history of the ancient hunter-gatherers of this area.

This paper is a brief review of the chronological framework of the Lower Pecos Region; it places into temporal perspective some of the major sites, artifact types, rock art, and other cultural patterns and phenomena. It was designed originally as a working paper to provide background material for a 1984 Witte Museum planning session on the Lower Pecos. Here, it serves as an overview of Lower Pecos archeology. Several chronological schemes have been published for the Lower Pecos (for one of the first, see Johnson 1964), and an effort has been made here (Table 1) to correlate some of the most recent ones.

THE PALEO-INDIAN PERIOD

The earliest indications of possible human occupation in the Lower Pecos come from two sites, Bonfire shelter (Dibble and Lorrain 1968; Bement 1986) and Cueva Quebrada rockshelter (41VV162A; Collins 1976, Lundelius 1984).

At the base of the Bonfire deposits, Bone Bed 1 has a variety of Pleistocene fauna, including mammoth, horse, camel, and bison. No definite evidence of human association has been found, but recent excavations by Bement (1986) have shed new light on this early deposit. Some of the faunal remains were fractured, and among the materials were several large stones that may have been carried in by humans.

The Cueva Quebrada site (41VV162A) is a small rockshelter about 4 km up the Rio Grande from the mouth of the Pecos River. Excavations of Zone I at the site exposed broken and charred animal bones, flakes, a uniface, and a late Pleistocene antelope bone with cut marks (Collins 1976). The materials have not been published fully, except for the faunal remains (see Lundelius 1984), and

Table 1. Correlation of Selected Chronologies for the Lower Pecos Region

DATE	AGE BP	PERIOD (HESTER, this paper)	INTERVAL (SHAFER 1986)	PERIOD (STORY 1966)	PERIOD/PHASE (DIBBLE in Turpin 1988)	INDEX MARKERS
1600	300	Historic	Historic	VIII	Historic	Metal points, brownware
					Infierno	
		Late			Flecha	
1000	1000	Prehistoric	Comstock	VII		Perdiz, Toyah, Livermore
		Transitional			Blue Hills	Frio, Ensor, Figueroa,Paisano
				VI		
		Archaic				
AD	2000					
BC		Late			Flanders	Shumla, Castroville, Montell
			Devils	V		
		Archaic				
1000	3000					
					San	
				IV	Felipe	Langtry, Val Verde
2000	4000		Pandale			
		Middle				
					Eagle	
		Archaic				
3000	5000			III	Nest	Pandale

4000	6000	Early Archaic	Baker			Baker, Bandy, Gower, Early Barbed (Bell), Early Triangular
5000	7000				Viejo	
				II		
6000	8000	Late Paleo-Indian				Angostura
7000	9000		Golondrina			Golondrina
					Oriente	
8000	10000	Early Paleo-Indian	Plainview	I		Plainview, Folsom
					Bonfire	
			Folsom			
9000	11000		Clovis			Clovis
10000	12000				Aurora	

the radiocarbon assays of 11,970 to 12,350 B.C., which imply a pre-Clovis age, have not been evaluated in terms of a late Pleistocene human occupation of the shelter. In an overlying stratum, Zone II, were additional burned and broken bones, 10 chert flakes, and a Clear Fork tool—a gougelike form (M. B. Collins, personal communication). A radiocarbon determination of 10,330 B.C. was obtained, but, again, a full review of this date, and the possibly associated artifacts from Zone II, has yet to be published.

No occupation or kill sites of the Clovis complex have been found in the Lower Pecos Region, but it is possible that Bone Bed I at Bonfire, upon further examination, might be linked to this cultural pattern. Some scattered surface finds of Clovis-like points have been made in the Val Verde County area (Greer 1968).

The Folsom complex is documented in Bone Bed 2 (Figure 1, a) at Bonfire shelter (Dibble and Lorrain 1968). Indeed, the bone bed in which was a classic Folsom point (Figure 1, a) represents a bison drive involving perhaps as many as 27 animals (though some of these may be from a later drive in Plainview times). Radiocarbon dates indicate that the Folsom activity took place around or before 8200 B.C. (Dibble 1970). Another Folsom point from Val Verde County (Figure 1, b) has been described by Bement and Turpin (1988).

Later Paleo-Indian complexes are more numerous in the Lower Pecos. Referring again to the research published for Bonfire shelter, we read of a Plainview complex bison kill, dated at about. 8200 to 8000 B.C. (Figure 1, c is a point from this kill). At the Devils Mouth site, at the confluence of the Devils River and the Rio Grande, Late Paleo-Indian points were found in gravel bar deposits in Area C (Johnson 1964). These include distinctive specimens such as Plainview and Angostura as well as a type originally defined as the Golondrina "variant of Plainview" (Figure 1, e). Projectile points now called Early Stemmed (Figure 1, d) also were found associated with these lanceolate forms.

Subsequent excavations at Devils Mouth by Sorrow (1968) provided more information on the Late Paleo-Indian era, especially on the dating of what is now called the Golondrina type (Figure 1, e), which was dated at 6820 B.C. on the basis of a single radiocarbon assay. At about the same time, James H. Word's excavations at Baker Cave, on a tributary of the Devils River, exposed stratigraphically secure deposits that had Golondrina points associated with faunal and floral remains. He obtained two radiocarbon assays of about 7000 B.C. for the Golondrina zone (Word and Douglas 1970). Later excavations in 1976 at Baker Cave by Hester and Heizer, led to the recovery of more Golondrina data (Chadderdon 1983). Hester (1983) has defined the Golondrina complex, which was represented at Baker Cave by Golondrina points, a bifacial Clear Fork tool, other lithic implements, and a hearth that yielded abundant floral and faunal remains—all deposited when the climate was somewhat more moist than today and when there was a notable absence of modern-day xeric plants such as sotol and lechuguilla. Two more radiocarbon dates of about 7000 B.C. have been obtained from the Golondrina occupation.

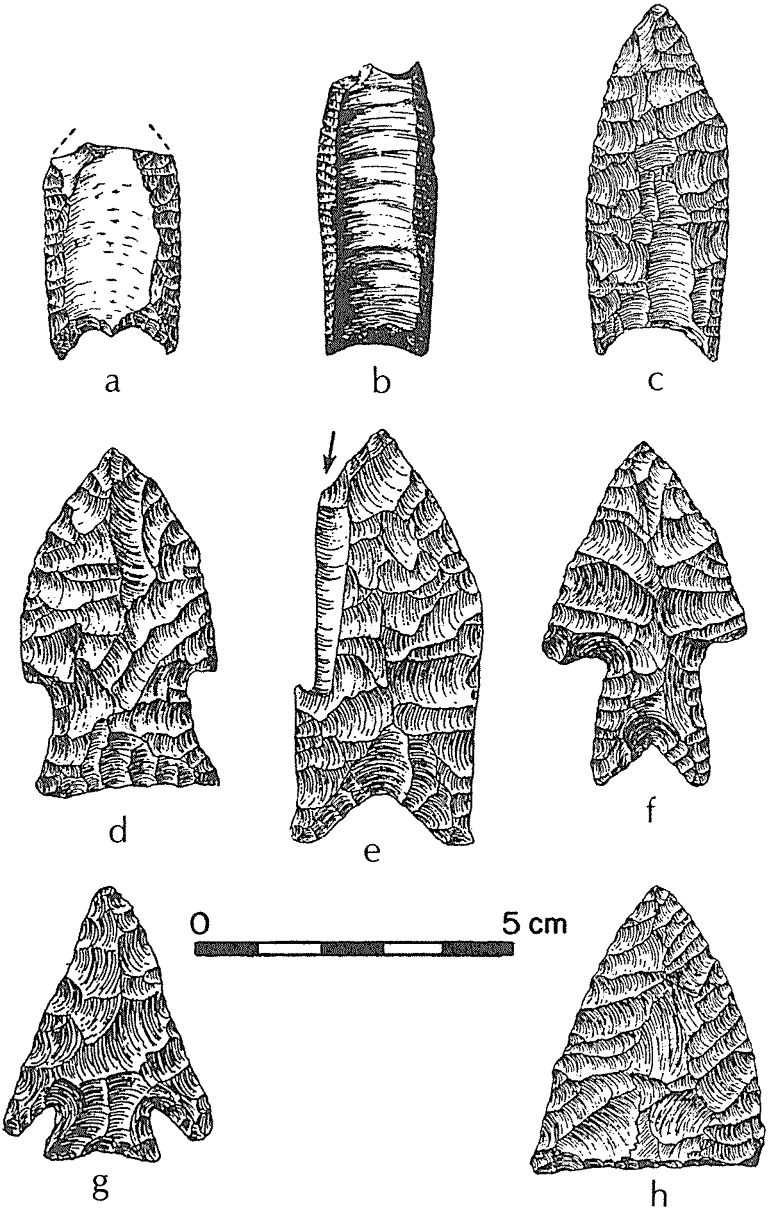

Figure 1. Projectile points typical of Paleo-Indian and Early Archaic occupations in the Lower Pecos: a, b, Folsom; c, Plainview; d, Early Stemmed; e, Golondrina; f, Baker; g, Bandy; h, Early Triangular. Provenience: a, c, Bonfire; b, possibly Hinds Cave; d, e, Devils Mouth; f, g, Witte Museum lower Pecos collections; h, Early Triangular point from Uvalde County (Turner and Hester 1985) resembles Baker Cave specimens. All drawings except b are by Kathy Roemer, courtesy of Turner and Hester (1985); b was drawn by Richard McReynolds *(La Tierra*, Vol. 15, No. 1, 1988).

Other early radiocarbon assays in the 6000 to 7000 B.C. range have come from sites such as Coontail Spin and Eagle Cave (Ross 1965, Story 1966) and from Arenosa shelter. However, the contexts of these dates and the associations of artifacts remain unclear, particularly in the case of Arenosa (e.g., Patton and Dibble 1982). At Hinds Cave, excavated by Shafer and Bryant (1977), more early radiocarbon dates have been recorded, and a Golondrina occupation (and possibly earlier material) is reported. Important to the culture history of the Lower Pecos is establishment of the antiquity of the basketry and other perishable materials found in the earliest occupations. These have been studied by Andrews and Adovasio (1980) and integrated into broad patterns of early textile manufacture in northern Mexico and the western United States.

Perhaps indicative of the terminal Paleo-Indian era in the Lower Pecos is the Angostura point (cf. Johnson 1964, Story 1966). An Angostura point was found in association with a hearth during the 1984 excavations conducted at Baker Cave by the author, James H. Word, and Kenneth M. Brown, and as yet unpublished. The hearth was at the base of a stratified series of cooking pits associated with Middle and Early Archaic occupations. A charcoal sample collected by Brown from the hearth that had the associated Angostura point was dated by radiocarbon assay at 6510±80 B.P. (Beta-14733), which can be calibrated within a range of 5705 to 5205 B.C. (Klein et al. 1982:126) .

THE ARCHAIC PERIOD

Early Archaic

This era encompasses Early Holocene occupations from about 6000 B.C. (or earlier) to around 3500 B.C. (or somewhat later). It is distinguished, in terms of diagnostic point types, by Baker and Bandy points, "Early Barbed" (many resembling the Bell type), Gower, and Early Triangular (Figure 1, f-h). All of these have what the author perceives to be contemporary counterparts in Central and southern Texas, and they apparently reflect a broad Early Archaic cultural pattern—once called the Pre-Archaic (Hester 1983)—that did not become associated with a particular region until Middle Archaic times. Radiocarbon dates are fairly numerous, but, as indicated above, there is some fluctuation in what are considered the beginning and ending dates for the period. Examples of radiocarbon dates include Baker Cave (6010 to 3000 B.C., Chadderton 1983), Eagle Cave (6810 to 2930 B.C., Ross 1965, Story 1966), and Bonfire shelter (5510 B.C., Ross 1965, Story 1966). Xeric plants such as sotol and lechuguilla appear at Baker Cave at about 6000 B.C., and, at Hinds Cave to the west on the Pecos River drainage, even earlier.

Coprolite studies at Hinds Cave have shed considerable light on the diet of the Early Archaic people (Shafer 1986:74). Little is known about burial patterns, but Turpin (1985) has reported the use during the Early Archaic of a sinkhole in Seminole Canyon for multiple interments that had an "early corner notched" point (cf. Baker) associated. Bement, in the same volume (Turpin 1985:41-43), provides a detailed review of Early Archaic deposits with associated radiocarbon assays in the Lower Pecos.

Middle Archaic Period

The early phase of the Middle Archaic is distinguished by the first regional Lower Pecos cultural pattern, noted in the archeological record by a distinctive index marker, the Pandale projectile point type (Figure 2, a). Radiocarbon dates, many of which fall between 2700 and 2100 B.C., are available for the Pandale-related materials from several sites (Baker Cave, Eagle Cave, Fate Bell, and Arenosa). Items of material culture such as basketry, matting, dart shafts, cordage, and netting are particularly well preserved. At Baker Cave, a large refuse pit containing worn-out sandals, discarded Pandale points, and other debris was partially excavated (Chadderdon 1983). In the early phase there is also a wide range of chipped and ground stone artifacts. Painted pebbles appear at this time, if not somewhat earlier (Shafer 1986).

The late phase of the Middle Archaic is perhaps the most distinctive and dominant occupational period in the Lower Pecos in terms of the sheer amount of cultural refuse. Characterized by contracting-stem Langtry points (Figure 2, b), and Val Verde points (Figure 2, c), which appear to postdate Langtry points, the late Middle Archaic has been dated by radiocarbon determinations between 2100 and 1100 B.C. The Langtry type appears to change in stem form through time at some sites, e.g. at Baker Cave (Word and Douglas 1970, James H. Word, personal communication). Other point styles include Almagre (probably unfinished Langtrys or Langtry preforms) and Arledge.

Almost all rockshelters have deposits of the Middle Archaic's late phase; radiocarbon assays have been made on materials from Fate Bell and Arenosa shelters, and Eagle and Centipede caves, among others (Story 1966, also Epstein 1963). There is an abundance of fiber, wood, bone, shell, and leather artifacts, and a wide range of lithics—projectile points and preforms, thin bifaces used as knives, unifacial scrapers, burins, and artifacts of ground stone. Painted pebbles also are found, and it is likely that much of the Pecos River Style polychrome art was executed during this phase of the Middle Archaic (Shafer 1986, Bement 1988).

Other types of sites also are commonly found in addition to rockshelters; open occupation sites on terraces were heavily used. Burned rock midden sites, which represent specialized plant processing areas, probably reflect a technology that was prevalent in Central Texas at the same time.

Late Archaic Period

The Middle Archaic appears to have been uniquely regional in character, whereas the Late Archaic reflects influences from Central Texas and from areas to the north. For example, during this period, bison—absent since the late Paleo-Indian period—once again were in the Lower Pecos region in some numbers,

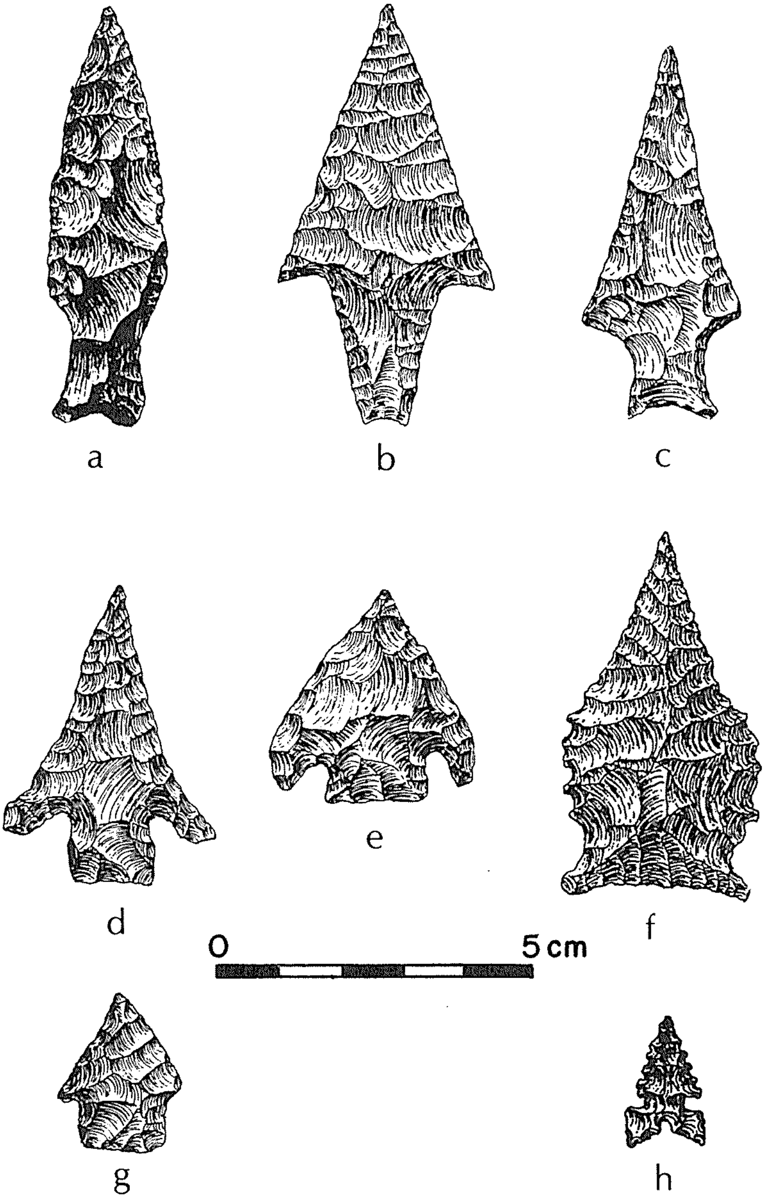

Figure 2. Projectile points typical of Archaic and Late Prehistoric occupations in the Lower Pecos: a, Pandale (early Middle Archaic); b, Langtry; c, Val Verde (late Middle Archaic); d, Shumla; e, Conejo (Late Archaic); f, Paisano; g, Figueroa (Transitional Archaic); h, Toyah (Late Prehistoric). All drawn by Kathy Roemer, courtesy of Turner and Hester (1985).

and a bison drive and kill has been recorded in Bone Bed 3 at Bonfire shelter (Dibble and Lorrain 1968). Associated with the bison bones were large, broad-bladed Castroville and Montell dart points. Projectile point styles of this era that are distinctive of the Lower Pecos are the Shumla type (Figure 2, d) and Conejo type (Figure 2, e). In general, the Late Archaic is dated between 1000 B.C. and the beginning of the Christian era (but see Turpin 1982:25 for a slightly different view). Dates of 360 to 800/860 B.C. come from the bison kill at Bonfire; other radiocarbon dates come from Coontail Spin and Fate Bell shelter (Story 1966). Perishable materials, chipped and ground stone artifacts, and other items of material culture characteristic of the Middle Archaic persist, albeit sometimes in different form, into this period. Turpin (1982:195, 198) indicates that the Red Linear Style of rock art was introduced into the Lower Pecos at about this time, noting that hunting motifs, perhaps related to the movement of bison hunters into the area (e.g., into Bonfire shelter, Bone Bed 3), are its central theme.

Transitional Archaic Period

This period is sometimes combined with the Late Archaic (see Table 1). However, it is identified by distinctly different index marker projectile points, such as Ensor, Frio, Paisano (Figure 2, f), and Figueroa (Figure 2, g) and can be dated to the period between the first or second century of the Christian era and about A.D. 1000 or somewhat later. Transitional Archaic deposits are widespread in rockshelters and open terrace sites in the Lower Pecos. Indeed, there may have been an intensified use of open sites at this time. The distinctive ring- or crescent-shaped burned rock middens (see Shafer 1986), which presumably were related to the roasting of bulbs of desert plants, are found in the uplands during the Transitional Archaic. Painted pebbles, found in the rockshelter refuse, and, perhaps, the Red Linear Style rock art, continue.

LATE PREHISTORIC PERIOD

From around A.D. 1000 to 1600 there is a notable difference in certain aspects of Lower Pecos archeology. There seems to have been a reduction in occupation (even of population?), or perhaps there was a shift away from intensive use of rockshelters to a more mobile life style that led to frequent use of open terrace and upland sites. Change in material culture is most notable in the introduction of the bow and arrow. Arrowpoint types include Perdiz, Scallorn, Livermore, and Toyah (Figure 2, h), as well as several minor styles and arrowpoint preforms. Sherds of plain, bone-tempered ceramics are found at a handful of sites, but never in large numbers. Other traits include distinctive end scrapers (Bement and Turpin 1987), brownware sherds (Turpin 1982), and beveled knives (Greer 1968).

Depictions of the bow and arrow in the Red Monochrome rock art style clearly date that style to the Late Prehistoric. Although it is probably safe to say that an "Archaic" style hunting and gathering lifeway persisted from earlier times, it is possible that the age-old traditions of the Lower Pecos region were disrupted in the Late Prehistoric, perhaps by new groups moving into the region. The shifts in settlement pattern (which, owing to the bias for excavation of rockshelters, we know little about), the appearance of new types of sites such as Infierno (41VV446), with its stone tipi rings (Turpin 1982), and the introduction of a new rock art style, might together indicate disruption of the indigenous groups by intrusive peoples. The Late Prehistoric materials often form, quite literally, a thin veneer over the long-lived Archaic. Much more research is needed in practically every facet of study involving this period.

HISTORIC PERIOD

Equally little is known about the succeeding Historic period, when Apache and, later, other Indian groups from various regions moved into the Lower Pecos. Fielder Canyon Cave reported by Kirkland in 1942 (Kirkland 1942) remains one of the few Historic Indian occupation sites that have been reported. In addition to a few scattered metal arrowpoints, these groups left behind only their distinctive rock art depicting Spaniards, guns, missions, and priests (Kirkland and Newcomb 1967, Turpin 1989). A recent paper of Turpin's (1987) presents a detailed review of the ethnohistoric problems surrounding the study of the Historic Indians of the Lower Pecos region.

REFERENCES CITED

Andrews, R. L., and J. M. Adovasio

1980 Perishable Industries from Hinds Cave, Val Verde County, Texas. *Department of Anthropology, University of Pittsburgh, Ethnology Monographs* 5.

Bement, L. C.

1986 Excavation of the Late Pleistocene Deposits of Bonfire Shelter, Val Verde County, Texas. *Texas Archeological Survey, The University of Texas at Austin. Archeology Series* 1.

1988 The Lower Pecos Canyonlands. In *A Cultural Resources Overview of Region 3, Southwest Division, Corps of Engineers*, by T. R. Hester et al. In press. Arkansas Archeological Survey, Fayetteville.

Bement, L. C., and S. A. Turpin

1987 Technological Continuity and Functional Change: The Case of the Dorso End Scraper. *Plains Anthropologist* 32(116):191-196.

1988 A Folsom Point from Hinds Cave, 41VV456, Val Verde County, Texas. *La Tierra* 15(1):5-7.

Collins, M. B.

1976 Terminal Pleistocene Cultural Adaptations in Southern Texas. *IX Congress of Prehistoric and Protohistoric Sciences, Colloque XVII*:120-135, Nice.

Chadderdon, M. F.
1983 Baker Cave, Val Verde County, Texas: The 1976 Excavations. *Center for Archaeological Research, The University of Texas at San Antonio. Special Report* 13.

Dibble, D. S.
1970 On the Significance of Additional Radiocarbon Dates from Bonfire Shelter. *Plains Anthropologist* 15(50):251-254.

Dibble, D. S., and Dessamae Lorrain
1968 Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas. *Texas Memorial Museum, Miscellaneous Papers* 1.

Epstein, J. F.
1963 Centipede and Damp Caves: Excavations in Val Verde County, Texas, 1958. *Bulletin of the Texas Archeological Society* 33 (for 1962):1-130.

Greer, J. W.
1968 Some Unsual Artifacts from Val Verde County, Texas. *Texas Journal of Science* 20(2):183-192.

Hester, T. R.
1983 Late Paleo-Indian Occupations at Baker Cave, Southwestern Texas. *Bulletin of the Texas Archeological Society* 53:101-120.

Johnson, LeRoy, Jr.
1964 The Devil's Mouth Site: A Stratified Campsite at Amistad Reservoir, Val Verde County, Texas. *Department of Anthropology, University of Texas. Archeology Series* 6.

Kirkland, Forrest
1942 Historic Material from Fielder Canyon Cave. *Bulletin of the Texas Archeological and Paleontological Society* 14:61-71.

Kirkland, Forrest, and W. W. Newcomb, Jr.
1967 *The Rock Art of Texas Indians.* University of Texas Press, Austin.

Klein, J., J. C. Lerman, P. E. Damon, and E. K. Ralph
1982 Calibration of Radiocarbon Dates. *Radiocarbon* 24(2):103-150.

Lundelius, E. L., Jr.
1984 A Late Pleistocene Mammalian Fauna from Cueva Quebrada, Val Verde County, Texas. In *Carnegie Museum of Natural History. Special Publication* 8:456-481.

Patton, P. C., and D. S. Dibble
1982 Archeologic and Geomorphic Evidence for the Paleohydrologic Record of the Pecos River in west Texas. *American Journal of Science* 282:97-121.

Ross, R. E.
1965 The Archeology of Eagle Cave. *Papers of the Texas Archeological Salvage Project* 7.

Shafer, H. J.
1986 *Ancient Texans: Rock Art and Lifeways Along the Lower Pecos.* Photographs by Jim Zintgraff. Texas Monthly Press, Austin.

Shafer, H. J., and V. M. Bryant
1977 Archeological and Botanical Studies at Hinds Cave, Val Verde County, Texas. *Anthropology Laboratory, Texas A&M University, Special Series* 1.

Sorrow, W. S.
1968 The Devil's Mouth Site: The Third Season, 1967. *Papers of the Texas Archeological Salvage Project* 14.

Story, D. A.
1966 Archeological Background. In D. A. Story and V. M. Bryant, eds., A Preliminary Study of the Paleoecology of the Amistad Reservoir Area, pp. 7-30. Report submitted to the National Science Foundation.

Turner, E. S., and T. R. Hester
1985 *A Field Guide to Stone Artifacts of Texas Indians.* Texas Monthly Press, Austin.

Turpin, S. A.
1982 Seminole Canyon: The Art and the Archeology. *Texas Archeological Survey, The University of Texas at Austin. Research Report* 88.

1984 The Red Linear Style Pictographs of the Lower Pecos River Region. *Plains Anthropologist* 29(105):181-188.

1987 Ethnohistoric Observations of Bison in the Lower Pecos River Region: Implications for Environmental Change. *Plains Anthropologist* 32(118):424-430.

1989 The Iconography of Contact: Spanish Influence on the Rock Art of the Middle Rio Grande. In *Columbian Consequences Vol. I, Archaeological and Historical Perspectives on the Spanish Borderlands West*, ed. by D. H. Thomas, pp. 277-299. Smithsonian Institution, Washington, D. C.

Turpin, S. A., compiler
1985 Seminole Sink: Excavation of a Vertical Shaft Tomb, Val Verde County, Texas. *Texas Archeological Survey, The University of Texas at Austin. Research Report* 93.

Word, J. H., and C. L. Douglas
1970 Excavations at Baker Cave, Val Verde County, Texas. *Texas Memorial Museum Bulletin* 16.

The Live Oak Hole Complex: Plains Indian Art and Occupation in the Lower Pecos River Region

Solveig A. Turpin and Leland C. Bement

ABSTRACT

A search for historic Indian occupation sites in the Lower Pecos River Region, centered on demonstrably postcontact pictographs, resulted in the recording of several circular stone features near Live Oak Hole, where a rock art panel was painted between A.D. 1700 and 1775. Site 41VV828 was surveyed, surface collected, and mapped with computer-aided photographics. One intact feature, a possible Plains Indian stone ring, was excavated. Two artifacts of equivalent age, a Guerrero arrowpoint and a ceramic fragment, were exposed on the surface of the site and cannot be related to any of the stone features or the pictograph panel. The sparsity of artifactual material may be attributable to the mobility of the horse nomads of this era and to severe erosion of the shallow site deposits.

INTRODUCTION

Most of archeological research in the Lower Pecos River Region has concentrated on Archaic-age material culture preserved in dry rock shelter deposits and in the spectacular pictographic sequence. The total evidence for historic Indian occupation of this region consists of one rockshelter reported by Kirkland (1942), scattered metal arrowpoints (Parsons 1962; files of the Texas Archeological Research Laboratory), scanty ethnohistoric references (Griffen 1969, Daniel 1955), and 15 rock art panels (Turpin 1989) (Figure 1). The need for more detailed studies of the protohistoric and historic periods became apparent during a recent synthesis of the historic pictographs (Turpin 1989). On the premise that the best place to search for camp sites of this age was in the vicinity of the postcontact pictographs, in 1986 the area surrounding several known historic panels was surveyed. At Live Oak Hole, 41VV169, a series of sites consisting of stone circles—features usually identified as tipi rings on the Great Plains—was recorded.

In addition to the well-known pictograph (Jackson 1938, Kirkland and Newcomb 1967, Grieder 1966), Graham and Davis (1958) had recorded one burned rock midden, 41VV170, slightly upstream from the pictograph site. Newly recorded were 41VV827, comprising two stone circles and a burned rock midden above the pictograph; 41VV828, comprising four stone circles, a cairn, and extensive burned rock middens across the creek; and 41VV844, disturbed stone features and a dense lithic scatter above 41VV170, upstream and across a small tributary from the pictograph (Figure 2). The recovery of one small

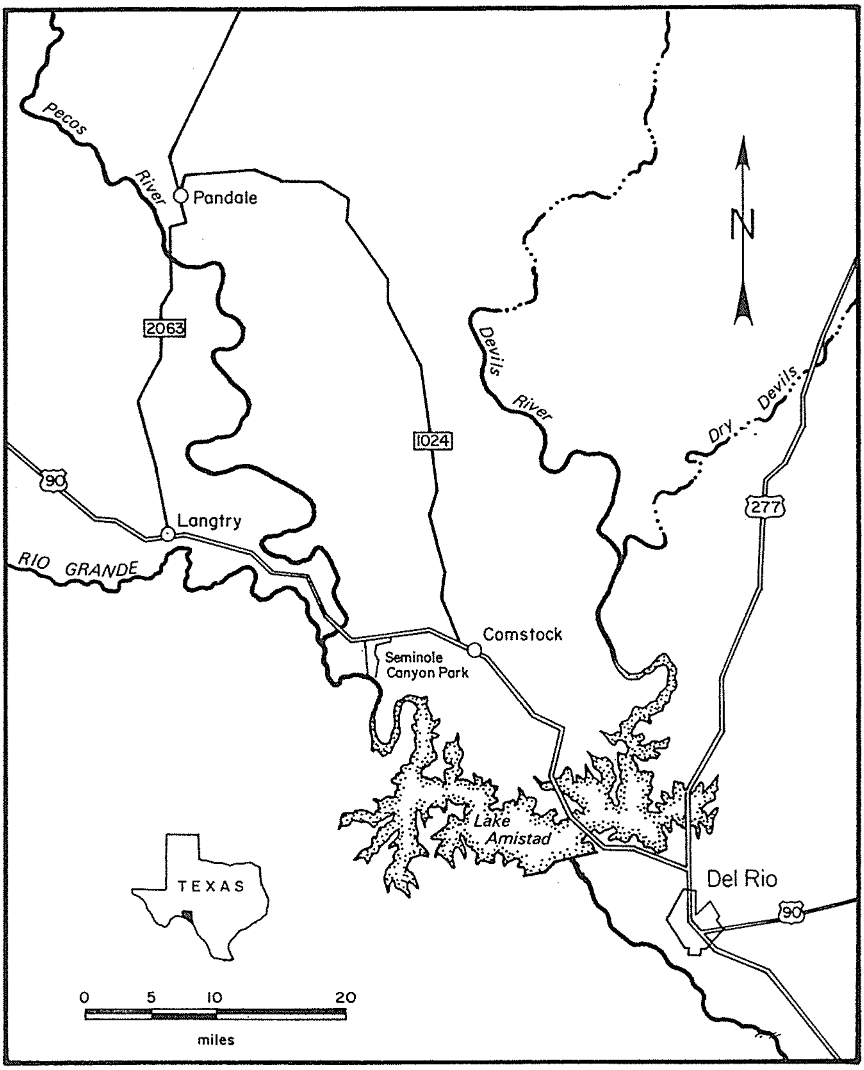

Figure 1. Map of the Lower Pecos River Region of Texas.

fragment of plain brown pottery from one stone circle at 41VV828 confirmed the late date of at least one component at that site. Another stone circle at this site was substantially intact and retained sediments sufficient to have buried artifactual material within and adjacent to the ring. This feature seemed to hold potential for the recovery of more evidence of a historic period occupation and was selected for excavation.

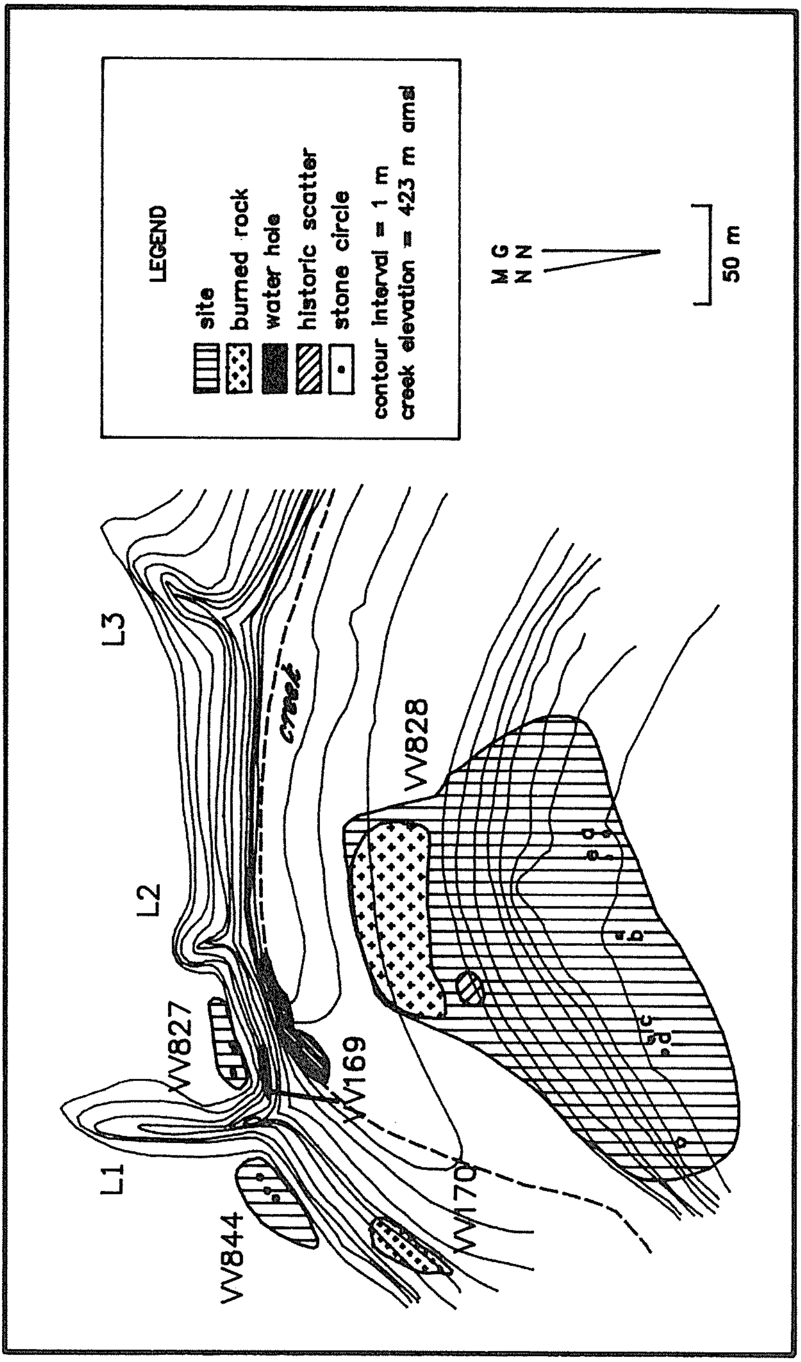

Figure 2. Topographic map of the Live Oak Hole complex, Val Verde County, Texas.

THE LIVE OAK HOLE SITE COMPLEX

Live Oak Hole is a permanent tinaja on a long, meandering tributary of the Rio Grande east of the mouth of the Pecos River. The tinaja abuts the limestone bluff on the outside of a horseshoe bend in the creek. Three entrenched tributaries (L1, L2, and L3) cut through the bluff on the left bank (Figure 2). A smaller water hole is contained within the uppermost (L1) tributary. The right bank stairsteps down from a rounded hilltop, creating level benches above the stream. The surrounding countryside is rolling hills cut by relatively gentle drainageways that eventually entrench nearer the Rio Grande.

Soils in this area are stony residual sediments, deflated and eroded to bedrock on the level benches. The creek bottom is mobile gravel, washed and scoured by recurrent discharge. The slopes are rocky scree gravels. The vegetation is typical desert scrub, its growth intensified by abnormally abundant recent rainfall.

41VV169, Live Oak Hole

A shallow overhang, protected by roof fall across the front, lies under the left bank at a corner formed by the confluence of the L1 tributary and the creek (Figure 2). The cultural deposits in the shelter are eroded and vandalized. Bedrock mortars, burned rock, flint flakes, mussel shell, a large metate, and, above all, the pictographs testify to former occupation of the shelter.

The Pictograph at Live Oak Hole

The pictograph at Live Oak Hole, 41VV169, has been known to students of Lower Pecos rock art for 50 years (Kirkland and Newcomb 1967:Plate 52, Jackson 1938:Site 195, Figure 195; Graham and Davis 1958, Grieder 1966:34), but its historic importance has been overlooked. All previous descriptions remark about the length of the serpentine line that traverses the shelter wall (Figure 3); more than 13 meters (44 feet) long, this undulating red streamer originates in three concentric circles and ends in a trident. Above and below are monochromatic deer and geometric designs, and next to the concentric circles stands a small, frontally posed stick figure. All of these designs are roughly of the same soft red hue and are probably contemporaneous. Superimposed on the small stick figure is a larger, darker red rectangular-bodied male figure with pronounced genitals and half-painted face. The frontal half of a horned animal—bison or cow—faces the larger man. Central in the shelter, above the undulating line, is a triangular-bodied bison with horns, beard, and hooks for hooves painted in the same dark red. Below, on the downstream corner of the shelter wall, are two bright red miniature figures. One stands facing the viewer; the other, in profile astride a horse, carries a lance that is longer than his steed.

The serpentine line, deer, and smaller stick human are not easily dated, but they would not be out of place in an Archaic context. The small, square geometric design could belong to the Bold Line Geometric style, estimated to be of Late

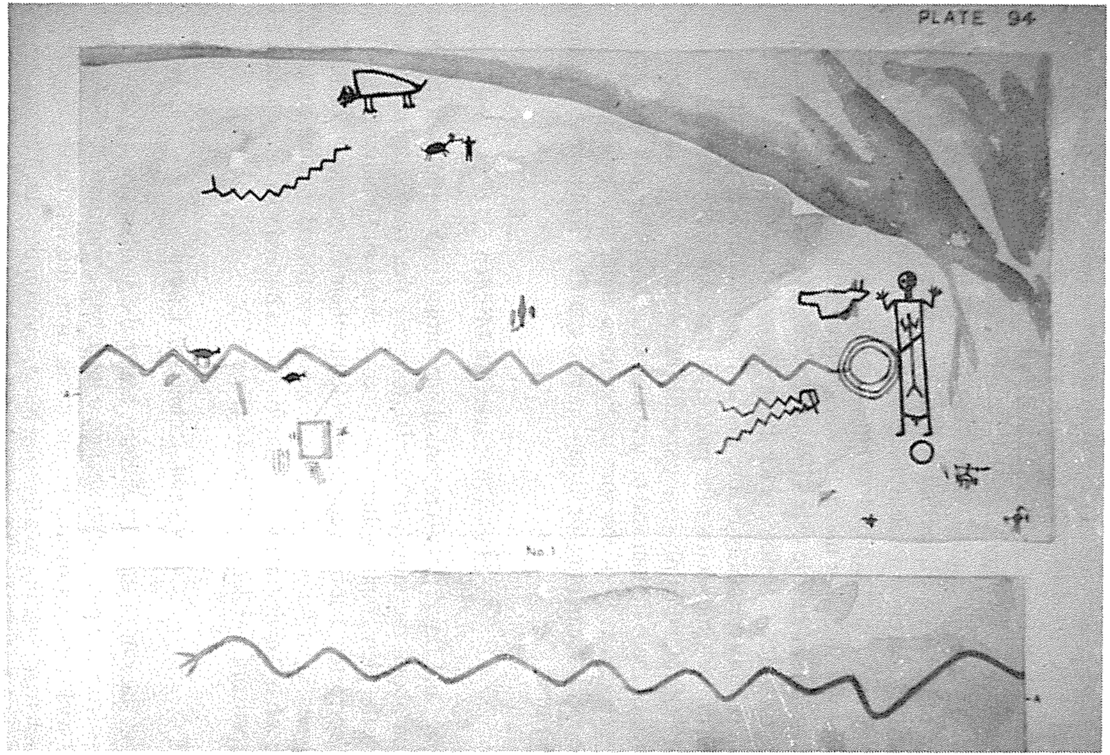

Figure 3. Photograph of Kirkland's reproduction of the pictograph at Live Oak Hole; scale 1:48. (Photograph courtesy of the Texas Memorial Museum.)

Prehistoric age (Turpin 1986). The small horse and rider are undoubtedly historic; their companion figure is probably of the same age. The triangular bison and the largest human figure are stylistically akin to iconography characteristic of the Northern Plains between A.D.1700 and 1775 (Keyser 1987). Static, rectangular bodied figures are attributed to the late prehistoric Ceremonial style, dated from A.D. 1000 to 1700, and the protohistoric transition to the Early Biographic style between A.D. 1625 and 1775 (Keyser 1987). The rectangular male and triangular bison of Live Oak Hole bear a strong resemblance to figures at North Cave Hills in South Dakota (Keyser 1987:Figure 3f).

The advent of the Plains Indians in the Lower Pecos Region presumably transpired after the Great Pueblo revolt of 1680. By 1729, Berroterán, who was leading a punitive and exploratory mission to the Lower Pecos Region, commented that the area was under the domination of Apache, Jumanos, and Pelones, all fierce and hostile tribes (Weddle 1968:200). The ethnohistory and the stylistic similarities, therefore, place the pictograph at Live Oak Hole within the eighteenth century, probably before 1775. Although the Apache were in control of the area at this time, neither the pictograph panel nor any of the surrounding sites can be attributed firmly to any specific ethnic group. The recognition of the historic age of these human and animal figures at Live Oak Hole, however, led to our intensive survey of the surrounding area under the assumption that the best place to start searching for historic period camps was in the vicinity of their pictograph sites.

41VV170, Live Oak Midden

Graham and Davis (1958) recorded one burned rock midden in the floor of the canyon above the mouth of the L1 tributary that marks the upper end of 41VV169, the pictograph shelter. The plotting of the site location in the TARL files was corrected, but little could be added to their description. The midden is scoured by each discharge down the creek and is scattered into the creek bed, so it no longer has any distinctive morphology. This burned rock accumulation lies slightly upstream and below 41VV844 (Figure 2).

41VV844, Robertson Camp

On the flat rim of the L1 tributary, above the smaller tinaja and 41VV170 and across from the pictograph shelter, a large site composed of several highly disturbed rock features overlooks the creek from the left bank (Figure 2). A rough ranch road, leading to a hunting blind, ends on the site. The placement of the blind, which, incidentally, is anchored by large blocks borrowed from the features, testifies to the broad view of the surrounding countryside commanded by the site. A dense lithic scatter, exposed on the barren limestone, included burned rock, flakes, biface fragments, and several projectile points. Langtry, Shumla, Ensor, Frio, and Figueroa dart points and four arrowpoints of differing morphology reflect occupation from Middle Archaic to Late Prehistoric or historic times, with the more recent types predominating.

41VV827, Live Oak Camp

On the bluff, between the L1 and L2 tributaries and above the pictograph shelter, are two highly disturbed stone rings, a small burned rock scatter, and moderately dense lithic debris, mostly near the burned rock scatter. At present, the rock features are two abutting circular piles of angular blocks, with a larger pile paralleling the rim of the canyon. The dispersed midden is some 10 meters northwest of the stone features. Two Ensor points were found during the survey on the western periphery of the rings, midway between them and the midden, and one Montell point was recorded on the slope near the burned rock scatter.

41VV828, The Tonto Site

The Tonto site, 41VV828, lies on the right creek bank, opposite the water hole and pictograph. On initial survey, four relatively intact stone rings, a cairn, and dense lithic debris on the second bench above the creek met expectations for the layout of a historic aboriginal campsite. Temporal diagnostics recorded during the survey included Uvalde and Late Archaic dart points, three arrow-point fragments, and one small fragment of plain brown pottery associated with one of the rings.

Site Features

Five stone features, a historic debris area, and a series of burned rock middens were mapped at 41VV828 (Figure 2). A long, linear concentration of burned rock, fire-darkened soil, and flint debris parallels the creek at the base of the slope opposite the permanent water hole in the canyon bottom. This low-lying, densely occupied area has been frequently subjected to high water flooding and erosion. The rich soil and high moisture content have promoted the growth of dense, thorny brush, so a veritable scrub thicket extends some 80 meters along this inside meander of the creek. A second burned rock concentration lies on the second bench above the creek at the west end of the site. Projectile point styles probably related to the midden areas include Uvalde, Langtry, Shumla, Marshall, and Ensor, covering the entire span of the Archaic Period.

A cluster of historic trash—glass, ceramics, and metal scraps—lies opposite the water hole on the first bench above the creek bed. Nothing of singular merit or great antiquity was noted. Such debris concentrations are common in these settings, since they were favored camping locations for shepherds, hunters, and ranch workers.

The five aboriginal features of possible Late Prehistoric to Historic age are four complete or partial rings of stone and one rectangular cairn. All lie on the second bench above the creek on deflated and eroded surfaces.

Feature E

Feature E—the cairn—consists of 17 large and about a dozen smaller rocks in a pile 60 cm tall, 1.3 meters on the north-south axis, and 1 meter on the east-west axis. The longer dimension can be attributed to collapse of a once-taller pile. The function of this cairn is problematical, but its antiquity is apparent in the dense lichen growth and discoloration of the exposed surfaces.

Feature D

Two contiguous rock ovals lie side by side on the west end of the second bench above the creek. One has eroded to bedrock; the other is filled with sediments that support thorny scrub. The original configuration of the structures is not easily discerned, but this is the area of densest lithic debitage, perhaps because of its proximity to a burned rock midden. A few burned rocks are trapped against the west edge of the feature.

Feature C

Two parallel lines of rock are aligned roughly north and south. C-east is a pile, consisting of 22 rocks, 3.2 meters long and 1.5 meters wide. C-west, separated from C-east by a gap 1.3 meters wide, is 1.9 meters long and 1.3 meters wide. Scattered blocks on the south end suggest that this feature was originally an oval ring. The one fragment of plain brownware found during site recording was next to a block in C-west.

Feature B

A semicircle of approximately 55 contiguous rocks from 2 to 5 blocks thick lies on exposed bedrock 50 meters east of Feature C. The largest component block measures 35 by 30 by 14 cm. The interior diameter of this crescentic feature is 2.6 meters; the exterior 3.8 meters. The horseshoe opens 50 degrees west of north. Minimal sediment is entrapped within the rock pile. Dense lichen growth and in situ cracking of blocks testify to considerable antiquity for this feature.

Feature A

The most intact ring, Feature A, is on the eastern edge of the upper site area, 50 meters east of Feature B (Figure 2). A double ring of 71 large blocks forms a circle 2.5 meters in diameter (Figure 4). The component blocks are massive, the largest measuring 94 cm along its longest dimension. A few blocks have been displaced into the interior of the ring. An opening, 50 cm wide, faces south. The apparent integrity of the stone structure and the sediments trapped within suggested that excavation might confirm the estimated historic age of this feature. Between February 12 and 14, Michael W. Davis, David G. Robinson and Jeff Turpin joined Bement and Turpin to excavate the interior of Feature A.

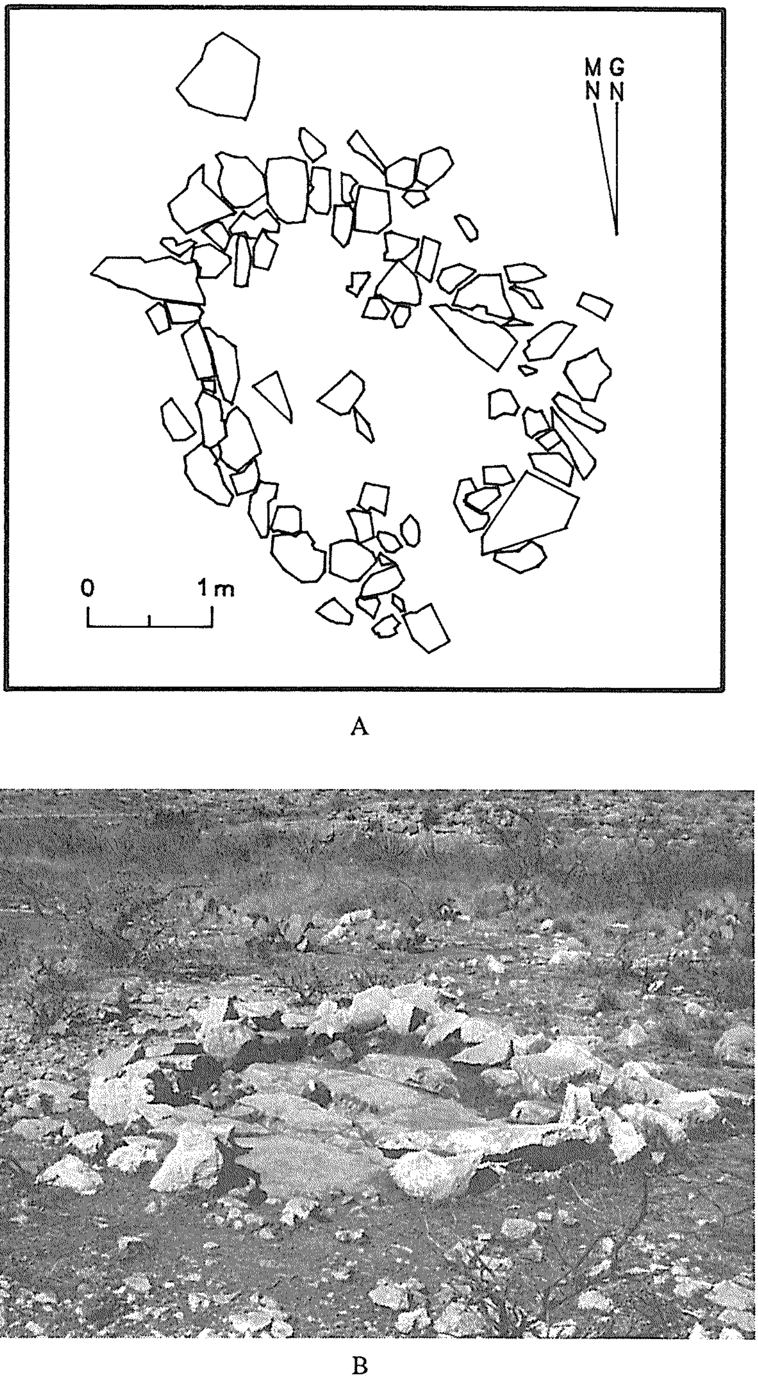

Figure 4. Plan (A) and photograph (B) of stone ring, Feature A, at the Tonto site (41VV828).

Methods

The site was first mapped with transit and stadia rod to establish the locations of all features and the site's relationship to adjacent sites 41VV169, 41VV170, 41VV827, and 41VV844 (Figure 2). Surficial artifacts and features were flagged and plotted; the formal artifacts were later collected. Center and end points were established in and around Feature A as controls for vertical photographs taken from a bipod built by E. Mott Davis, of The University of Texas, Department of Anthropology. A series of black-and-white photographs was taken with a 35 mm Nikkormat FTN camera elevated 3 meters above the stone circle (Figure 5). The grid, stadia rod, and folding ruler served as scales. Four overlapping photographs covered the entire feature. Series of photographs were taken before, during, and after excavation.

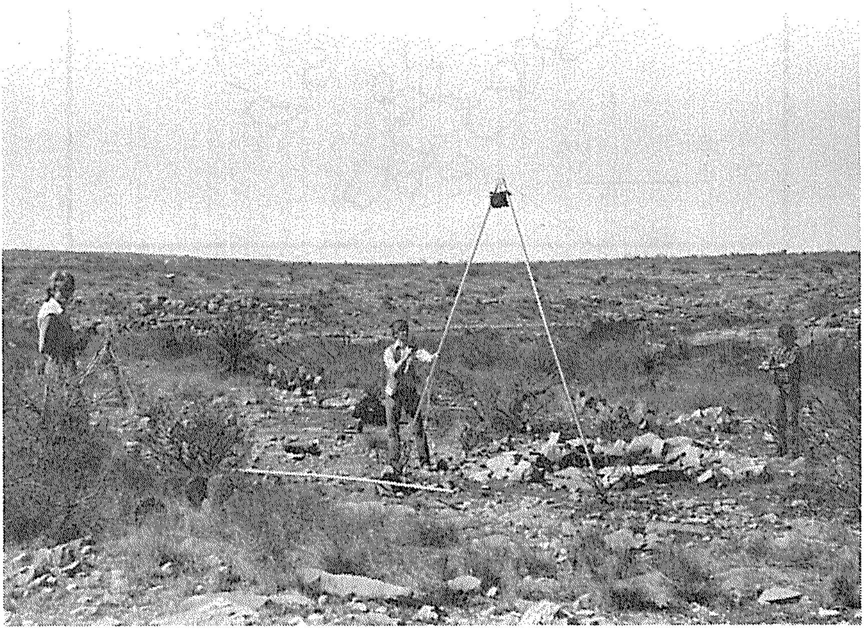

Figure 5. Vertical photography in action. The bipod in use at the Tonto site (41VV828), Feature A.

The feature was then gridded into 50-cm squares, and the matrix was removed with trowels and water-screened through window screen at the tinaja in the canyon bottom. The excavation continued until the sloping bedrock floor was exposed between 5 and 20 cm below the surface. At the upper (north) end bedrock was encountered just beneath the vegetation mat of moss and small grasses; at the lower (south) end as much as 20 cm of sediment was trapped within the feature. No cultural strata were apparent; only the root mat at the surface, and the increase in clay content with depth differentiated the interior matrix from the surrounding soil.

The area surrounding the ring was barren bedrock, so no test pits could be dug to compare exterior and interior artifact densities. As is so often the case on these exposed surfaces, most of the surficial artifacts have been moved from their original contexts and are lying trapped in pockets in the limestone or along the edges of the vegetation that fringes the benches.

Analysis of the recovered materials was carried out at the Texas Archeological Research Laboratory (TARL), The University of Texas at Austin, where all site information is curated. Site and feature maps were computer-generated from the transit data and vertical photographs using IBM-ATs equipped with digitizing table and AUTOCAD software, a system assembled and refined at TARL by H.H. Eling, Jr.

Results of Excavation

The artifactual recovery from within the feature was minimal. The one possible interior feature, a cluster of burned rocks, extended under the eastern peripheral blocks, indicating that the hearth predated construction of the ring. The upper bench surrounding the rings is largely exposed bedrock, and it can be assumed that much of the cultural material originally exposed on the surface all over the site area had been displaced by sheetwash and deflation.

Artifacts

A total of 27 lithic items was recovered during the excavation and screening of the ring deposits, including 15 pieces of burned chert, 3 secondary flakes, 4 tertiary flakes, and 5 chips. All materials could be attributed to ground clutter, and none had ties to the structure or its inhabitants.

In addition to the items recovered during the excavation, 14 temporally diagnostic artifacts were recovered during intensive surface survey (Figure 6). The part of the site area around the rock alignments and the uppermost burned rock midden was the focus of this search. Each diagnostic artifact was flagged, plotted on the site map, and collected for inclusion in the analysis of site materials. The 14 specimens collected represent 8,000 years of prehistoric use of this campsite. Projectile points, from oldest to most recent, are Uvalde, Langtry, Shumla, Marshall, Marcos, and Ensor types (Figure 6, f-k). Minimally Late Prehistoric (post-A.D. 600) times are indicated by the stemmed arrowpoints, including one with broad barbs similar to those of the Sabinal type (Figure 6, d) (Turner and Hester 1985:188). The most recent projectile point is an unstemmed triangular form (Figure 6, b) assigned to the Guerrero type (Turner and Hester 1985:177).

In addition to projectile points, an end scraper (Figure 6, e) morphologically consistent with the Dorso type (Bement and Turpin 1987) was collected. Use wear along its distal edge includes the rounding, striated pattern attributed to hide preparation (Hayden 1979:25, Bement and Turpin 1987:194). Also a single

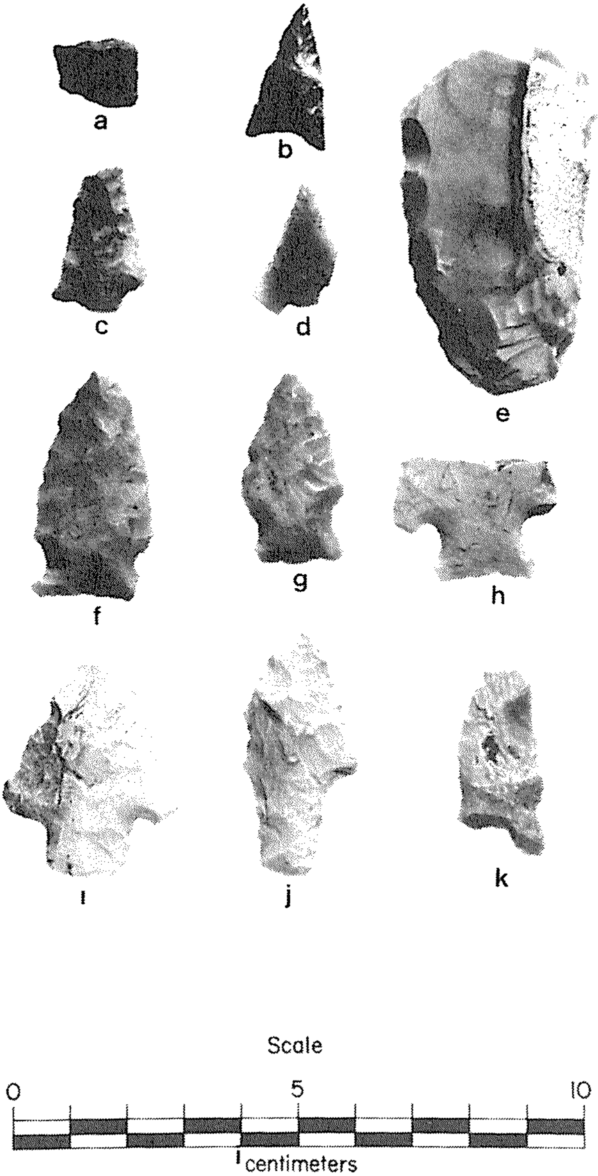

Figure 6. Artifacts from the Tonto site (41VV828): a) fragment of plain brownware pottery, b) Guerrero arrowpoint, c) stemmed arrowpoint, d) Sabinal arrowpoint, e) Dorso end scraper, f-g) Ensor dart points, h) Marcos-like dart point, i) Shumla dart point, j) Langtry-like dart point, k) Uvalde dart point.

fragment of bone-tempered brownware pottery was collected adjacent to Feature C-west (Figure 6, a).

The stemmed arrowpoints, Dorso end scraper, and ceramic sherd are components of an assemblage consistently associated with circular rock alignments in the Lower Pecos Region (Turpin 1982:109). They are defining characteristics of the Infierno phase (Dibble 1978), now estimated to be Late Prehistoric or protohistoric in age, ranging from A.D. 1400 to 1600 in this region. No absolute dates have been obtained for Infierno phase sites. The Guerrero arrowpoint is common on mission-era sites, dated to about A.D. 1700 (Turner and Hester 1985). Unfortunately, at 41VV828, none of the artifacts could be securely tied to any feature, with the possible exception of the one sherd found directly adjacent to Feature C-west.

DISCUSSION

Stone circle sites, especially those considered to be tipi rings, are a common phenomenon throughout the Plains, where they have aroused archeological interest for decades (Davis 1983). In Texas, Mallouf (1985, personal communication) has investigated several ring sites in the Big Bend, where they are a major component of the Cielo complex, dated from A.D. 1200 to 1750. Young (1985) excavated several wickiup rings at the Squawteat Peak site in Pecos County. Similar sites were first recognized in the Lower Pecos River Region on the margins of the Southern Plains at Infierno Camp, the type site of the Infierno phase, in the 1970s (Dibble 1978).

Subsequent survey in the heart of the Lower Pecos River Region has increased the inventory of stone circle sites, leading to more precise definition of their salient characteristics and permitting an assessment of the variability at different sites. With the notable exception of Infierno Camp, which has more than 100 stone rings (Dibble 1978), most of the sites have from one to four such features. Characteristically, stone circles are found on high promontories, canyon rims, or level limestone benches above permanent water holes. Due to massive erosion in these exposed locations, the building surfaces usually are barren limestone, with pockets of sediment trapped behind rock outcrops or in shallow depressions in the bedrock. Vegetation is sparse, restricted to desert shrubs such as ocotillo and prickly pear and low grasses.

The typical Infierno ring is a circle of paired stones, presumably used as pole supports for brush- or hide-covered huts. Morphological variations at other sites include subrectangular, semicircular, or straight lines of piled rock, rarely more than one course high. The Lower Pecos rings are usually only about 3 meters in diameter, much smaller than the classic late tipi rings of the Plains (Davis 1983). The superstructure probably resembled the more casual domed huts often seen in early historic photographs (Figure 7). The stone ring excavated at 41VV828, the Tonto site, is unusual in that it is a continuous circle, broken only by a possible doorway on the south side. The configuration of this ring could have resulted from rocks piled around a hide superstructure to help it withstand high winds. A few examples of this contiguous placement of blocks were identified at Infierno Camp (see Patterson 1987: Figure 38).

The orientation of the two intact features, A and B, permits some estimation of the seasonality of occupation. The semicircular course of rock (B), arcs into the southeast wind; the opening faces 50° west of north. During the excavation of Feature A in mid-February, the wind was blowing strongly from the southeast directly toward the buffer formed by this arc. Feature B would have served admirably as a windblock on this winter day. The opening, or doorway, of Feature A faces south; the densest grouping of rock clusters is on the north end (Figure 4). The opening is also slightly upslope, suggesting that runoff from the hill was not a serious consideration. The double arrangement of stones implies that considerable weight had to be applied along the base to enable the structure to withstand the wind. The ring is the best construction for warding off the effects of cold, windy, dry weather that, in this region, usually comes as *blue northers*—icy blasts of Arctic air blown down from the Plains between December and March. The different orientations of Features A and B suggest that they were not contemporaneous.

The small number of artifacts found within the stone circle supports the implication that Feature A at 41VV828 was used only for shelter, possibly as sleeping quarters for two or three individuals. Cooking and other day-to-day activities would have been conducted outside the hut, and the residue from those activities would have blended with the long-term habitation debris at the site.

SUMMARY AND CONCLUSIONS

The mapping and excavation of 41VV828 provided no conclusive evidence that the stone features are directly related to the historic pictograph or the historic period. The surface artifact assemblage yielded two temporal diagnostics of protohistoric or historic age—a Guerrero arrowpoint assigned to the mission era in Texas and northern Mexico, about. A.D. 1700 (Turner and Hester 1985) and a minute sherd of plain brownware (Figure 6, a, b). Similar ceramics were recovered from Infierno Camp, usually considered protohistoric in age (Dibble 1978), and at San Lorenzo de la Santa Cruz, the Lipan Apache mission established in 1762 on the headwaters of the Nueces River and abandoned in 1771 (Tunnell and Newcomb 1969).

The entire span from Early Archaic through Late Prehistoric is evidenced in the lithic assemblage at the site. Predictably, population concentrated around permanent water sources such as Live Oak Hole throughout prehistory. The distribution of sites and features at Live Oak Hole illustrates in microcosm the larger settlement pattern in the Lower Pecos, with the burned rock middens on the floodplain and lowest slopes and the stone circles on the high, flat limestone benches above. The burned rock middens fringing the creek are probably Archaic as are the older pictographs. The stone features and later pictographs are much more characteristic of the late Late Prehistoric and early Historic periods. In their setting, the three adjacent stone ring sites typify these sites throughout the region, situated as they are on promontories with views up and down the water course. The location of the pictograph, under a shallow overhang facing a broad, flat, grassy expanse, is typical of the historic art in this region (Turpin 1989).

These few stone features, arranged in clusters, that comprise the sites described here, possibly reflect the size and composition of the groups who built them. The dearth of occupational debris associated with the features and the distance between rings give the impression of small groups camping independently around the water hole. Some of the rings may have been contemporaneously occupied, but the orientation of the more intact features suggests that they were constructed to meet differing weather conditions.

The difficulty in detecting historic (and prehistoric) campsites is best explained by referring to a photograph of a historic Indian campsite (Figure 7). To change their camp, this family had to move only one basket, one water jar, two kettles, a couple of cans, and the hut coverings. All that would remain would be the dirt embankment surrounding their hut, soon to be leveled by erosion, and the hearth. The limited artifactual material attributable to the historic period at 41VV828 is consistent with the mobile lifeways of the intrusive Plains Indians. During one episode, they lingered long enough to paint the pictograph in Live Oak Hole, but, otherwise, their tenure is marked only by one tiny fragment of a protohistoric or historic ceramic vessel and one complete arrowpoint of the mission era. Therefore, although there can be no doubt that people camped at Live Oak Hole during the historic period, the threads of evidence can not tie the artifacts to the stone circles or the circles to the pictograph. The excavation of Feature A at 41VV828 proved useful in identifying construction techniques and site layout, estimating the season of occupation, and emphasizing the fragility of

Figure 7. Photograph of a historic Indian camp in New Mexico. (Photo from the National Archives, iii-sc-85775.)

the archeological record in a region best known for the preservation of deposits in dry rock shelters. The value of the bipod and the computer-generated mapping of the site and its features was demonstrated, but the presence of the Plains Indians in the Lower Pecos remains best documented in the ethnographic and pictographic record while the search for occupational sites continues.

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REFERENCES CITED

Bement, L. C., and S A. Turpin
1987 Technological Continuity and Functional Change: The Case of the Dorso End Scraper. *Plains Anthropologist* 32(116):191-196.

Daniel, J. M.
1955 The Advance of the Spanish Frontier and the Despoblado. Masters thesis, The University of Texas at Austin.

Davis, L. B.
1983 From Microcosm to Macrocosm: Advances in Tipi Ring Investigation and Intepretation. *Plains Anthropologist Memoir* 19, Vol. 28(102).

Dibble, D. S.
1978 The Infierno Phase: Evidence for a Late Occupation in the Lower Pecos River Region, Texas. Paper presented to the 43rd Annual Meeting, Society for American Archeology, Tucson, Arizona.

Graham, J. A., and W. B. Davis
1958 Appraisal of the Archeological Resources of Diablo Reservoir, Val Verde County, Texas. Report to the National Park Service by the Inter-Agency Archeological Salvage Program, Field Office, Austin, Texas.

Grieder, Terence

1966 Speculations on Some Pictograph Sites in the Region of Amistad Reservoir. Report submitted to the National Park Service by the Texas Archeological Salvage Project, The University of Texas at Austin.

Griffen, W. B.

1969 Culture Change and Shifting Populations in Central Northern Mexico. *Anthropological Papers of the University of Arizona* 13, Tucson.

Hayden, Brian

1979 Snap, Shatter and Superfracture: Use-Wear of Stone Skin Scrapers. In *Lithic Use-Wear Analysis*, edited by B. Hayden. Academic Press, New York.

Jackson, A. T.

1938 Picture-Writing of Texas Indians. *Anthropological Papers*, Vol. II and *Bureau of Research in the Social Sciences Study No.* 27, The University of Texas at Austin.

Keyser, James

1987 A Lexicon for Historic Plains Indian Art: Increasing Interpretive Potenial. *Plains Anthropologist* 32(115):43-72.

Kirkland, Forrest

1938 A Description of Texas Pictographs. *Bulletin of the Texas Archaeological and Paleontological Society* 1:11-40.

1942 Historic Material from Fielder Canyon Cave. *Bulletin of the Texas Archaeological and Paleontological Society* 14:9-25.

Kirkland, Forrest, and W. W. Newcomb, Jr.

1967 *The Picture Writing of Texas Indians*. University of Texas Press, Austin.

Mallouf, R. J.

1985 A Synthesis of Eastern Trans-Pecos Prehistory. Masters thesis, The University of Texas at Austin.

Parsons, Mark

1962 Testing and Reconnaissance in Amistad Reservoir, Val Verde County, Texas. A report to the National Park Service on file at the Texas Archeological Research Laboratory, The University of Texas at Austin.

Patterson, P. E.

1987 Archaeological Excavations at 41LL78, The Slab Site, Llano County, Texas. *Texas Department of Highways and Public Transportation, Highway Design Division*, Publications in Archaeology Report No. 34, Austin.

Tunnell, C. D., and W. W. Newcomb, Jr.

1969 A Lipan Apache Mission, San Lorenzo de la Santa Cruz 1762-1771. *Texas Memorial Museum Bulletin* 14, The University of Texas at Austin.

Turner, E. S., and T. R. Hester

1985 *A Field Guide to Stone Artifacts in Texas*. Texas Monthly Press, Austin.

Turpin, S. A.

1982 Seminole Canyon: The Art and the Archeology. *Texas Archeological Survey Research Report* 83, The University of Texas at Austin.

1985 Toward the Definition of a Pictograph Style: The Lower Pecos Bold Line Geometrics. *Plains Anthropologist* 31(112):153-161.

1989 The Iconography of Contact: Spanish Influences on the Rock Art of the Middle Rio Grande. IN: *Columbian Consequences*, Vol. I: Archaeological and Historical Perspectives on the Spanish Borderlands West. Smithsonian Institution Press.

Weddle, R. S.

1968 *San Juan Bautista, Gateway to Spanish Texas*. University of Texas Press, Austin.

Young, W. C.

1981 Investigations at the Squawteat Peak Site, Pecos County, Texas. *State Department of Highways and Public Transportation, Highway Design Division Publications in Archaeology* Report No. 20, Austin.

The 1987 Parida Cave Conservation Project, Val Verde County, Texas

Joseph H. Labadie

ABSTRACT

Parida Cave (41VV187) is an extensive rockshelter in an isolated part of the Amistad International Reservoir near Del Rio, Texas. The site long has been a popular place to visit for the local population and, more recently, by boaters on the reservoir and long has been the target of illegal digging and vandalism. During the summer of 1987 the National Park Service spearheaded a major conservation project to clean up and revitalize the site. The Parida Cave Conservation Project, with a volunteer work force, picked up trash, back-filled potholes, and built a rock pathway for visitors. The project dramatically illustrates the kind of success that is possible through cooperative undertakings involving the National Park Service, private landowners, and a responsive regional archeological community.

INTRODUCTION

Parida Cave is a large rockshelter on the Rio Grande at Amistad Reservoir near Del Rio, Texas (Figure 1). The site has historic and prehistoric pictographs together with significant archeological deposits. In the recent past this site has been a popular destination for the boating public, campers, and local fishermen, since it is readily accessible from the lake (see Figure 2). This popularity has led to great damage to the site; campers inadvertently harmed the archeological deposits by digging fire pits and latrines and burying garbage. Other visitors to the site have vandalized the pictographs and dug for artifacts.

The site is unusual in that it is owned jointly by the federal government and two private owners. The shelter floor and lower half of the site are the property of the International Boundary and Water Commission (IBWC), and this part of the property is administered by the National Park Service. The upper half of the site (the part above 1144.3 feet above mean sea level (amsl)) and the cave walls that have the pictographs are coowned by Amos Humphrey and Clifton Lowry, of Del Rio. Vandalism of the lower, publicly owned, half of the site is a prosecutable offense under the Archeological Protection Act of 1979, but vandalism above 1144.3 feet amsl, on private property, can be prosecuted only under the Texas Antiquities Code.

The degree of vandalism, the legal situation, and the sheer proportions of Parida Cave all combine to create a complex and formidable preservation problem. During the summer and fall of 1987, the Parida Cave Conservation Project was formed to find solutions to these problems. The project, begun under the joint sponsorship of the National Park Service and the Texas Historical

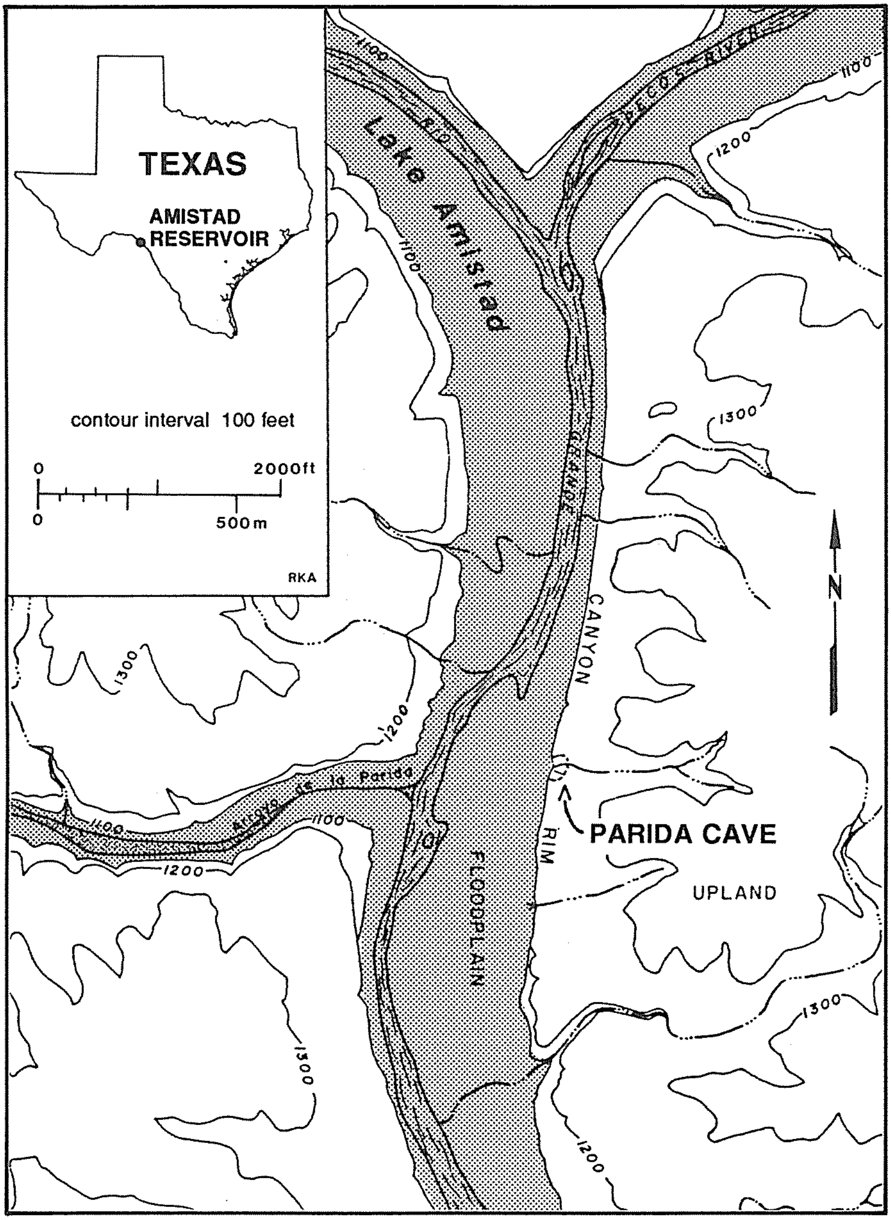
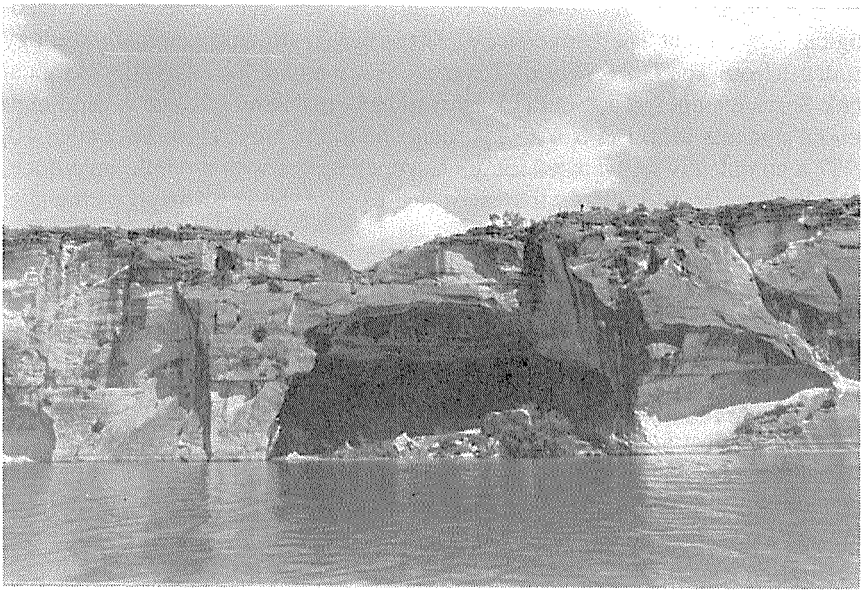


Figure 1. Topographic map of part of the Lower Pecos River Region showing the location of Parida Cave (from Alexander 1979:Figure 1, courtesy of Texas Archeological Research Laboratory).



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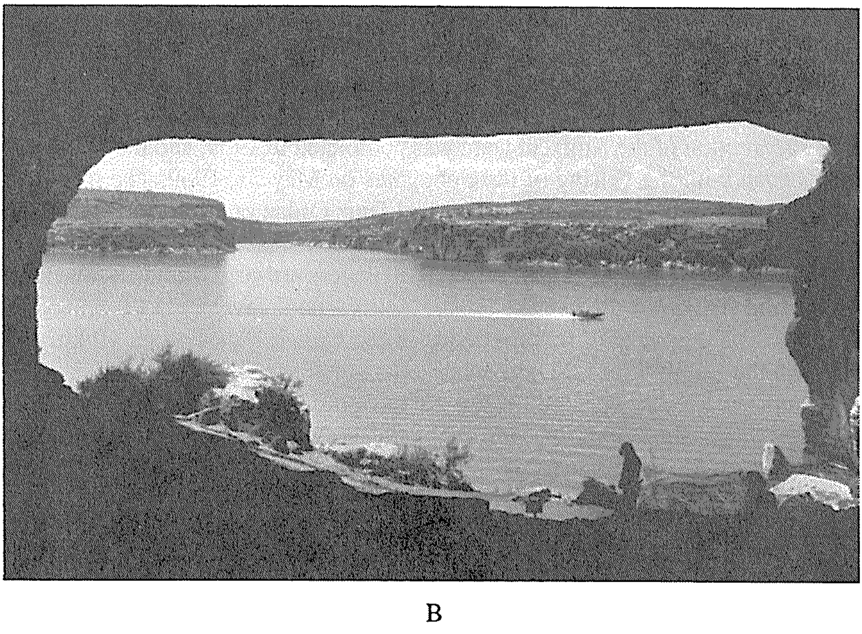

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Figure 2. Photographs showing views; (A) Parida Cave from the Rio Grande, and (B) Arroyo de la Parida, in Mexico, from Parida Cave.

Commission, relied on volunteers for the bulk of the labor and included personnel from the Texas Archeological Society, the Southern Texas Archaeological Association, the Coastal Bend Archeological Society, the Center for Archaeological Research at The University of Texas at San Antonio, and anthropology students from The University of Texas at Austin and at San Antonio. National Park Service employees, Youth Conservation Corps members, and several high school students from Del Rio also participated in the project. On December 10, 1987 a completely rejuvenated Parida Cave, complete with a public boat dock, rock-lined trails, and interpretive signs that explain the key aspects of the site, was reopened to the public.

BACKGROUND

A 1944 Water Treaty between the United States and Mexico created the International Boundary and Water Commission (National Park Service 1987). The original intent was to plan, construct, operate, and maintain three international hydroelectric dams along the Rio Grande. Two—Falcon and Amistad dams—have been built, and before they were closed, preinundation surveys and inventories of the reservoir basins were mandated by the National Archeological Salvage Program.

The IBWC controls all land adjacent to the reservoir on the American side up to 1117.0 feet (335 meters) amsl and owns or has a permanent flowage easement on all land up to 1144.3 feet amsl. Under a 1965 agreement with the IBWC, the National Park Service became responsible for administering all recreational activities on the reservoir, including the conservation and protection of all historic and prehistoric sites on IBWC property adjacent to the reservoir (National Park Service 1987:Appendix A).

Construction of the Amistad Dam was completed in 1969, and the storing of water began with the closing of the floodgates on May 31, 1969. The dam was dedicated by Presidents Richard Nixon and Diaz Ordaz on September 8, 1969. The Amistad Reservoir stores about 67,000 surface acres of water at a pool level of 1117.0 feet (335 meters) amsl. Impounded waters are used primarily for flood control and irrigation downriver. At the normal pool level (1117.0 feet [335 meters] amsl), impounded water extends in the United States about 40 km (25 miles) up the Devils River, 22 km (14 miles) up the Pecos River, and 118 km (74 miles) up the Rio Grande. The reservoir has an estimated shoreline of about 1,360 km (850 miles), about 864 km (540 miles) of which are in Texas (National Park Service n.d.).

PREVIOUS RESEARCH

Overview

The Amistad Reservoir basin is probably the most extensively and intensively studied geographic region in Texas. The region, known as the Lower

Pecos River Archeological Region, has become one of the most well defined culture areas in Texas (cf. Shafer 1986). The limited geographic distribution of regionally distinctive artifact types and unique pictograph styles has long suggested a culture core area at the mouth of the Pecos River at the Rio Grande (Suhm et al. 1954).

The Lower Pecos River Region has some of the oldest and best-preserved archeological deposits in North America. Dry rockshelter deposits often contain deeply stratified cultural remains consisting of textiles, bone and wooden artifacts, stone tools, and food remains. Many walls of the rockshelters are adorned with pictograph panels. Radiocarbon dates have determined that there has been about 10,000 years of near-continuous human habitation in the region. The first archeological survey for the proposed Amistad Reservoir in 1958 described the significance of the area.

> In several respects the Diablo [Amistad] Reservoir area is one of the unique archeological regions in North America. Probably no area of comparable size can boast of so rich a series of archeological and pictographic sites, and in the stratified terrace sites are preserved an unusually complete array of materials. For this reason alone the archeology of the area is of exceptional scientific significance. But in addition to this rich inventory of archeologic materials, here exists one of the truly unique pictograph regions of the world. The magnificent galleries of superb cave murals, executed in polychromatic and monochromatic styles, in stylized and naturalistic forms, are perhaps comparable only to the famous cave paintings of Europe [Graham and Davis 1958:84, 85].

Four archeological districts and a single site are listed in this region on the National Register of Historic Places. All are in or adjacent to the Amistad Recreation Area. In the four districts are 183 sites that are listed at the national level of significance. Historic sites are associated with the building of the second transcontinental railroad from 1881 to 1882. Almost as many recorded sites have yet to be nominated to the Register but are, in the opinion of Curtis Tunnell, State Historic Preservation Officer, also clearly eligible for listing (personal communication, December 1987). A complete inventory of resources on federal lands adjacent to the reservoir has never been completed. Twenty-seven new archeological sites were documented by the National Park Service in 1987; twenty-nine more were documented in 1988. It is clear that hundreds more sites remain to be identified and recorded.

There have been three major historical periods of archeological research in the Amistad Reservoir basin. They are Early Research, Preinundation Research, and Current Research.

Early Research (1930-1958)

Several nineteenth century explorers and travelers noted the presence of pictographs in caves of the Devils and Pecos rivers (see Turpin 1984a). However, Gutzeit and Carson (1931) are generally recognized as the first to document accurately some of the sites in the region. Sponsored by the Witte Museum in San Antonio, they produced watercolor paintings of 18 pictograph panels from about half a dozen sites (Roberta McGregor, personal communication, January 1988). Gutzeit and Carson's original works and field notes are part of the Witte Museum's permanent collection.

A. T. Jackson (1938) included extensive research on pictographs and petroglyphs of the Lower Pecos River Region in his monumental work *Picture Writing of Texas Indians.* He did not limit his book to just the lower Pecos but included his research for the entire State of Texas. In 1932, Jackson visited Parida Cave (Jackson's site 71), and his drawings (Jackson 1938:185) were the first to record accurately the pictographs at Parida Cave (Figure 3). Jackson's original field notes and glass negatives with proofs are cataloged and are on file at the Texas Archeological Research Laboratory, The University of Texas at Austin.

Figure 3. A. T. Jackson's illustrations of pictographs at Parida Cave (Jackson 1938:185, Figures 164 and 165).

The best-known early pictograph researcher is Forrest Kirkland. Kirkland (1937a, 1937b, 1938, 1939), with the assistance of his wife Lula, produced detailed watercolors for many of the region's better-known sites. However, it was not until the publication of *The Rock Art of Texas Indians* (Kirkland and Newcomb 1967) that many of his original works were first seen by the public.

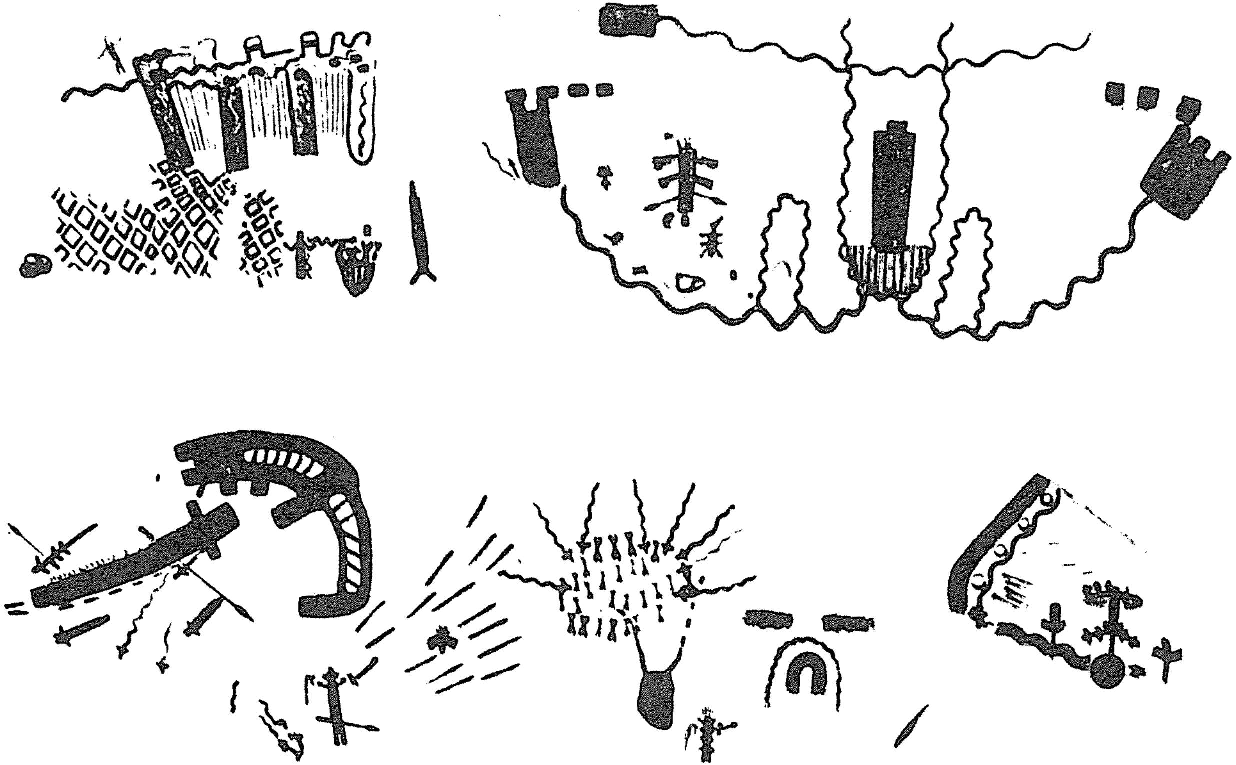


Figure 4. Pictographs at Parida Cave, drawn on July 7, 1937 by Forrest Kirkland. (From Kirkland and Newcomb 1967:55.)

Figure 5. Pictographs at Parida Cave, drawn on July 7, 1937 by Forrest Kirkland. (From Kirkland and Newcomb 1967:55.)

Kirkland visited Parida Cave in July 1937 and completed watercolors of all of the pictograph panels (Figures 4 and 5) (Jackson had copied only one of the four panels). Kirkland's original artwork and field notes are cataloged and maintained in acid-free archival folders and boxes at the Texas Memorial Museum at The University of Texas at Austin (Causey 1985:16).

The first archeological excavations in the reservoir basin were made by Pearce and Jackson (1933, Thomas 1933) who dug at Fate Bell Shelter (41VV74). In 1965, this site was briefly reinvestigated (Parsons 1965) by the Texas Archeological Salvage Project of The University of Texas as part of their larger preinundation study. Fate Bell Shelter is now part of Seminole Canyon State Historical Park, which is operated by the Texas Parks and Wildlife Department. Public tours of the site are offered twice a day all year round.

The Witte Museum conducted several private projects at Shumla Caves and Eagle Cave. These expeditions investigated nine rockshelter sites that are collectively named the Shumla Caves. Shumla Cave No. 5 (41VV115) was completely excavated by Martin (1933, 1935). The archeological assemblages have since been analyzed by Schuetz (1956, 1961, 1963). The first radiocarbon dates from the Lower Pecos River Region came from the Shumla Caves (Schuetz 1957). The unusual hafted knife illustrated on the cover of Turner and Hester's *Field Guide to Stone Artifacts of Texas Indians* (1985) was excavated by Martin (1953) at Shumla Cave No. 5. Another site, Eagle Cave (41VV167), also was first dug by the Witte Museum (Davenport 1933). It was later reinvestigated by the Texas Archeological Salvage Project (Ross 1965) during preinundation studies.

The Smithsonian Institution sponsored several early expeditions to the Lower Pecos River Region. In 1933, Frank Setzler dug at Moorehead shelter (41VV55) and Goat Cave (41VV67) on the Pecos River, but these excavations were only briefly reported (Setzler 1933, 1934), and none have been made at either site since the 1930s. Prewitt (1970) reported on some Moorehead shelter materials he examined at the Smithsonian Institution, and Masolowski (1978) analyzed the Smithsonian collection from Moorehead for his dissertation at the University of Pittsburgh.

In 1937 the West Texas Museum excavated Murrah Cave (41VV351), located about 40 km (25 miles) up the Pecos River from its mouth at the Rio Grande, and a brief report was published by Holden (1937). The lithic assemblage from Murrah Cave has since been analyzed by Holiday (n.d.); Horseshoe Cave (41VV171) was later excavated by Woolsey and The University of Texas. These excavations were not published (Woolsey 1936) but were later the topic of Butler's (1948) M.A. thesis at The University of Texas. Other early reports on sites or artifacts from what is now the Amistad Reservoir basin include Davenport, Walker, and Chelf (1941), Gardner, Fletcher, and Martin (n.d.), Harris and Lewis (1941), Martin and Woolford (1932), Sayles (1935, 1941), and H. C. Taylor (1948, 1949a, 1949b).

Preinundation Research Period (1959-1969)

Early research in the Amistad Reservoir basin firmly established the scientific value of the region. However, early research was tremendously biased, since it concentrated almost exclusively on rockshelter sites and the collection of museum specimens. In contrast, preinundation research was holistic in approach and was the first systematic survey of the entire Lower Pecos River Region. The definition of a regional chronology, reconstruction of past lifeways, and the study of the larger cultural processes involved, were the hallmarks of the Preinundation Research Period. The period began in the late 1950s and lasted until about mid-1969.

The Austin Field Office of the Archeological Salvage Program of the National Park Service conducted the initial survey for the proposed Diablo (later changed to Amistad) Reservoir. The survey (Graham and Davis 1958) located 188 sites on the United States side of the reservoir. The initial National Park Service study recommended that implementation of the recommendations of the Graham and Davis survey be contracted to the Texas Archeological Salvage Project, The University of Texas at Austin.

Surveys on the Mexican side of the reservoir basin have located 78 sites. Herbert Taylor (1948) had found 10 sites along the Rio Grande in northern Coahuila before the reservoir was planned. Sixty-eight sites on the Mexican side, all prehistoric, were inventoried during preinundation research by W. W. Taylor, Direccion de Prehistoria, Mexican National Institute of Anthropology and History (Taylor 1958, Taylor and Ruhl 1961). No other surveys, excavations, or mitigating actions were undertaken on the Mexican side of the reservoir during preinundation studies, and none have been taken since.

Graham and Davis (1958:2) surveyed about 70 percent of the area to be affected by the reservoir. Later surveys (Parsons 1962, Dibble and Prewitt 1967) would eventually reduce the unsurveyed area to about 10 percent. Dibble and Prewitt (1967) located an additional 68 sites. Parson's research (1962) is the only historic sites survey made in the reservoir area. He surveyed and documented 11 historic sites associated with the construction from 1881 to 1882 of the southern transcontinental railroad along the Rio Grande. By the end of 1967, about 300 archeological sites had been located, and 24 had been tested or extensively excavated (Story and Bryant 1966:8).

Several major pictograph surveys and studies were completed as part of the preinundation studies. These include Gebhard (1960, 1961, 1965) and Grieder (1965, 1966a; see also 1966b).

Site survey and excavation reports and other articles have been published on many of the sites investigated by the Texas Archeological Salvage Project at Amistad Reservoir. Reports completed for and submitted to the National Park Service, Denver Service Center, include Damp and Centipede caves (Epstein 1960, also 1963), the Devils Mouth site (Johnson 1961, 1964, Sorrow 1968a), Arenosa Shelter (Dibble 1967), the Javelina Bluff site (McClurkan 1968), Fate Bell shelter (Parsons 1965), Bonfire shelter (Dibble 1965, 1970, Dibble and

Lorrain 1968), Eagle Cave (Ross 1965), the Nopal Terrace site (Sorrow 1968b), Parida Cave (Alexander 1970), the Perry Calk site, Conejo shelter, and 41VV162-A, Cueva Ponderosa, sites 41VV160, 41VV161, 41VV163, 41VV176, 41VV186, and 41VV422 (Collins 1969), and Coontail Spin, Zopolite Cave, Mosquito Cave, and the Doss site (Nunley, Duffield, and Jelks 1965).

Extensive excavations were conducted at Parida Cave (Alexander 1970) in 1967. The site was then coowned by Perry Calk, of Comstock, and the International Boundary and Water Commission. There are no photographs of the 1967 excavations because a mechanical failure of the field camera went unnoticed until the film was developed after the field season was over (Alexander 1970:17).

The Texas Archeological Salvage Project excavated five major test units at Parida Cave (41VV187), the deepest of which extended more than three meters from the ground surface. Postexcavation studies indicated that the principal occupations of the site were from about 4000 to about 200 B.C. A later component at the site was dated to A.D. 1000 to 1600. More than 100 dart points were recovered (notably absent were Ensor and Frio dart points), nine painted pebbles, mostly decorated with thin black lines, and a fragmentary valve of a freshwater mussel that had traces of red ochre, apparently in a liquid state when deposited, adhering to the inner surface (Alexander 1970:45). Among other artifacts recovered were bone awls, pieces of abraded dark red hematite, bone beads, matting, basketry, cordage, sandals, netting, and a variety of knotted vegetable fibres.

Only a small part of the total faunal assemblage has been analyzed, but identified taxa (Alexander 1970:64) include cottontail *(Sylvilagus* sp.), jackrabbit *(Bepus californicus)*, coyote *(Canis latrans)*, fox *(Urocyon* sp.), deer *(Odocoileus* sp.), squirrel *(Citellus* sp.), catfish *(Ictalutus* sp.), flathead catfish *(Pylodictris olivaris)*, and gar *(Lepisosteus* sp.). All of the materials from Texas Archeological Salvage Project excavations at Amistad are in long-term curation at the Texas Archeological Research Laboratory in Austin.

Current Research (1970-present)

National Park Service research in the Amistad Reservoir basin has been sporadic since the completion of the preinundation studies in 1969. Most research since then has been outside the basin. Regional research projects have been sponsored by non-National Park Service agencies, many of which have concentrated on pictograph research (Turpin 1979, 1984b, 1985a), and significant archeological research projects have been undertaken at Baker Cave (Chadderden 1983) and Hinds Cave (Shafer 1977). The Texas Parks and Wildlife Department established Seminole Canyon State Historical Park in 1980, and since then, Seminole Canyon Park has been the focus for most regional research.

Several significant reports on the rock art (Turpin 1986a, Silver 1986) and archeology (Turpin 1982, 1985b, Patterson 1980) of Seminole Canyon Park have been completed. The Pecos River style (Turpin 1986b), the Red Monochrome style (Turpin 1986c), the Bold Line Geometric style (Turpin 1986d), and the Red Linear style (Turpin 1984c) have been defined as the primary prehistoric rock art styles. Several historic period pictographs (Turpin 1988a, 1988b) also have been reported recently.

A detailed analysis of a Lower Pecos child bundle burial from a private collection was funded and published by the Texas Archeological Foundation (Banks and Rutenburg 1982), and the Texas Historical Foundation funded the construction of the protective fence at Panther Cave (41VV83) and the interpretive shelter at the National Park Service boat dock on the Pecos River. Regional Late Archaic mortuary practices have been described by Turpin, Henneberg, and Riskind (1986).

Ethnohistoric observations on bison in the Lower Pecos Region have been reported by Turpin (1987). The Dorso end scraper (Bement and Turpin 1987) has been suggested as a regional Late Prehistoric bison-processing tool. A reexamination of the deepest materials at Bonfire shelter (Bement 1986) has provided additional information on the Western Hemisphere's oldest known bison jump site.

Salvage excavations were conducted by the National Park Service at three sites in the Amistad Recreation Area. At Skeleton Cave (41VV671) on the Rio Grande, a back-country camper discovered a burial while digging a pit for garbage disposal at the rear of the shelter (Anderson 1978). Anderson (ibid.) reported that a bison-horn core and an arrowpoint of unspecified type were found in association with the human remains. A second burial was salvaged from this site in 1988. The author (Labadie 1988) noted that an Ensor dart point was found in situ in matrix between the left scapula and clavicle. At Techo Bajo (41VV621), also on the Rio Grande, a fisherman reported a skeleton (Lehnert 1983) washing out at the waterline of a partly inundated rockshelter, and a partial skeleton of an adult male was excavated there by Lehnert (1983). In May 1987, Texas Historical Commission archeologist Wayne Bartholomew found a skeleton eroding out of the deposits at the dripline of a shelter (41VV129) on the Pecos River. Dental patterns suggested that the skeleton was probably prehistoric (Bartholomew, personal communication 1987), but before a salvage operation was organized, the skeleton was stolen from the site.

Since 1970, several major reports have been published by the National Park Service that involve the cultural resources at Amistad Recreation Area. A review of previous research and delineation of future resource management needs at the park were completed in 1974 by NPS archeologist Bruce Anderson. A new General Management Plan/General Development Concept (National Park Service 1987) for the park was issued recently by the National Park Service. Issued every 10 years, this document establishes short- and long-term resource management priorities for the park. The addition of two archeologists to park staff was recommended (National Park Service 1987:99); one permanent archeologist has been hired, and a seasonal archeologist was added during the summer of 1988. Also in 1988, the Park Service began a major project to catalog materials from the Amistad Reservoir at the Texas Archeological Research Laboratory. Artifacts, field notes, photographs, maps, and drawings will be inspected, reinventoried, and cataloged. The project is part of a nationwide effort by the Park Service to account for, and upgrade the curation of, federally owned archeological collections.

Historic Archeology in the Region

The first historic sites survey in the Lower Pecos River Region was part of the Park Service preinundation studies (Parsons 1962); several identified sites were later resurveyed by Briggs (1974:5) in 1969. Briggs (1974) has reported on the artifacts from two Southern Pacific Railroad 1881 to 1882 construction camps, one near Langtry and the other just east of the mouth of the Pecos along the Rio Grande. The only other research in historic sites has been Patterson's (1980) at Seminole Canyon State Historical Park and at the Jersey Lilly site (Patterson 1987) near Langtry. A compilation of State Historical Markers inVal Verde County has been published by the Val Verde County Historical Commission (Val Verde County Historical Commission 1986).

The Historic Era for the Lower Pecos River Region technically begins from 1590 to 1591, with Gaspar Castano's expedition from Monclova, Mexico to the Pecos Pueblo in New Mexico (Turpin 1984a:32). DeSosa's expedition probably crossed the Rio Grande near modern Del Rio and may have camped near Seminole Canyon (Turpin 1984a:32). During the next two centuries, at least six more Spanish incursions took place. Cabeza deVaca did not travel through the Amistad Reservoir basin (Campbell 1988:Fig. 1). In 1674, Brother Manual de La Cruz crossed the Rio Grande near the Devils River in pursuit of Indians who had left Mission Santa Rosa de Maria on the Rio de Las Sabinas (Turpin 1989). In the following year (1675), Fernando del Bosque led an expedition that crossed the Rio Grande near Del Rio in search of the "Sierra Dacate y Yascole," mountains Bolton identifies as those southeast of modern Bracketville, Texas (Bolton 1908:297). Jose de Barroteran traveled through the modern reservoir basin in 1729 (Castañeda 1936:336), crossing the Rio Grande near present-day Langtry and from there proceeding northward to near Dryden, Texas (Turpin 1984a:37). Garza Falcon passed through the area in 1735 (Patterson 1987:7). In 1773, Vincete Rodriguez attacked a Mescalero camp near the mouth of the Pecos, killing many, capturing 16 women and children and 200 horses, and freeing three Spanish captives (Turpin 1984a:37). In 1775, Ugarte and Loyola are reported (Turpin 1984a:37) to have lost three Spanish soldiers in a battle with Indians on the San Pedro (Devils) River.

Texas statehood and the arrival of the U.S. Army signaled the beginning of the end of the long succession of Native Americans who inhabited the reservoir basin. By the nineteenth century, the Comanche and, later, the Apache dominated the region. In 1853, the U.S. Army skirmished with Indians at the mouth of the Pecos (Turpin 1984a:37). Later, in 1873, the army engaged a group of Lipan Apache at the mouth of the Pecos; their chief and 40 women and children were captured (Turpin 1984a:37).

The eradication or removal of the Indians from the area by the U.S. Army and the Texas Rangers was essentially completed by 1881, when the first Southern Pacific Railroad surveys were made in the reservoir basin. By 1882, construction of the second transcontinental railroad was in full swing, with more than 10,000 laborers comprising Germans, Italians, Mexicans, Afro-Americans, and Chinese building grades and laying track between Shumla and Del Rio. On January 12, 1883 east and west sections of the first southern transcontinental railroad were joined with a silver spike about 1-1/5 km (1 mile) north of the mouth of the Pecos (Patterson 1980:12).

The Southern Pacific Railroad built a station between Tunnel No. 1 (the first railroad tunnel in Texas) and the bridge across the mouth of the Pecos. It was named Painted Cave—a reference to Parida and two other nearby rockshelters with pictographs. For nine years, passenger trains pulled by American Standard 4-4-0s and freight trains pulled by 4-6-0s (the numbers describe wheel alignment of the locomotives) passed the Painted Cave Station (Seminole Canyon State Historical Park display, n.d.).

Parida Cave provided a welcome water stop for weary train travelers, who sometimes left painted messages on the shelter's walls (Figure 6). Painted Cave Station consisted of at least two wooden buildings, one of which housed a section gang whose job it was to maintain the dangerous stretch of track between Comstock and Shumla. This stretch of track had two 450-meter (1,500 foot) rock tunnels, 900 meters (3,000 feet) of wooden trestle, and 14 metal spans between 36 and 90 meters (120 and 300 feet) long (Briggs 1974). In 1892, Painted Cave Station and a 39-km (24.5-mile) section of track were closed in favor of a newer, shorter, and less treacherous 18-km (11.1-mile) route that crossed the Pecos River about 8 km (5 miles) upstream from the mouth of the Rio Grande (Briggs 1974).

The buildings were gone before the area was flooded in 1969; foundation remnants that might have survived into the twentieth century were most probably swept away in the flood of 1954. An International Boundary and Water Commission marker on the Pecos River near the railroad bridge tells of rains spawned by a tropical depression that raised the prereservoir level in a 24-hour period from about 321 meters (1,070 feet) amsl to 347 meters (1,156.78 feet) amsl. The highest recorded level for the Amistad Reservoir is 341 meters (1,138.0 feet) amsl in 1975; the level in Figure 2 is 335 meters (1,117.0 feet) amsl.

All that remains today of the Painted Cave Station is old photographs (Figure 7). Much of the old railroad grade is now inundated by the waters of the reservoir, and the physical evidence of the railroad grade below Parida Cave is about 9 to 12 meters (30 to 40 feet) under water.

The 1987 Parida Cave Conservation Project

The 1987 Parida Cave project is part of a much larger conservation project at the Amistad Recreation Area. In 1985, the Texas Historical Commission (THC) initiated a public response campaign to focus the regional archeological

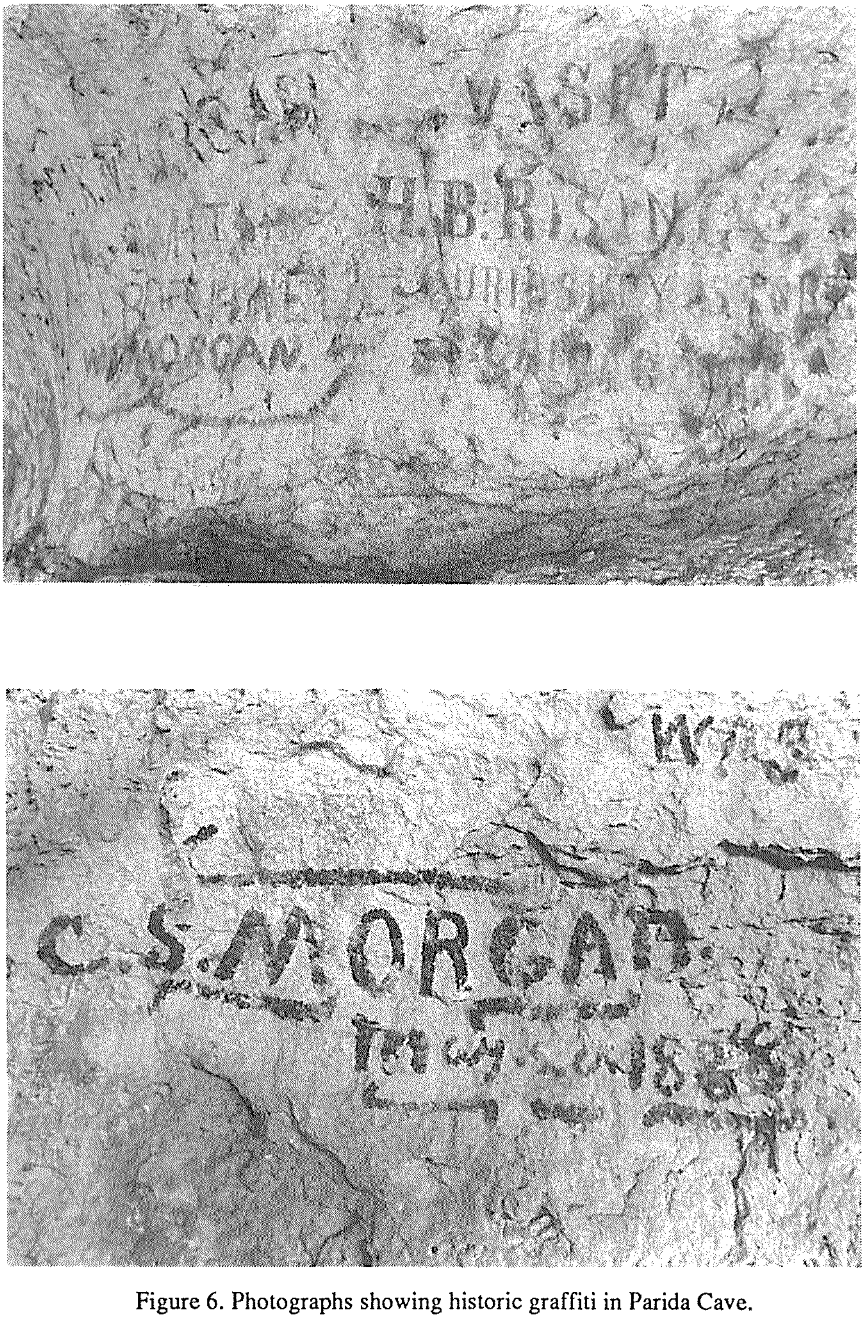


Figure 6. Photographs showing historic graffiti in Parida Cave.

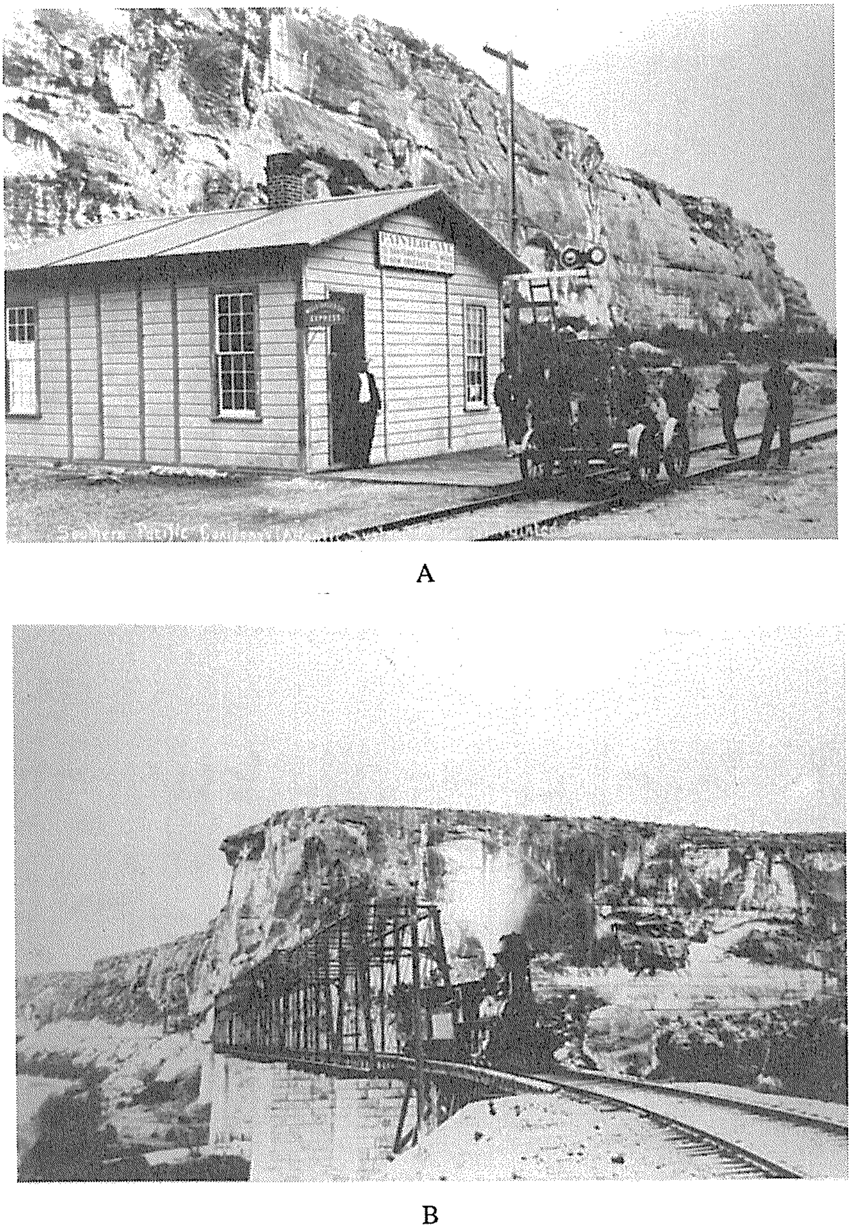


Figure 7. Southern Pacific Railroad photographs: A, Painted Cave Railroad Station, 1883 to 1892); B, Southern Pacific locomotive crossing the bridge at the mouth of the Pecos

community's attention on the area. In 1986, the Historical Commission issued an invitation to concerned archeologists to attend a public hearing in Austin that was jointly sponsored by the Commission and the National Park Service. As a result of this meeting, the Park Service agreed to a joint cultural resources evaluation whose goals were to update the archeological data base and evaluate current and projected site management needs. Fieldwork on the project began in November 1986.

The work focused on the Lower Pecos River Region, which probably has the highest concentration of sites in the park. To solicit support, staff archeologists of the Texas Historical Commission and National Park Service personnel met with owners of adjacent land, for archeological resources on their lands also were being adversely impacted as a result of increased public access occasioned by the reservoir construction. Texas Historical Commission archeologists met with representatives of the news media and local historical associations with the result that 40 volunteers representing eight organizations and private landowners donated more than 1,750 hours to the project. More than 30 previously recorded sites were visited and evaluated; many were rerecorded on new site forms, mapped, photographed, and cleaned up. Modern human organic and inorganic waste was removed.

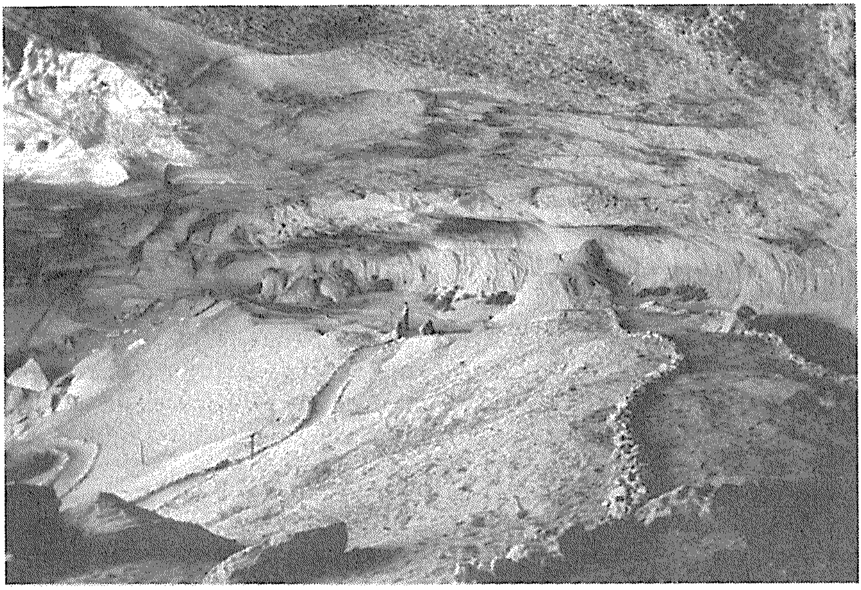
In spring, 1987 a seasonal archeologist was hired by the Park Service at Amistad Recreation Area in Del Rio, and, by the fall, the Park Service upgraded the archeologist's position to a full-time staff position.

The Parida Cave Conservation Project became the first priority for the seasonal archeologist. Before this project was initiated, the Park Service had made no attempt to restrict access or to set up onsite interpretive displays.

The first phase of the restorative work began with making the site off-limits to all overnight camping and day-use activities. Modern accumulations of trash, including latrine-related waste, were removed. Thirty-one potholes (one meter in diameter or larger) were mapped, photographed, and backfilled (two potholes that remain open are incorporated into the interpretive display). In all, 91 artifacts were found during the backfilling, among them 13 dart points, 2 painted pebbles, a sandal fragment, cordage, manos, and trimmed and utilized flakes. After the backfilling was completed, the topography of the ground surface before the potholing was estimated and reconstructed.

The second phase of development consisted of designing and placement of a trail system of more than 120 meters (400 feet) of rock-bordered trails leading from about 335 meters (1,117 feet) amsl to an estimated level of about 352 (1,175 feet) amsl—the top of the midden at the rear of the shelter. The trails were designed to maximize the effect of a trip to Parida Cave while minimizing the impact of increased traffic. All rocks on the floor of the cave, except the largest roof spalls, were incorporated into the rock trail. Nearly 800 man hours were spent just in collecting and placing the rocks after the path had been laid out and graded.

A



B

Figure 8. Photographs of Parida Cave before (A) and after (B) the conservation project.

The third phase of the project was the development of texts for five interpretive signs that explain the key aspects of the site. Texts were so designed that they could be understood by the average park visitor with no background in history or archeology. Descriptive signs explain Parida Cave's geological history, its colorful rock art panels, the composition of the archeological deposits, and the damage done by vandalism at the site. The signs were typeset and silk-screened by the Institute of Texas Cultures of The University of Texas at San Antonio.

The final phase of development was the placement of the interpretive signs and the construction of a National Park Service courtesy boat dock, since the site is accessible only from the water. The dock, similar to the one at Panther Cave, accomodates as many as four boatloads of visitors at a time.

The Parida Cave project was the labor of many unsung heros who worked behind the scene picking up trash, backfilling potholes, and carrying bucketfulls of rocks. The project dramatically illustrates the kind of successes that result from cooperative undertakings among the National Park Service, private landowners, and a responsive regional archeological community (Figure 8). For their part in this project, Edward C. Rodriguez, Jr., Superintendent of Amistad Recreation Area, and Amos Humphreys and Clifton Lowery, coowners, received 1987 Texas Historic Preservation Awards from the Texas Historical Commission. Preservation awards were also presented to Jack and Missy Harrington and the Val Verde County Historical Commission for their roles in the overall efforts of the Amistad cultural resources evaluation.

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REFERENCES CITED

Alexander, R. K.

1970 Archeological Investigations at Parida Cave, Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* 19, The University of Texas at Austin.

Anderson, B. A.

1974 *An Archeological Assessment of Amistad Recreation Area, Texas.* Division of Archeology, Southwest Region, National Park Service.

1978 Preliminary Report on the Salvage Excavation of a Burial From an Inundated Rockshelter at Amistad Recreation Area, Texas. Southwest Cultural Resources Center, Sante Fe, New Mexico. Ms. on file, Texas Archeological Research Laboratory, The University of Texas at Austin.

Banks, K., and G. Rutenburg

1982 *A Child Bundle Burial from Val Verde County, Texas.*. Texas Archeological Foundation, Inc. Austin.

Bartholomew, Wayne

1987 Personal communication regarding vandalism at site 41VV129, July 1987, notes and photographs on file at the Texas Historical Commission.

Bement, L. C.

1986 Excavation of the Late Pleistocene Deposits of Bonfire Shelter, Val Verde County, Texas. *Texas Archeological Survey, Archeology* Series 1. The University of Texas at Austin.

Bement, L. C., and S. A. Turpin

1987 Technological Continuity and Functional Change: The Case of the Dorso End Scraper. *Plains Anthropologist* 32:191-196.

Bolton, H. E.

1908 *Spanish Exploration in the Southwest*, 1542-1705. Barnes and Noble, New York.

Briggs, Alton K.

1974 The Archeology of 1882 Labor Camps on the Southern Pacific Railroad, Val Verde County, Texas. M. A. thesis, Department of Anthropology, The University of Texas at Austin.

Butler, C. T., Jr.

1948 A West Texas Rock Shelter. Unpublished M. A. thesis. Department of Anthropology, The University of Texas at Austin.

Castañeda, Carlos E.

1936 *Our Catholic Heritage in Texas.* Vol. II. St. Edwards University. Austin.

Causey, C. A.

1985 Texas Rock Art: Sixty Years of Preservation. *Heritage*, Fall, 1985: 11-17.

Chadderdon, M. F.

1983 Baker Cave, Val Verde County, Texas: The 1976 Excavations. *Center for Archaeological Research, The University of Texas at San Antonio Special Report* 13.

Collins, M. B.

1969 Test Excavations at Amistad International Reservoir, Fall 1967. *Miscellaneous Papers of the Texas Archeological Salvage Project* 16, The University of Texas at Austin.

Davenport, J. W.

1938 The Archeological Explorations at Eagle Cave, Langtry Texas. *Witte Memorial Museum Bulletin* 4. San Antonio.

Davenport, J. W., and C. Chelf

1941 Painted Pebbles from the Lower Pecos and Big Bend Regions of Texas. *Witte Memorial Museum Bulletin* 5. San Antonio.

Dibble, David S.

1965 Bonfire Shelter: A Stratified Bison Kill Site in Amistad Reservoir, Val Verde County, Texas. *Miscellaneous Papers of the Texas Archeological Salvage Projuet* 5, The University of Texas at Austin.

1967 Excavations at Arenosa Shelter 1965-1966. Texas Archeological Salvage Project Report, The University of Texas at Austin. Report submitted to the National Park Service.

Dibble, D. S., and E. R. Prewitt

1967 Survey and Test Excavations at Amistad Reservoir, 1964-65. *Texas Archeological Salvage Project Survey Report* 3, The University of Texas at Austin.

Epstein, J. A.

1960 Centipede and Damp Caves: Excavations in Val Verde County, Texas 1958. Texas Archeological Salvage Project Report. Report submitted to the National Park Service.

1963 Centipede and Damp Caves: Excavations in Val Verde County, Texas 1958. *Bulletin of the Texas Archeological Society* 33:1-129.

Gardner, Fletcher, and Martin

n.d. A New Type of Atlatl from a Cave Shelter on the Rio Grande near Shumla, Val Verde County, Texas. *Witte Memorial Museum Bulletin* 2. San Antonio.

Gebhard, D.

1960 Prehistoric Paintings of the Diablo Region of Western Texas. *Roswell Museum and Art Center, Publication in Art and Science* No. 3. Roswell New Mexico.

1961 The Diablo Cave Paintings. *The Art Journal* 20 (2):79-82.

1965 Prehistoric Rock Paintings of the Seminole Canyon Area, Val Verde County Texas. Report submitted to the National Park Service.

Gilmore, M. R.

1937 An Interesting Vegetal Artifact from the Pecos Region of Texas. *University of Texas Publication* 3734:17-26. Austin.

Graham, J. A., and W. B. Davis

1958 Appraisal of the Archeological Resources of Diablo Reservoir, Val Verde County, Texas. A Project of the Inter-Agency Archeological Salvage Program, Archeological Salvage Program Field Office, Austin. National Park Service, U. S. Department of the Interior.

Grieder, T.

1965 Report on a Study of Pictographs in the Satan Canyon, Val Verde County, Texas. *Miscellaneous Papers of the Texas Archeological Salvage Project* 2. The University of Texas at Austin.

1966a Speculations on Some Pictograph Sites in the Region of Amistad Reservoir. Report submitted to the National Park Service.

1966b Periods in Pecos Style Pictographs. *American Antiquity* 37:710e

Gutzeit and Carson

1931 Field notes and original artwork from 18 different pictograph panels on file at the Witte Museum, San Antonio.

Harris, R. K. ,and R. L. Lewis

1941 A Report on an Indian Burial Blanket from Val Verde County, Texas. *The Record* 2 (6):27-29, Dallas Archeological Society.

Holden, W. C.

1937 Excavations at Murrah Cave. *Bulletin of the Texas Archeological and Paleontological Society* 9:48-73.

Holiday, V.

n.d. Manuscript on file at the Texas Archeological Research Laboratory, Austin.

Jackson, A. T.

1938 Picture-Writing of Texas Indians. *The University of Texas Publication* 9.

Johnson, LeRoy, Jr.

1961 The Devils Mouth Site: A River Terrace Midden, Diablo Reservoir, Texas. *Bulletin of the Texas Archeological Society* 30 (for 1959): 253-285.

1964 The Devils Mouth Site: A Stratified Campsite at Amistad Reservoir, Texas. *Archeology Series,* 6, Department of Anthropology, The University of Texas at Austin.

Kirkland, F.

1937a A Comparison of Texas Indian Pictographs With Paleolithic Paintings of Europe. *Central Texas Archeologist* 3:9-26.

1937b A Study of Indian Pictures in Texas. *Bulletin of the Texas Archeolological and Paleontological Society* 9:98-119.

1938 A Decription of Texas Pictographs. *Bulletin of the Texas Archeolological and Paleontological Society* 10:11-40.

1939 Indian Pictures of the Dry Shelters of Val Verde County, Texas. *Bulletin of the Texas Archeological and Paleontological Society* 11: 47-76.

Kirkland, F., and W.W. Newcomb, Jr.

1967 *The Rock Art of Texas Indians*. University of Texas Press. Austin.

Labadie, J. H.

1988 Archeological Salvage of Human Remains at Skeleton Cave (41VV962), Amistad Recreation Area, 1988. Manuscript on file with the National Park Service, Southwest Cultural Resources Center, Santa Fe.

Lehnert, E. C.

1983 Report on the Salvage of a Burial from a Previously Inundated Cave in the Cliffs along the Rio Grande Arm of Amistad Recreation Area, Texas. Manuscript on file, Texas Archeological Research Laboratory. Austin.

Martin, G. C.

1933 Archeological Explorations of the Shumla Caves. *Witte Museum Bulletin* 3. San Antonio.

1935 Report on Four Shumla Cave Packets. *Bulletin of the Texas Archeological and Paleontological Society* 7:115-117.

Martin, G. C., and S. Woolford

1932 Painted Pebbles of the Texas Big Bend. *Bulletin of the Texas Archeological and Paleontological Society* 4:20-24.

Masolowski, R. F.

1978 The Archeology of Moorehead Cave: Val Verde County, Texas. Ph.D dissertation, The University of Pittsburgh.

McClurkan, B.B.

1968 Test Excavations at the Javelina Bluff Site, Val Verde County, Texas. Mimeographed. Report submitted to the National Park Service.

National Park Service

1987 General Management Plan/Development Concept Plan for Amistad Recreation Area, Val Verde County, Texas. U.S. Department of the Interior, National Park Service, Southwest Cultural Center. Sante Fe.

n.d. National Park Service pamphlet and map on Amistad Recreation Area.

Nunley, J. P., L. F. Duffield, and E. B. Jelks

1965 Excavations at Amistad Reservoir, 1962 Season. *Miscellaneous Papers of the Texas Archeological Salvage Project* 3. The University of Texas at Austin.

Parsons, M. L.

1962 Testing and Reconnaissance in Amistad, 1962. Unpublished manuscript on file at the Texas Archeological Salvage Project, the Texas Archeological Research Laboratory, The University of Texas at Austin.

1965 1963 Test Excavations at Fate Bell Shelter, Amistad Reservoir Area, Val Verde County, Texas. *Miscellaneous Papers of the Texas Archeological Salvage Project* 4. The University of Texas at Austin.

Patterson, P. E.

1980 Relocation and Restoration of a Baking Oven (Site 41VV588) in Val Verde County, Texas. *Texas State Department of Highways and Public Transportation, Publications in Archeology, Highway Design Division Report* No. 18. Austin.

1987 Test Excavations at Site 41VV199 The Jersey Lilly Val Verde County, Texas. *Texas State Department of Highways and Public Transportation, Highway Design Division, Publications in Archeology Report* No. 33. Austin.

Pearce, J. E., and A. T. Jackson

1933 A Prehistoric Rockshelter in Val Verde County, Texas. *University of Texas Bulletin* 3327, Austin.

Prewitt, E. R.

1970 The Piedra Del Diablo Site, Val Verde County, Texas, and Notes on Some Trans-Pecos, Texas Archeological Material in the Smithsonian Institution, Washington, D. C. *Texas Historical Survey Committee, Archeological Report* No. 18. Austin.

Ross, R. E.

1965 The Archeology of Eagle Cave. *Miscellaneous Papers of the Texas Archeological Salvage Project* No. 7, The University of Texas at Austin.

Sayles, E. B.

1935 An Archeological Survey of Texas. *Medallion Papers* 17. Gila Pueblo, Globe, Arizona.

1941 Some Texas Cave Dweller Artifacts. *Bulletin of the Texas Archeological and Paleontological Society* 13:163-168.

Schuetz, M. K.

1956 An Analysis of Val Verde County Cave Material. *Bulletin of the Texas Archeological and Paleontological Society* 27:129-160.

1957 A Carbon-14 date from Trans-Pecos Texas. *Bulletin of the Texas Archeological Society* 28:288-289.

1961 An Analysis of Val Verde County Cave Materials: Part II. *Bulletin of the Texas Archeological Society* 31:167-205.

1963 An Analysis of Val Verde County Cave Materials: Part III. *Bulletin of the Texas Archeological Society* 33:131-165.

Texas Parks and Wildlife Department/SCSHP Display
n.d. Seminole Canyon State Historical Park display on the Southern Pacific Railroad, located at Park Headquarters, Seminole Canyon State Historical Park, Comstock, Texas.

Setzler, F. M.
1933 Prehistoric Cave Dwellers of Texas. *Explorations and Fieldwork of the Smithsonian Institution in 1932*:53-56.
1934 Cave Burials in Southwestern Texas. *Explorations and Fieldwork of the Smithsonian Institution in 1933*:35-37.
1935 A Prehistoric Cave Culture in Southwestern Texas. *American Antiquity* 37 (1):104-110.
1939 Exploring a Cave in Southwestern Texas. *Explorations and Fieldwork of the Smithsonian Institution in 1938*:75-78.

Shafer, H. J.
1977 Archeological and Botanical Studies at Hinds Cave, Val Verde County, Texas. *Texas A & M University, Anthropology Laboratory, Special Series* 1.
1986 *Ancient Texans: The Rock Art and Lifeways Along the Lower Pecos.* Texas Monthly Press. Austin.

Silver, Constance
1985 The Rock Art of Seminole Canyon State Historical Park: Deterioration and Prospects for Conservation. *Texas Parks and Wildlife Department* Contract 340-299. Austin.

Sorrow, W. B.
1968a The Devil's Mouth Site: The Third Season. *Miscellaneous Papers of the Texas Archeological Salvage Project* 14, The University of Texas at Austin.
1968b Text Excavations at the Nopal Terrace Site, Val Verde County, Texas. *Miscelaneous Papers of the Texas Archeological Salvage Project* 15, The University of Texas at Austin.

Story, D. A., and V.M. Bryant, Jr. (eds.)
1966 A Preliminary Study of the Paleoecology of the Amistad Reservoir Area. Report to the National Science Foundation (GS 667) by the University of Texas at Austin.

Suhm, D. A., Alex Krieger, and E. B. Jelks
1954 An Introductory Handbook of Texas Archeology. *Bulletin of the Texas Archeological Society,* Vol. 25.

Taylor, H. C., Jr.
1948 An Archeological Reconnaissance in Northern Coahuila. *Bulletin of the Texas Archeological and Paleontological Society* 19:74-87.
1949a A Tentative Cultural Sequence for the Area About the Mouth of the Pecos. *Bulletin of the Texas Archeological and Paleontological Society* 20:73-78.

1949b The Archeology of the Area About the Mouth of the Pecos. M. A. thesis Department of Anthropology, The University of Texas at Austin.

Taylor, W. W.

1958 Archeological Survey of the Mexican Part of Diablo Reservoir. Appendix A, published in *Appraisal of the Archeological Resources of Diablo Reservoir, Val Verde Country, Texas.* Archeological Salvage Program Field Office, Austin. National Park Service, U.S. Department of the Interior.

Taylor, W. W., and Francisco Gonzales Rul

1961 An Archeological Reconnaissance Behind the Diablo Dam, Coahuila, Mexico. *Bulletin of the Texas Archeological Society* 31:153-165.

Thomas, S. J.

1933 The Archeological Investigation of Fate Bell Shelter, Seminole Canyon, Val Verde County, Texas. M. A. thesis, The University of Texas, Department of Anthropology.

Turner, E. S., and T. R. Hester

1985 *A Field Guide to Stone Artifacts of Texas Indians.* Texas Monthly Press. Austin.

Turpin. S. A.

1982 Seminole Canyon: The Art and Archeology. *Texas Archeological Survey Research Report* 83. The University of Texas at Austin.

1984a Prehistory in the Lower Pecos River Region: An Overview. *Texas Archeological Survey Research Report* 90, The University of Texas at Austin.

1984b Smoke Signals on Seminole Canyon: A Prehistoric Communication System? *Plains Anthropologist* 29(104):131-138.

1984c The Red Linear Style Pictographs of the Lower Pecos River Region. *Plains Anthropologist* 29(105):181-198.

1985a Pictograph Support for the Smoke Signal Hypothesis. *Plains Anthropologist* 30(108):165-166.

1985b Seminole Sink: Excavation of a Vertical Shaft Tomb, Val Verde County, Texas. *Texas Archeological Survey Research Report* 93. The University of Texas at Austin.

1986a Absolute Dating of Red Monochrome Pictographs: A Failed Experiment. *Texas Archeological Survey Technical Bulletin* 88. The University of Texas at Austin.

1986b An Example of a Mythical Creature in Pecos River Style Art: Southwest Texas. *La Tierra* 13(4):15-19.

1986c Pictographs of the Red Monochrome Style in the Lower Pecos River Region, Texas. *Bulletin of the Texas Archeological Society* 55: 123-144.

1986d Toward a Definition of Pictograph Style: The Lower Pecos Bold Line Geometric. *Plains Anthropologist* 31(112):153-162.

1987 Ethnohistoric Observations of Bison in the Lower Pecos River Region: Implications for Environmental Change. *Plains Anthropologist* 32:424-429.

1988a Arroyo de los Indios: A Historic Pictograph in Northern Coahuila, Mexico. *Plains Anthropologist* 33(120):279-284.

1988b Rock Art of the Despoblado. *Archaeology* 41(5):50-55.

Turpin, S. A., M. Henneberg, and D. H. Riskind

1986 Late Archaic Mortuary Practices of the Lower Pecos River Region, Southwest Texas. *Plains Anthropologist* 31:295-316.

Turpin, S. A., R. P. Watson, S. Dennett, and H. Mussig

1979 Stereophotogrammetric Documentation of Exposed Archeological Features. *Journal of Field Archeology* 6(3):329-337.

Woosley., A. M.

1936 Excavations of a Rock Shelter on the Martin Kelly Ranch Six Miles Southeast of Comstock in Val Verde County, Texas, February 13 to February 19, 1936. Unpublished manuscript on file at the Texas Archeological Research Laboratory, The University of Texas at Austin.

Val Verde County Historical Commission

1986 *Historical Markers of Val Verde County, Texas.* Val Verde County Historical Commission. Del Rio, Texas.

Diet Change in the Lower Pecos: Analysis of Baker Cave Coprolites

Kristin D. Sobolik

ABSTRACT

This paper reviews the many coprolite studies that have been conducted in the Lower Pecos Region, where coprolites range in time between about 7500 B.C. and A.D. 900 and geographically throughout southwestern Texas and northern Mexico. A study of coprolites dated at about A.D. 900 from Baker Cave, Val Verde County, Texas has provided new data from the Lower Pecos. Comparison of the data from Baker Cave with those from the previous studies illustrates the changes in diet in the prehistoric Lower Pecos Region through time. The diet, although increased in diversity, particularly in the amount of fish, birds, and flowers consumed, has continued to revolve primarily around stable resources such as prickly pear, agave, sotol, and rodents.

INTRODUCTION

Coprolite analyses are important for determining the diet, seasonality of occupation, and subsistence patterns of the prehistoric inhabitants of the Lower Pecos Region of southwestern Texas, where, due to the aridity of the climate, they are sometimes abundant in dry limestone rockshelters. The many analyses of coprolites from this area have revealed some aspects of the prehistoric Lower Pecos diet over a long time range and sizeable geographic area.

An analysis of the coprolites from Baker Cave (Sobolik 1988), which are dated to about A.D. 900, is important for two reasons. It provides additional dietary data on prehistoric Lower Pecos populations, and it extends knowledge of dietary habits into Late Prehistoric time. Baker Cave, although it is in the Lower Pecos Region, has a more mesic biological environment than the rockshelters examined in previous studies. The cave is on a tributary of the Devils River in an ecotonal environment bordered by the mesquite-chaparral zone of the Tamaulipan biotic province in southern Texas, the oak-cedar zone of the Edwards Plateau in the Balconian biotic province to the east, and the sotol-lechuguilla zone of the Chihuahuan biotic province to the west (Blair 1950; Chadderdon 1983).

The Lower Pecos Region is in southwestern Texas and Coahuila in northern Mexico, centering on the confluence of the Pecos and Devils Rivers with the Rio Grande. The mainly semiarid environment, which is similar to much of the southwestern United States, contributes to the excellent preservation of the cultural remains in the rockshelters and open sites of the area. The marginally desertic conditions in the area are probably the same today as in much of the past, but around 750 B.C. there may have been a brief climatic shift in the area to more mesic conditions (Dering 1979; Bryant and Holloway 1985).

Prehistoric occupation of the Lower Pecos canyon areas began at least 9,000 years ago (Shafer 1981). The lifeways of these populations, determined by the semiarid environment, were mainly conservative foraging adaptations. However, slight shifts in the pattern have been noted (Stock 1983; Shafer 1986). The continuous subsistence search of the prehistoric occupations of the Lower Pecos Region was centered around a stable resource, the desert succulents, consisting mainly of sotol, prickly pear, and lechuguilla (Shafer and Bryant 1977; Williams-Dean 1978; Dering 1979; Shafer 1981; Stock 1983; and Brown 1986). These desert succulents were eaten and burned and were used in textiles, basketry, sandals, and netting (Shafer 1986). One of the main reasons why subsistence and cultural practices probably remained stable for such a long time was that the xeric conditions prevailed, and the flora and fauna of the area remained relatively unchanged (Dering 1979; Lord 1984).

Paleoecology became an important consideration for Lower Pecos archeologists, with the focus of research centering on obtaining new kinds of information. Some of the Lake Amistad Reservoir salvage excavations during the late 1960s that focused on obtaining paleoecological material (Figure 1) were conducted at Parida Cave, 41VV187 (Alexander 1970), and Conejo Shelter, 41VV162 (Alexander 1974). The coprolites from these excavations—the first to systematically save coprolite material—were analyzed by Riskind (1970) and Bryant (1969, 1974b) respectively. Among other archeological investigations conducted in order to further the information on Lower Pecos paleoecology were extensive excavations at Hinds Cave, 41VV456 (Shafer and Bryant 1977), and Baker Cave, 41VV213 (Brown n.d.; Hester 1983, 1986). The excavations at Hinds Cave yielded more than two thousand bags of plant remains and cultural material and more than a thousand human coprolites. The careful recovery procedures used at Hinds and Baker Caves will permit continued analysis of the prehistoric Lower Pecos Region long after all of the archeological sites in the area are gone.

THE VALUE OF COPROLITE STUDIES

The evaluation of prehistoric subsistence practices has become important for archeologists. Knowledge of subsistence, the reconstruction of diet, and information on health status can be obtained by several means, most significantly, the analysis of coprolites (dessicated human feces), ethnobotanical material, faunal remains, and ethnographic information. All of these analyses need to be made in order to support comprehensive statements about the diet or nutritional status of a population. Coprolites, however, are a unique resource for determining prehistoric subsistence; their analyses offer direct answers to questions of diet (Bryant 1974a) and encompass most other types of information. The constituents of a coprolite are mostly the remains of intentionally eaten food

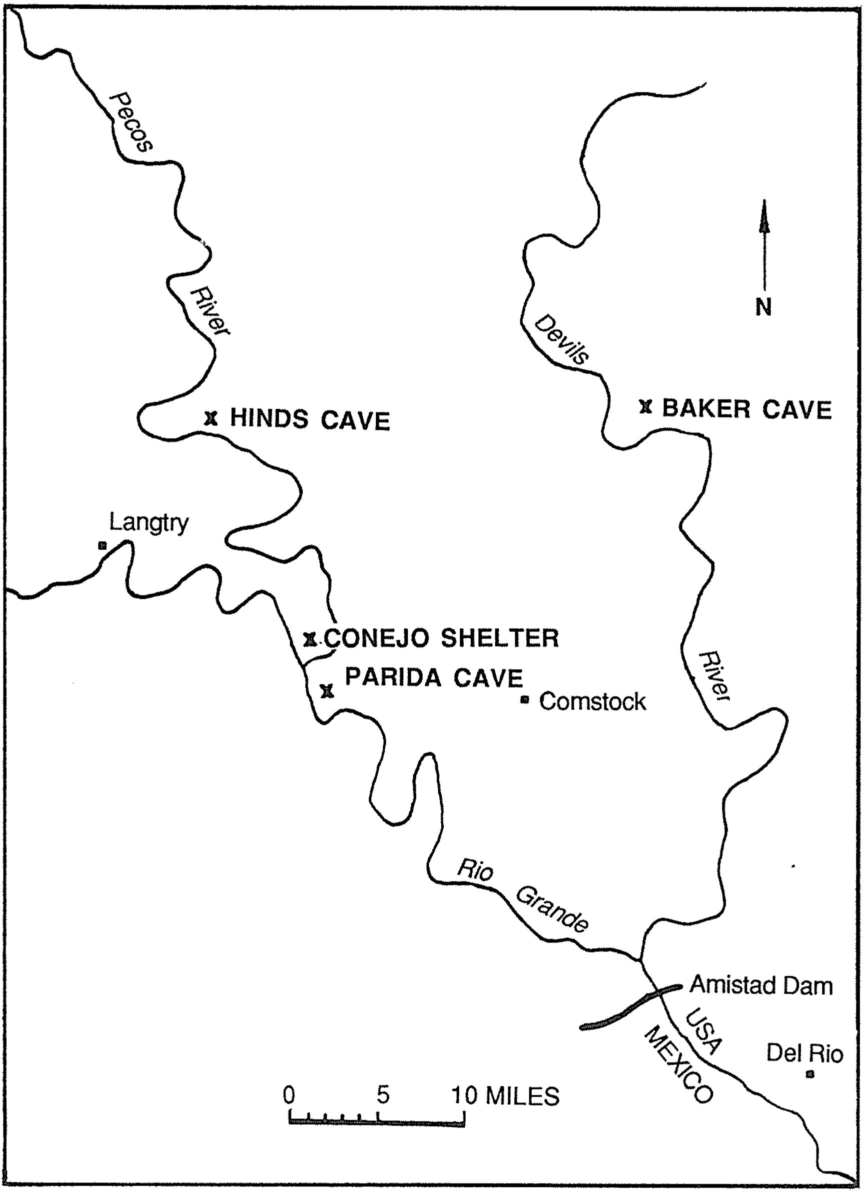

Figure 1. Plan of the Lower Pecos Region, showing sites in Texas from which coprolites have been analyzed. Coprolites were also recovered at Frightful Cave, in Coahuila, Mexico, which is off the map to the south.

items, but they also contain wind-blown pollen, contaminants, grit, and feces-thriving insects. Coprolites, therefore, can, under ideal conditions, be used to determine diet, health, seasonality of occupation, processing practices, and overall subsistence patterns. Coprolites, since they are the dietary remains of specific individuals, are precise samples, supplying data that cannot be replicated accurately from the other animal and plant debris from archeological sites.

Although the potential of human coprolites as dietary indicators was realized by Harshberger as early as 1896, the first scientific analyses of coprolites were conducted in the early twentieth century. Initial studies were conducted on materials from North American caves (Young 1910, Loud and Harrington 1929), and dried fecal remains from Nubian mummies (Smith and Jones 1910). The processing techniques for these early analyses consisted of either cutting open the dry coprolites and observing the large, visible contents, or grinding the samples through screens, breaking much of the material in the process.

Improved techniques for analyzing coprolites were developed by Callen and Camerion (1960), who refine a technique developed by Benninghoff (1947) for herbarium specimens, and by Van Cleave and Ross (1947), for zoological specimens. The samples are rehydrated in a mild solution of the detergent trisodium phosphate in order to break apart the materials gently for ease in screening. These techniques, which are still used, revolutionized the science of coprolite analysis.

However, some problems are inherent to coprolite analysis, mainly that they comprise only undigestible foods; the digestible portions have been absorbed in the digestive process—it is estimated that meat protein is usually completely absorbed during digestion (Fry 1985). The underrepresentation of meat in coprolites is apparent when the amount of bone materials recovered from zooarcheological analyses at a site is compared to the amount of meat protein in the coprolites. Lord (1984) recovered 64 different faunal taxa in his analysis of Hinds Cave material, and 40 different taxa were identified from Baker Cave material (Douglas 1970). Macroremains of Hinds Cave coprolites contained 11 (Stock 1983) and 20 (Williams-Dean 1978) different taxa respectively, and the Baker Cave coprolites contained only nine different faunal taxa. This strongly suggests that coprolites tend to severely underepresent meat intake. How closely the coprolite contents reflect actual food intake is unknown.

Another problem is the direct association of a coprolite or a group of coprolites with a group of people, as in a latrine, where the actual defecators are unknown. The coprolites may reflect deposition and food usage by the specific group, since "rarely are feces found away from the designated latrine area;" (Shafter 1986:99) indicating that almost everyone used the latrine. Alternatively, coprolites may reflect the deposition of one sick person forced to defecate in the area near his or her bed. In this example, the coprolites may contain a high amount of medicinal materials, although medicines probably were also used by the population in everyday life for minor problems.

A group of coprolites could also represent the fecal matter of mainly women and children of hunting and gathering groups, who stay near camp during the day while the men mainly defecated away from the camp during their hunting expeditions. This could be misleading when women and children eat different foods from the men or are deprived of certain dietary items due to cultual constraints, such as taboos.

BAKER CAVE COPROLITES

The coprolites studied here were excavated from Baker Cave (41VV213), a dry rockshelter on a high bluff, one of several archeological sites in Val Verde County in the Lower Pecos Region of southwestern Texas (Figure 2) The cave is 70 meters above Phillips Canyon, a dry tributary of the Devils River, and measures 15 meters in width, 37 meters in length, and has an overall surface area of about 451.5 square meters (Word and Douglas 1970). The fill of Baker Cave, which consists of spalls, limestone dust, and cultural material, is about 3 to 3.3 meters deep (Hester 1983). The occupational debris dates from no earlier than 7,000 B.C., during the late Paleo-Indian period (Word and Douglas 1970; Hester 1983), but most of the habitation was during the Archaic and Late Prehistoric periods.

The most recent excavations at Baker Cave were conducted by Thomas R. Hester and James H. Word during the 1984 and 1985 field seasons (Brown n.d., Hester 1986). The coprolites analyzed for this study were recovered from a latrine area during the 1984 season. Others working at Baker Cave were Thomas R. Hester and Robert F. Heizer in 1976 (Hester 1983; Chadderon 1983), John W. Greer, a graduate student at the University of Texas in 1968 (Greer 1968), and avocational archeologist James H. Word from 1962 to 1966 (Word and Douglas 1970).

The coprolites analyzed for this study were in a buried latrine area near the entrance to Baker Cave (Figure 2) in unit N6E9 stratum 2. Samples 1 and 2 from the latrine area were mapped at 98.37 meters elevation and are tentatively considered a part of the intact occupation floor found 10 to 20 cm below the surface that extends for a least 5 meters over the area of excavation (Brown, n.d.). Feature 84-3, from this occupation floor at grids N3E8 and N3E9, was a large grass-lined pit at least 30 cm deep. This feature contained bundles of green sotol flower stalks that radiated from the center of the pit to the outside rim, where they were bent down over the rim and covered with a thick layer of grass (Brown, n.d.). The green sotol flower stalks (Lab No F84-3) were dated in uncorrected radiocarbon years to 1100±100 B.P. (Beta-15634; $\partial^{13}C$ adjusted radiocarbon age 1090±100 B.P.; K. M. Brown, personal communication 1988). Since the latrine area has been tentatively placed within the same living floor as feature 84-3, the coprolites are considered to date to the same time period (K. M. Brown, personal communication, 1988).

Since some of the specimens in the latrine area could not be distinguished from one another and were taken out in chunks, each of the 38 specimens may not necessarily be a single, whole coprolite. However, in this analysis each of the 38 specimens will be considered a coprolite, although that may not always be the case.

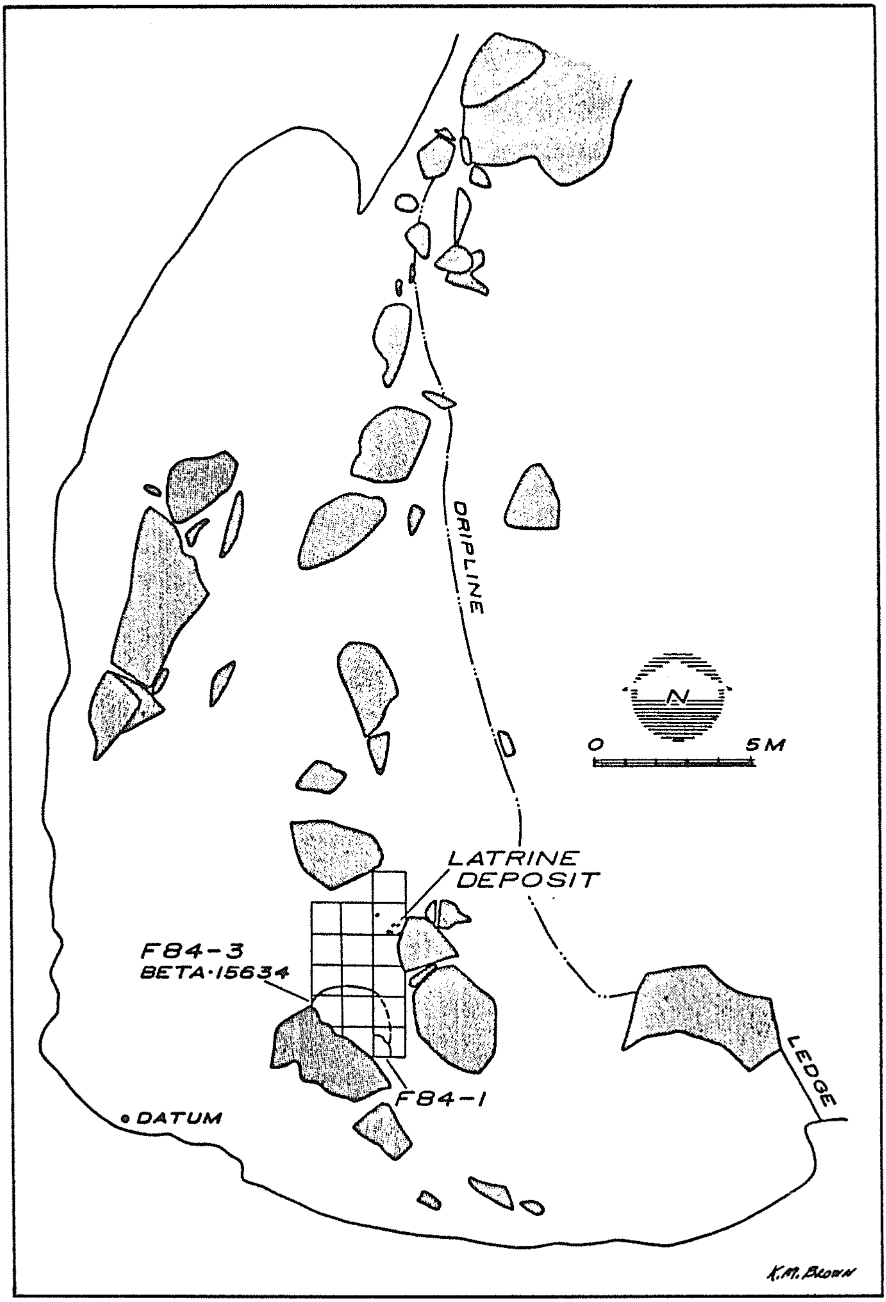

Figure 2. Plan of Baker Cave (41VV213), showing area (gridded) excavated in 1984 by the Center for Archaeological Research, The University of Texas at San Antonio, and the Witte Museum of San Antonio. Drawn by Kenneth M. Brown.

The specimens analyzed were processed for extraction of dietary information from pollen and macroremains. Half of each coprolite, except in cases where the coprolite weighted less than 10 grams, was analyzed. The samples were halved, mainly to preserve some of the sample for analysis at a future time when techniques may be more sophisticated. The samples were then placed in a 0.5 percent trisodium phosphate mixture for at least 48 hours, in accordance with the method descibed by Callen and Cameron (1960). At this time, one tablet of an exotic marker *(Lycopodium* spores 11,300±400 spores) per gram of sample weight was added to permit calculation of overall pollen concentration.

After the samples had broken apart, they were screened through 850- and 250-micrometer mesh screens. The macroremains on the screens were allowed to dry, were separated, and were identified with the help of the reference collection at Texas A&M University of material collected near Baker cave, and a seed manual (Martin and Barkley 1973).

The heavy sedimentation material that passed through the screen was processed for pollen. Chemical extraction techniques were used in order to remove organic debris and silicates. The cellulose material was softened with 10 percent potassium hydroxide (KOH) and subsequently removed, together with organic material, during acetolysis (9 parts acetic anhydride to 1 part sulfuric acid). Silicates removal by heavy density separation was conducted with zinc chloride, and the material remaining was placed in vials with glycerol and mounted on slides for identification of pollen, which was made with the aid of the pollen reference collection at Texas A&M University and with Kapp's pollen identification key (1969).

Macrofossil contents not readily identified from local reference materials were sent to specialists for identification. The insect renains were identified by Richard Blume, of Bryan, Texas, the fish scales were sent to David J. Lee, of the Department of Wildlife and Fisheries, Texas A&M University, and the bird feathers were sent to Keith Arnold, also of the Department of Wildlife and Fisheries, Texas A&M University.

Baker Cave Diet

The occupants of Baker Cave at about A.D. 900 used what was available in their environment in order to obtain a balanced diet and for medicinal needs. The coprolites reflect a diet that included a large variety of plants and small game animals. Another material that should have been important to the Baker Cave diet yet is not reflected in the coprolites is meat from larger game animals.

All of the coprolites analyzed had large quantities of fiber, mainly from the prickly pear cactus, which probably provided the stable subsistence base for the Lower Pecos populations (Williams-Dean 1978, Stock 1983). Prickly pear items identified from the Baker Cave coprolites included fiber, fruit seeds, calcium oxylate druse crystals, epidermis, and spines. Prickly pear pollen was not observed in the samples, indicating that at the time of deposition prickly pear flowers were not eaten. Most of the prickly pear seeds were fragmented, suggesting that the fruit was processed before consumption, possibly by milling or grinding with metates.

Although a few spines were recovered from the coprolites, the processing technique used on the prickly pear tunas probably involved a way of removing the spines; they could have been burned off (Vestal 1952, Whiting 1978), rubbed off (Millspaugh 1974, Stevenson 1915), or rolled off (Whiting 1978).

Onion bulbs and fibers were also prevalent in the coprolite samples. Onion was probably eaten whole and unwashed, fresh from the ground, because sand and dirt were found in high frequency in coprolites associated with the onion remains. Onion bulbs were also found in association with fish remains, suggesting that the onion may have been used as a seasoning or relish (Whiting 1939, Vestal 1952).

The fiber from desert succulents—yucca, agave, and sotol—was also observed in the coprolite samples, indicating that these plants, which have been considered staples (Williams-Dean 1978, Stock 1983), were also important dietary resources for the Baker Cave inhabitants. No pollen grains from yucca and agave were seen in the coprolite samples, suggesting that the flowers of these plants were not ingested at the time of deposition. But sotol pollen was observed, although in frequencies so low that it is doubtful that sotol flowers were ingested. If they were eaten, the coprolites that contained sotol pollen probably were deposited many days after the flowers were ingested (Sobolik 1988).

Seeds were also eaten by the Baker Cave occupants, mainly those of the prickly pear cactus, as discussed above, but also seeds of juniper, mesquite, goosefoot, pincushion cactus, mustard family, hackberry, oak, and walnut. None of these seed remains, however, were observed in more than three of the samples analyzed, indicating that they probably were not a main dietary item.

Pollen grains from plants that produce the smaller seeds of *Chenopodium* (goosefoot) and *Brassicaceae* (mustard family) also were observed in the samples. One sample had a high frequency of both Cheno-am pollen (pollen from *Chenopodiceae* or *Amaranthus)* and *Chenopodium* seeds, suggesting that the seeds and inflorescences were eaten together. This is a likely possibility since the small goosefoot seeds would have been hard to separate from the rest of the plant. The most frequent pollen was *Brassicaceae*, but these same samples did not contain *Brassicaceae* seeds. *Brassicaceae* inflorescences and seeds could have been eaten together, with the remains showing up in different fecal samples (Sobolik 1988), but the evidence is not conclusive.

Hard hulls of *Juniperus* seeds and *Juglans microcaropa* walnut shells indicate that these items were ground up and ingested for the nutritious internal meats, shell, hull, and all.

Pollen analyses provided evidence that the flowers, seeds, or inflorescences of certain plants were also dietary or medicinal items of the Baker Cave occupants. The pollen from *Brassicaceae*, *Artemisia* (sagebrush), and *Gramineae* (grass family) occured in high frequencies in the samples, indicating that pollens from these plants were ingested a few days before sample deposition (Sobolik 1988). Grass pollen and seeds have been observed in all of the lower Pecos coprolite studies (Riskind 1970, Bryant 1974b, Williams-Dean 1978, Stock 1983, Reinhard et al. 1989), indicating that this resource may have been a stable, unchanging aspect of prehistoric Lower Pecos diet. Grass seeds in samples from Hinds Cave, however, have been interpreted as accidental ingestants through rodent or bird remains (Williams-Dean 1978, Stock 1983).

Fish, the most important faunal dietary item as determined from the coprolites, was seen in 37 percent of the samples. The scales extracted from the coprolites were mainly from the *Perciformes* and the *Cypriniformes* families. Scales from sunfish, from a member of the salmon family (probably trout), and from gizzard shad or threadfin shad were also identified. Fish bone and scale remains were associated with a high frequency of charcoal, suggesting that the fish were roasted on coals.

The remains of rodents were also prevalent in the Baker Cave coprolite samples, identified in 34 percent of the samples. These remains included bones of the mouse *(Peromyscus),* wood rat *(Neotoma),* and cotton rat *(Sigmodon).* A large amount of rodent hair was also observed, and all parts of the rodent were represented, suggesting that they were eaten whole.

Bird bones and feathers were extracted from 16 percent of the Baker Cave coprolites. Almost the entire array of bird bones were represented from these samples, indicating that birds too were ingested whole. The other faunal remains observed in the Baker Cave coprolites were a snake vertebra and scale, lizard bones and skin, a rabbit bone, and unknown mammal bones. Coprolites, however, do not provide identification for the entire dietary array; larger animals whose remains could not be identified in the coprolites were also important in the diet of the Baker Cave occupants. These animals probably were a large variety of mammals, reptiles, and amphibians and, to a lesser degree, large fish and bird species, such as those identified in the faunal array at Hinds Cave (Lord 1984).

OTHER LOWER PECOS COPROLITE STUDIES

Many coprolite studies have been conducted on Lower Pecos material, suggesting a time span of about 8,400 years (Table 1). The first analyses of coprolites were from Hinds Cave (6,280 B.C.; Stock 1983) and Frightful Cave (7,500 to 5,000 B.C.; Bryant 1975, Fry n.d.). Time periods represented from Hinds Cave also include 4,800 to 5,500 B.C. (Stock 1983), 4,000 B.C. (Williams-Dean 1978) and 2,500 to 3,680 B.C. (Reinhard et al. 1989). Coprolites were also analyzed from the 5,000 to 2,000 B.C. and 2,000 B.C. to A.D. 300 levels at Frightful Cave (Bryant 1975, Fry n.d.). The youngest coprolites previously analyzed included samples from Conejo shelter dating from about 500 B.C. to A.D. 800 (Bryant 1969, 1974a). The analysis of the Baker Cave coprolites presented here (which date to about A.D. 900) provides the most recent information on Lower Pecos diet (Sobolik 1988).

Table 1. Lower Pecos Coprolite Studies

Date	Location	Sample Size	Researcher
7,500-5,000 B.C.	Frightful Cave	15	Bryant (1975), Fry (n.d.)
6,280 B.C.	Hinds Cave	29	Stock (1983)
5,500-4,800 B.C.	Hinds Cave	26	Stock (1983)
4,000 B.C.	Hinds Cave	100	Williams-Dean (1978)
3,680-2,500 B.C.	Hinds Cave	25	Reinhard et al. (1989)
5,000-2,000 B.C.	Frightful Cave	16	Bryant (1975), Fry (n.d.)
2,000 B.C-A.D. 300	Frightful Cave	16	Bryant (1975), Fry (n.d.)
500 B.C-A.D. 800	Conejo Shelter	43	Bryant (1974b)
A.D. 900	Baker Cave	38	Sobolik (1988)
No Dates	Parida Cave	11	Riskind (1970)

The most comprehensive analysis of coprolites in this area was a study of 100 coprolites from Hinds Cave by Williams-Dean (1978). These samples are dated to about 4,000 B.C. and reflect a diet centered around gathering (plant foods) and foraging (animal foods such as rodents, avifauna, and herpetofauna). The main plant items recovered were fiber, epidermis, spines, and seeds of the prickly pear cactus. Other plants identified from the samples were onion, persimmon, hackberry, sotol, lechuguilla, and walnut.

Other studies of Hinds Cave (41VV456) coprolites include analyses by Stock (1983) and Reinhard, Jones, and Barros (1989). Stock (1983) analyzed the macroremains of 55 coprolite specimens from two different areas of occupation at Hinds Cave. Twenty-six coprolites with an average date of 5,286 B.C. and 29 specimens with an average date of 6,280 B.C. were analyzed for comparison with those in Williams-Dean's study and to support generalizations about diet change and subsistence of the Hinds Cave occupants. Stock's analysis also showed that prickly pear was the main dietary item; other significant dietary items were onions, persimmons, walnuts, fish, and rodents.

Stock (1983) conducted extensive statistical comparisons (analysis of variance and Wilcoxon test) between the Hinds Cave coprolites as represented in her study and the chronologically later samples analyzed by Williams-Dean (1978). She found that the incidence of fiber decreased as the number of species increased. Cacti and succulents remained important in the diet at all time periods, but a trend toward increase in the amount of constituents—particularly fauna, rodent, and rodent hair—was observed. Animal protein and fish were observed—but not in abundance—in the earlier time periods; bird remains were observed only in the later period.

Pollen remains from Hinds Cave coprolites were studied by Williams-Dean (1978) who noted a variety of pollen types in the coprolites, including sotol, agave, cenizo, cactus, and prickly pear.

In the recent study of 25 coprolite samples conducted by Reinhard, Jones, and Barros (1989), parasites, pollen, and macroremains were analyzed. The samples were excavated from levels dating between about 2,500 and 3,680 B.C., (slightly later than those analyzed by Williams-Dean) and contained a variety of economic pollen types, including grass pollen aggregates (suggesting the eating of anthers), agave, sotol, hackberry, and *Lycium. Opuntia* seeds and fiber were major constituents, and bone was observed in 64 percent of the samples.

Only about 25 percent of the more-than-1,000 coprolites excavated from Hinds Cave (Shafer and Bryant 1977) have been analyzed; the remaining specimens are being held in reserve for future analysts when new methods and proceedures may yield more information. The reservation of coprolite samples is especially important, since substantial numbers of coprolites from Lower Pecos sites already have been lost, discarded by previous excavators as unimportant (Bryant 1987)

Macroremains (Fry n.d.) and pollen content of 47 coprolites recovered from Frightful Cave in Coahuila, Mexico (Bryant 1975) have been analyzed. These samples were divided into three groups; 15 samples date from 7,500 to 5,000 B.C., 16 samples date from 5,000 to 2,000 B.C., and 16 samples date from 2,000 B.C. to A.D. 300. Bryant (1975) analyzed the diet of the Frightful Cave occupants, observing that in all of the time periods they were eating flowers or inflorescences. *Opuntia* pollen was very important in the early levels, as well as *Leucaena* and *Umbelliferae* pollen. Other items became important in the diet, but *Opuntia* pollen was not one of them. Bryant (1975) proposed from these data that the change in *Opuntia* pollen usage resulted mainly from cultural change rather than from degree of availability in the environment. Ingestion of other parts of *Opuntia* (prickly pear) did not drop off; it remained a steady, stable dietary item (Fry n.d.). Animal hair also was present in all of the macroremains (Fry n.d.), indicating that mammals remained an important dietary item.

Forty-three coprolites (Bryant 1969, 1974b) excavated from various levels of Conejo Shelter (41VV162) and dated from 500 B.C. to A.D. 800, are the youngest samples outside of the Baker Cave study. They indicated that the inhabitants of Conejo shelter were mainly eating a large variety of flowers and inflourescences, including yucca, agave, sotol, prickly pear, pincushion cactus, persimmon, gilia, leadtree, and mesquite. The plant macroremains (fiber and seeds) from 47 coprolites recovered from Frightful Cave in Coahuila, Mexico, indicated that *Opuntia* was still a main staple in the diet, and succulent fibers such as sotol and agave were also prevalent. The animal macroremains reflected the ingestion mainly of rodents but also some fish, lizards, and grasshoppers. The remains of mammals were observed in 23 percent of the samples—fewer than in the Hinds Cave studies (Williams-Dean 1978, Stock 1983).

Riskind's (1970) analysis of the pollen spectra from 11 coprolites from Parida Cave (41VV187)—all excavated from test pit 4 and representing many levels of occupation—identified the economic pollen types agave, pincushion cactus, yucca, grass, and mormon tea. The data from the Parida Cave coprolites

(Riskind 1970) are not included in this analysis, since the samples represent all levels of the cave matrix and have not been dated.

CONCLUSIONS

From the analysis of a variety of coprolites representing a wide time range in the Lower Pecos Region, prickly pear was found to be a main dietary staple. Evidence of prickly pear usage; fiber, seeds, spines, calcium oxylate crystals, and glochids, shows up in all of the coprolite studies. Other prominent dietary items include sotol, agave, and yucca fiber, which were used consistently in the Lower Pecos diet, and possibly during all seasons, but they may have been winter staples (Brown 1988).

The other dietary items observed in the coprolites varied in cosistency and variety. Rodent remains were observed with varying frequencies in all of the coprolites. The highest amount and variety of rodents in the diet was at Hinds Cave from 6,280 to 4,000 B.C.. Other coprolites studied indicate rodent usage, although in lower frequencies and with less variety. Instead of dietary change through time, the differences in rodent frequencies may indicate a difference in the distribution of rodent species through time. This difference may also indicate that larger game made up most of the animal protein during other time periods. Since protein from meat sources is entirely digested in the system and meat from larger game is usually removed from the bones before eating, no remains of larger animals would be seen in the coprolite material. For this reason, the importance of their meat protein to the diet cannot be estimated.

Together with the rodent remains, there apparently was an increase in faunal diversity, mainly bird and fish, through time. The Baker Cave coprolites had the highest incidence of fish and bird remains in the Lower Pecos Region. No bird remains were observed in the early coprolite samples, and fish were only observed at low frequencies.

Flower and inflorescence ingestion has also been observed in all time periods of the Lower Pecos. Through time, however, there tends to have been an increase in the diversity of flowers ingested, although this probably reflects seasonal differences. The mustard family, sagebrush, leadtree, and gilia are some of the new pollen types added toward the end of the Lower Pecos occupation. Grass pollen was observed in all of the coprolite studies, suggesting that their inflorescences and seeds were also a staple.

These differences through time and differences in the several coprolite studies may merely reflect seasonality. This is evident in the economic pollen assemblage at Conejo shelter, which has been tentatively designated a spring-early summer occupation. The pollens in these samples represent a large variety of plants. More plants bloom in the spring and summer months, and if flowers were a dietary item, more pollen types would be found in samples that were deposited during the spring and summer.

There were fewer economic pollen types at Baker Cave than at Conejo shelter. Since Baker Cave is postulated as a late summer-fall occupation (Sobolik 1988) when fewer plants bloom, less pollen variety would be expected in the coprolite samples. The economic pollen types observed, however, may indicate that new flower or inflorescence types were being ingested. The Baker Cave coprolites may also be the only ones analyzed that reflect a late summer-fall occupation, so the different pollen types observed in the samples reflect only seasonality and not the addition of a wider variety of species.

Turpin (1984, 1986) and Shafer (written communication) have indicated that the Late Prehistoric time period differed from the Archaic in the Lower Pecos Region, and that there may have been great social mobility and unrest as populations intruded from the north and west. The bow and arrow replaced the atlatl, the art stlye changed, the earlier pictograph styles were replaced by a different red monochrome style, and there was a shift in burials and living sites during this time period from the rockshelters to the uplands (Turpin 1984, 1986). A change in the diet of the Lower Pecos Region, as reflected in the most recent coprolites, may merely reflect this cultural change.

Diet change in the Lower Pecos Region may have several explanations. The differences among the coprolite studies may actually indicate change through time. Other explanations include seasonality differences, differences in species distribution through time, or changes in cultural practices and preferences.

Overall, the lower Pecos diet, as reflected by coprolites, has not changed drastically but has maintained a stable economic subsistence that has supported a population in the region for more than 9,000 years. The staples of the diet—items that were probably eaten year round—were prickly pear pads and yucca, sotol, and agave fiber and tissue. An increase in the variety of the diet, however, has been observed and is represented by a larger amount of fish and birds and an increase in the variety of flower types ingested.

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REFERENCES CITED

Alexander, R. K.

1970 Archeological Investigations at Parida Cave, Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* No. 19, Austin.

1974 The Archaeology of Conejo Shelter: A Study of Cultural Stability at an Archaic Rockshelter Site in Southwestern Texas. Unpublished Ph.D. dissertation, Department of Anthhropology, The University of Texas, Austin.

Benninghoff, W. S.
1974 Use of Trisodium Phosphate with Herbarium Material and Microfossils in Peat. *Science* 183:1206-1207.

Blair, W. F.
1950 The Biotic Provinces of Texas. *The Texas Journal of Science* 2:93-117.

Brown, K. M.
n. d. The 1984 Season at Baker Cave. Manuscript on file at the Anthropology Library, Texas A&M University.

1986 Prehistoric Economics at Baker Cave: Some Thoughts on Optimal Rummaging. Paper presented in the symposium Recent Advances in Texas Archeology. Annual meeting of the Archeological Institute of America, San Antonio, Texas.

1988 Some Annoted Excerpts from Alonso De Leon's History of Nuevo Leon. *La Tierra* 15(2):5-20.

Bryant, V. M., Jr.
1969 Late Full-Glacial and Post-Glacial Pollen Analysis of Texas Sediments. Unpublished PhD. dissertation, Department of Botany, The University of Texas, Austin.

1974a The Role of Coprolite Analysis in Archeology. *Bulletin of the Texas Archeological Society* 45:1-28.

1974b Prehistoric Diet in Southwest Texas: The Coprolite Evidence. *American Antiquity* 39(3):407-420.

1975 Pollen as an Indicator of Prehistoric Diets in Coahuila, Mexico. *Bulletin of the Texas Archeological Society* 46:87-106.

1987 Pollen Grains: The Tiniest Clues in Archaeology. *Environment Southwest* 519:10-13, San Diego Society of Natural History.

Bryant, V. M., Jr., and R. G. Holloway
1985 A Late-Quaternary Paleoenvironmental Record of Texas: An Overview of the Pollen Evidence. In *Pollen Records of Late-Quaternary North American Sediments,* Bryant and Holloway (eds.). American Association Stratigraphic Palynologists Foundation, Dallas.

Callen, E. O., and T. W. M. Cameron
1960 A Prehistoric Diet Revealed in Coprolites. *The New Scientist* 8(190):35-40.

Chadderdon, M. F.
1983 Baker Cave, Val Verde County, Texas: The 1976 Excavations. *Center for Archaeological Research, The University of Texas at San Antonio, Special Report* 13.

Dering, J. P.
1979 Pollen and Plant Macrofossil Vegetation Record Recovered from Hinds Cave, Val Verde County, Texas. Unpublished M. S. Thesis, Department of Anthhropology, Texas A&M University.

Douglas, C. L.

1970 Analysis of the Faunal Remains. In Excavations at Baker Cave, Val Verde County, Texas, *Bulletin of the Texas Memorial Museum* No. 16, The University of Texas at Austin.

Fry, G. F.

1985 Analysis of Fecal Material. In *The Analysis of Prehistoric Diets.* Academic Press, New York.

n.d. Analysis of Human Coprolites from Frightful Cave. in *Contributions to Coahuila Prehistory,* (R. C. Carlisle., Ed.) Ethnology Monographs Series (n.d.).

Greer, J. W.

1968 Excavations at Baker Cave in Central Val Verde County, Texas. Notes on file at Texas Archeological Research Laboratory, The University of Texas at Austin.

Harshberger, J. W.

1896 The Purpose of Ethnobotany. *American Antiquarian* 17(2.)

Hester, T. R.

1983 Late Paleo-Indian Occupations at Baker Cave, Southwestern Texas. *Bulletin of the Texas Archeological Society* 53:101-119.

1986 Baker Cave: A Rich Archaeological Record. In *Ancient Texans: Rock Art and Lifeways Along the Lower Pecos.* Texas Monthly Press, Austin.

Kapp, R. O.

1969 *How to Know Pollen and Spores.* William C. Brown Company, Dubuque.

Lord, K. J.

1984 The Zooarchaeology of Hinds Cave (41VV 456). Unpublished Ph. D. dissertation, Department of Anthropology, The University of Texas at Austin.

Loud, L. L., and M. R. Harrington

1929 Lovelock Cave. University of California Publications in *America Archeology and Ethnology* 25(1).

Martin, A. C., and W. D. Barkley

1973 *Seed Identification Mannual.* (Second edition.) University of California Press, Berkley.

Millspaugh, C. F.

1974 *American Medicinal Plants.* Dover Publications, New York.

Reinhard, K. J., J. G. Jones, and R. P. Barros

1989 Bioculture Overview of the Lower Pecos Region of Texas. *Health and Disease in the Prehistoric Southwest II.* (Stan Rine and R. Ted Steinbock, Editors) Maxwell Museum, University of New Mexico, Albuquerque. In press.

Riskind, D. H.

1970 Pollen Analysis of Human Coprolites from Parida Cave. In Archaeological Investigations at Parida Cave, Val Verde County, Texas. *Papers of the Texas Archeological Salvage Project* 19. Austin.

Shafer, H. J.

1981 The Adaptive Technology of the Prehistoric Inhabitants of Southwest Texas. *Plains Anthropologist* 26:129-138.

1986 *Ancient Texans: Rock Art and Lifeways Along the Lower Pecos.* Texas Monthly Press, Austin.

Shafer, H. J., and V. M. Bryant, Jr.

1977 Archaeological and Botanical Studies at Hinds Cave, Val Verde County, Texas. *Annual Report to the National Science Foundation* 1-66.

Smith, G. E., and F. W. Jones

1910 *Archeological Survey of Nubia 1907-1908.* Cairo.

Sobolik, K. D.

1988 The Prehistoric Diet and Subsistence of the Lower Pecos Region, as Reflected in Coprolites from Baker Cave, Val Verde County, Texas. Unpublished M.A. thesis, Department of Anthropology, Texas A&M University.

1989 The Importance of Pollen Concentration Values from Coprolites: An Analysis of Southwest Texas Samples. *Palynology* 12:201-214.

Stevenson, M. C.

1915 Ethnobotany of the Zuni Indians. *Thirtieth Annual Report of the Bureau of American Ethnology.*

Stock, J. A.

1983 The Prehistoric Diet of Hinds Cave (41VV456), Val Verde County, Texas: The Coprolite Evidence. Unpublished M.A. Thesis, Department of Anthropology, Texas A&M University.

Turpin, S. A.

1984 The Red Monochrome Style Pictographs of the Lower Pecos River Region, Texas. *Bulletin of the Texas Archeological Society* 55:123-144.

1986 The Red Monochrome Style and Later Pictographs: The Art of Newcomers to the Lower Pecos. In *Ancient Texans: Rock Art and Lifeways Along the Lower Pecos,* Harry J. Shafer (Ed.). Texas Monthly Press, Austin.

Van Cleave, H. J., and J. A. Ross

1947 A Method for Reclaiming Dried Zoological Specimens. *Science* 105.

Vestal, P. A.

1952 Ethnobotany of the Ramah Navaho. *Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University,* 40(4).

Whiting, A. F.
1939 Ethnobotany of the Hopi. *Museum of Northern Arizona Bulletin* 15.

Williams-Dean, G. J.
1978 Ethnobotany and Cultural Ecology of Prehistoric Man in Southwest Texas. Unpublished PhD Dissertation, Department of Anthropology, Texas A&M University.

Word, J. H., and C. L. Douglas
1970 Excavations at Baker Cave, Val Verde County, Texas. *Bulletin of the Texas Memorial Museum* 16.

Young, B. H.
1910 The Prehistoric Men of Kentucky. *Filson Club Publications* 25. Louisville, Kentucky.

A Preliminary Report on Archeological Resources in Southern Culberson County in the Vicinity of Van Horn, Texas

John A. Hedrick

ABSTRACT

This paper reports results of an ongoing survey of sites in six study areas in southern Culberson County, Texas. The region appears to have been occupied from the Paleo-Indian period through Late Prehistoric times.

INTRODUCTION

The locus of this study of archeological resources in the region around Van Horn, in southern Culberson County, Texas is a 3,500-km² area comprising six study areas. The study focuses on (1) surveying and recording sites and (2) cataloging private projectile point collections, particularly those with known proveniences. In conjunction with documenting the collection of Harold O. (Hock) Haynes, both Haynes and the late R. K. Wylie greatly furthered the survey by securing access to private property and assisting in recording the sites—described in this report—from which the projectile points were collected.

THE AREA

The 3,500-km² region (Figure 1) encompasses Salt Flat, Michigan Flat, Lobo Valley, and adjacent mountain ranges of southern Culberson County, southeastern Hudspeth County and western Jeff Davis County. The area is part of a broad corridor of classic basin and range topography that extends from the Guadalupe Mountains and Salt Basin in the north to the Davis Mountains in the south. It is bordered on the west by the Sierra Diablo, Baylor, Beach, Carrizo, and Van Horn mountains, and on the east by the southern Delaware, Apache, and northern Davis mountains. The Wylie and Chispa mountains divide the southern basin into the Lobo Valley and Michigan Flat. Elevations range between 1,110 meters (3,700 feet) at Salt Flat and more than 1,800 meters (6,000 feet) in the Sierra Diablo and Davis Mountains.

The topography is typical of the Trans-Pecos region, varying from rugged mountains with deep canyons, flat-topped mesas, alluvial fans, slopes, and terraces to volcanic cones and lava flows. In the survey area are alluvial valleys, large dune fields, flatlands, and alkaline flats.

Water resources include large draws that carry runoff from the mountains into the basin and eventually into Salt Flat to the north. There are also many arroyos, springs, seeps, and *tinajas* (bedrock pools) in the hills and mountains, and playas in the flatlands.

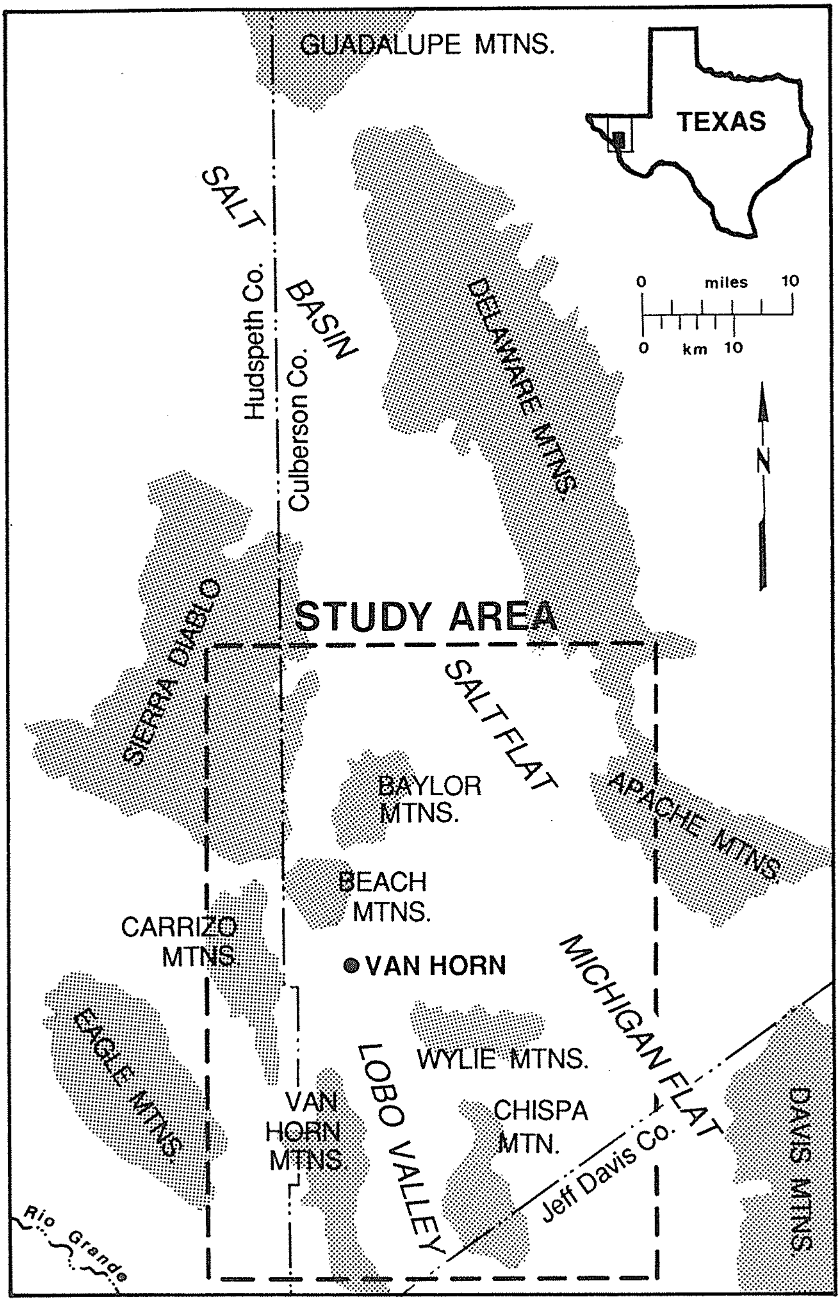

Figure 1. Map of parts of Culberson, Hudspeth, and Jeff Davis counties showing the extent of the survey area.

The basin and mountains contain enormous quantities of lithic resources. In addition to very fine grades of chert, these resources include limestone, sandstone, schist, shale, rhyolite, felsite, conglomerate (puddingstone), basalt, vesicular basalt, quartz, quartzite, talc, soapstone, agate, jasper, chalcedony, petrified wood, and small obsidian nodules.

To the north are the salt deposits of the Salt Basin and Salt Flat (Henry and Price 1986; Price et al. 1986).

The basin is part of the north-central Chihuahuan Desert and has the flora and fauna usually associated with the district. Annual average precipitation is 239 mm, about half of which falls as thunderstorms during July, August, and September (Foster and Kelley 1987:1).

Archeological reports on the region are few; the first is by Joe Ben Wheat in Lehmer's (1960:122) *A Review of Trans-Pecos Texas Archeology.* Other investigations have been reported by Hedrick (1968, 1975, 1986), and additional work in the region has been in conjunction with construction of a floodwater diversion channel between Three-Mile and Sulphur draws (Skinner and Bousman 1973, Banks 1975, Gerald 1978, Cliff and Fifield 1980, Foster and Kelley 1987). The peripheral areas of the study region, particularly those in the Guadalupe Mountains and Guadalupe Mountains National Park, have been studied more thoroughly (Clark 1974, Katz and Katz 1974, Phelps 1974, Katz, P. 1978, Boisvert 1980, Katz and Lukowski 1981, Katz, S. 1983).

THE SURVEY

The focus of the survey is toward establishing an overview of the kinds of sites that can be expected in the region. It is hoped that this phase will be followed by intensive, controlled follow-up surveys of selected areas and recording of all sites.

Site data have been recorded on specifically designed survey forms, with close attention to key informational categories such as site and feature description, cultural material density and description, land forms, soil types, vegetation, and water resources. Sites were plotted on U. S. Geological Survey 15-minute quadrangles. Surface collections were selective, with emphasis on lithic and diagnostic samples. Most, but not all, sites were photographed. Trinomial site numbers have been assigned by the Texas Archeological Research Laboratory. No subsurface testing or excavation has been undertaken.

For the purposes of this survey, four ecological zones have been defined:

1. **Flatlands and dune areas,** with amaranth, beargrass, creosote, dock, flowers, grasses, mesquite, mormon tea, sage, salt bush, snakeweed, and yucca.
2. **Hills and slopes,** with agave, cholla, ocotillo, prickly pear, sotol, and *Yucca baccata.*
3. **Canyons and watercourses,** with allthorn, catclaw, desert willow, and sumac.
4. **Mountains,** with buckeye, juniper, and scrub oak.

The six study areas in the region are:
Study Area 1—The Plateau complex (Figure 3).
Study Area 2—Central and southern Wild Horse Draw (Figure 4).
Study Area 3—Van Horn Mountains Area 1 (Figure 4).
Study Area 4—Van Horn Mountains Area 2 (Figure 4).
Study Area 5—Carrizo Mountains Area 1 (Figure 5).
Study Area 6—Carrizo Mountains Area 2 (Figure 5).

SURVEY RESULTS

The Sites

One hundred twenty-seven sites are reported here (Table 1). Sixteen had been reported previously (Hedrick 1975), and three already had been assigned site numbers by the Texas Archeological Research Laboratory . A tabulation of data for all sites is presented in the Appendix.

Base Camps

Base camps are the second largest category of sites. They are extensive areas of cultural debris and associated features that may include multiple, separate, or overlapping rock hearths, burned rock scatters, fire-blackened sand, lithic work areas, and, occasionally, ring middens. Moderately dense to very dense cultural debris at these sites consists of chipped stone debitage, chipped stone tools, and ground stone tools. Artifact assemblages include, in addition to very few ceramics, projectile points, scrapers, choppers, knives, bifaces, retouched and utilized flakes, cores, manos, and metates in all stages of manufacture and use. Base camps appear to be multiuse sites that may have been either seasonally or continuously occupied, and seem to be associated with hunting, food processing, and tool manufacture.

Twenty-three base camps were recorded in the survey area. All but two are in the Plateau Complex Study Area (Table 1), but their absence cannot be assumed in other areas. The average area of the sites is 18,930 m^2; all are near water resources (Table 2).

Campsites

The largest category of sites recorded is campsites. Campsites are similar to base camps but they are smaller and have a lower density of cultural debris. Features may include multiple—sometimes overlapping—hearths, scattered burned rock, and areas of fire-blackened sand areas. Cultural material is scattered throughout the site in light-to-moderate density but may be concentrated around hearths. Artifact assemblages are similar to those at base camps and include, in addition to ceramics, projectile points, scrapers, choppers, knives, bifaces, retouched and utilized flakes, cores, manos, and metates in all stages of manufacture and use. Campsites appear to be hunting, food processing, and tool manufacture sites.

Table 1. Distribution of Different Kinds of Sites in the Study Areas

(**PC,** Plateau Complex; **C/SWHD,** Central and Southern Wild Horse Draw; **VHM-1,** Van Horn Mountains Area; **VHM-2,** Van Horn Mountains, Area 2; **CM-1,** Carrizo Mountains, Area 1; **CM-2,** Carrizo Mountains, Area 2.).

SITE CATEGORY	PC	C/SWHD	VHM-I	VHM-2	CM-1	CM-2	TOTAL	PERCENT
Base Camps	21	1	1	–	–	–	23	18.11
Campsites	38	7	5	–	9	–	59	46.46
Rockshelters	–	–	2	1	15	–	18	14.17
Quarries	4	–	–	2	–	3	8	6.30
Ring Middens	1	–	-	–	4	–	5	3.94
Rock Circles	1	1	–	–	–	–	2	1.57
Rock Art	1	–	–	1	–	–	2	1.57
Lithic Scatter	1	1	–	2	1	–	5	3.94
Isolated Hearths	1	2	–	–	–	–	3	2.36
Cairns	–	–	–	–	–	1	1	0.79
Isolated Finds	1	–	–	–	–	–	1	0.79
TOTALS	69	12	8	5	29	4	127	100.00

Table 2. Distribution of Base Camps in Relation to Water Resources

(**PC,** Plateau Complex; **C/SWHD,** Central and Southern Wild Horse Draw; **VHM-1,** Van Horn Mountains Area 1.).

Water Resource	Study Area		
	PC	C/SWHD	VHM-1
Draw or Creek			
Draw/Creek Edge	10	1	-
0.5 km or Less	2	-	-
0.6 to 1.5 km	7	-	-
More than 1.5 km	1	-	-
Arroyo	-	-	1
Playa	1	-	-

Fifty-nine campsites, with average areas of 4,650 m^2 were recorded in the survey area. Fifty-five are near draws, arroyos, or playas (Table 3).

Rockshelters

Eighteen rockshelters were recorded in the survey area, two of which contained stratified cultural material. All but one of the remaining sixteen had talus slope midden or ground level midden deposits. All of the shelters are near creeks, draws, springs, seeps, or tinajas.

Quarries

Eight quarries were recorded. The Purple-Tan Chert quarry (41CU449) and

Table 3. Distribution of Campsites in Relation to Water Resources

(**PC**, Plateau Complex; **C/SWHD**, Central and Southern Wild Horse Draw; **VHM-1**, Van Horn Mountains Area 1; **CM-1**, Carrizo Mountains, Area 1).

Water Resource	Study Area			
	PC	C/SWHD	VHM-1	CM-1
Draw or Creek				
Draw/Creek Edge	12	2	-	2
0.5 km or less	14	1	-	5
0.6 to 1.5 km	7	1	-	-
More than 1.5 km	2	-	-	-
Arroyo	1	-	5	1
Playa	2	-	-	-

the white chert quarries (41CU349, CU372, and CU379) have been reported by Hedrick (1975:58-60; 1986:17).

The Purple-Tan Chert quarry (41CU449) covers about 390,000 m^2 on the ridge and slopes of a range of Cretaceous limestone hills in the eastern part of the Plateau Complex. The chert, exposed in nodules, is extremely dense, and has a fine, glossy texture. It produces an excellent concoidal fracture andthin, translucent flakes. Predominant colors are grayish orange (10YR7/4), very pale orange (10YR8/2), grayish red-purple (5RP4/2). pale red (5R6/2) and pinkish gray (5YR8/1) (Rock Color Chart Committee 1984). The entire area of the quarry is densely covered with evidence of removal from matrix, testing, and trimming of the chert.

Three white chert quarries (41CU349, CU372, and CU379) are on ridges and slopes of three separate cretaceous limestone hills in the Plateau Complex Study Area. The sites range in size between 4,800 and 70,000 m^2. Colors range between white (N9) and medium light gray (N6)—some have fossil inclusions—and pinkish gray (5YR8/1) (Rock Color Chart Committee 1984). The chert is coarse to fine grained and has good conchoidal fracture. The three sites are densely covered with debris from testing and preparation of material.

The Van Horn Mountain quarry (41CU389) is on a mesa in Study Area 4, the Van Horn Mountains, Area 2. The material is scattered over an area of about 9,000 m^2 and consists of broken nodules that have eroded out of the limestone cap. The raw material is spotted and/or marbled combinations of moderate red(5R5/4) to grayish red (5R4/2) and very pale orange (10YR8/2) (Rock Color Chart Committee 1984). It has a medium- to fine-grained, matte texture and excellent conchoidal fracture. Debris from testing and preparation of material is scattered over the area.

Pebbles and boulders of a felsite quarry (41HZ397) are scattered among the pediment gravels in Study Area 6, Carrizo Mountains, Area 2. The coarse- to fine-grained material is extremely hard and dense. Colors are dark reddish brown (10YR3/4), dark red (5R3/4), moderate red (5R5/4), and grayish red (5YR4/1 and 5R4/2). Activity areas are easily recognized by the remnants of pebbles and boulders that have been broken in the initial stages of tool manufacture.

Two more felsite quarries (41CU441 and CU443) are on terraces 300 meters and 500 meters east of 41HZ397. The materials and preparation areas are like those at site 41HZ397.

Tumbled fragments of agate, jasper, and chalcedony are found in the gravels, which are identical to those at the three felsite quarries.

An additional source for raw material in the north end of the Wylie Mountains has been described by Joe Ben Wheat (personal communication 1988), and by Garry and Sally Elder (personal communication 1987). The precise location has not been recorded because of lack of access to the property, but a type site, 41CU424, has been identified about 3,200 meters from the area pointed out by Wheat and the Elders. About 60 to 75 percent of the lithics on the site are of the distinctive agate that looks like butterscotch taffy. Colors vary from light brown (5YR5/6) and dark yellowish brown (10YR6/6) to moderate brown (5YR4/4) (Rock Color Chart Committee 1984). This agate is found throughout the basin.

Ring Middens

Five ring midden sites were recorded. Greer (1968:127) defines a ring midden as a "doughnut-shaped structure appearing as a ring of mounded hearthstones, ash, or a combination of these surrounding a depression of almost rock-free gray ash." Creel (1981:175) reported that 170 such features in the Eagle Mountains were 8 to 10 meters in diameter with rings 2 to 3 meters wide, and were only rarely more than 30 cm high.

Site 41CU416 has five ring midden features, apparently partially buried, ranging between 5 and 11 meters in diameter with central depressions ranging between 3 and 8 meters in diameter; heights vary from 10 to 20 cm. The middens are on the flatlands below and on a saddle in the limestone hills west of the Apache Mountains in the Plateau Complex Study Area. Associated cultural debris is light and scattered and consists, in addition to a single mano, of chips and flakes.

Site 41HZ396 has two ring middens and one piled rock hearth. The middens have outside diameters of 7 and 8 meters and central depression diameters of 2.8 and 3.5 meters; heights are 10 to 20 cm. Diameter of the hearth is 1.5 meters. The partially buried site is on a gravel terrace in the Carrizo Mountains, Area 1. Associated cultural material consists of chips and flakes.

Rock Circle

Two rock circle sites were recorded. Site 41CU378 is on top of and on ledges near the top of a limestone hill east of Michigan Draw in the Plateau Complex Study Area. The site has 18 rock circle features 1.2 to 3 meters in diameter (Figure 2). The location provides an unobstructed view for at least 60 km (about 40 miles) in all directions. There appear to be no interior features or stratigraphy, and the purpose of the circles is unknown. Mallouf visited the site in 1985 and determined that these features are not the same as the circular stone enclosures of the Cielo complex (Mallouf 1985:Figure 58). Similar rock circles are found in the Jornada del Muerto of southern New Mexico and may be observation posts of the historic Apache Indians (Jay Sharp, personal communication 1988). The site is on the same hill as 41CU349, one of the white chert quarries.

Site 41CU384 is on a small hill of volcanic tuff in the southern Wild Horse Draw area of the Lobo Valley. The four rock circle features, lying directly on bed rock, are 3 to 5 meters in diameter. The circles are similar in construction to those at 41CU378 and also afford an unobstructed view in all directions.

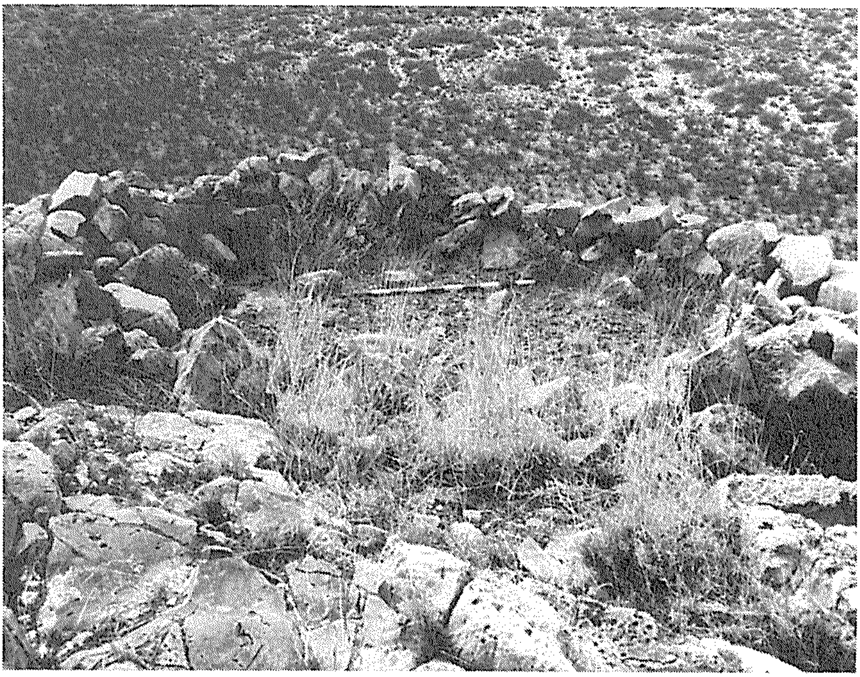

Figure 2. Photograph of a rock circle feature overlooking Michigan Flat at site 41CU378.

Rock Art

Two rock art sites were recorded. Site 41CU446 is on sandstone boulders in a canyon of the Van Horn Mountains. The petroglyphs are mainly a series of random straight and wavy lines. Identifiable elements are a sunburst, several circles, and one handprint.

The second rock art site (41CU259) was recorded originally by Jackson (1938). It is on conglomerate sandstone boulders near a small range of hills in the eastern part of the Plateau Complex Study Area. The petroglyphs consist of straight and wavy lines, and circles.

Lithic Concentrations and Scatters

Lithic concentrations and scatters are defined in this report as areas of chipped stone debris and chipped stone tools that have no discernible associated features. Lithic concentrations have moderate to heavy density; scatters have light to moderate density. Cultural materials may include cores, flakes, chips, tools, and projectile points. Five of these sites were recorded, averaging 2,500 m^2 in size.

Isolated Hearths

Three isolated hearths—single hearths with or without associated cultural material—were recorded. Cultural material, which, when present, is of light to moderate density and scattered, may include chipped stone debris and artifacts. These hearths apparently are single or short-term occupation areas that were used for food preparation, for keeping warm, or in hunting and gathering activities.

Cairns

The only cairn site, 41CU442, comprises five distinct piles of large rocks on a gradual slope below the terrace between the felsite quarries, 41CU441 and CU443. The most concentrated pile of rocks measures about 80 by 200 cm and is 30 to 40 cm high. The remaining four are scattered in more or less circular patterns 1.5 to 3 meters in diameter. These features are similar to a cache reported by Betancourt and Ralph (1981b:105, 106, Figure 19) on a high saddle in the Hueco Mountains.

Isolated Finds

The only isolated find (a single artifact with no associated features or evidence of activity) of the survey, recorded as site 41CU373, is a Folsom point fragment. The point, which has a broken base, measures 30 mm long and 23 mm wide; it is made from butterscotch agate. Three tiny flakes of different materials, possibly unrelated to the point, were nearby.

Study Areas

Study Area 1—Plateau Complex

Study Area 1—Plateau Complex is the best known of the study areas. It has been the focus of attention for many years (Hedrick 1968, 1975, 1986), and about 80 percent of it has been surveyed. The area lies between the eastern slopes of the Wylie Mountains and the western and southern slopes of the Apache Mountains (Figure 3). Water resources are Michigan Draw, China Draw, Plateau Draw, and the northern part of Wild Horse Draw. A chain of mesquite-stabilized, aeolian dune fields on packed sand extends northward from the southern end of Michigan Draw, near its intersection with Bunton Draw, and then northwestward across the basin to North Wild Horse Draw. The dune field is moderately covered with mesquite and yucca of Zone A, and the dune fields on the eastern side of Michigan Draw have been partially destroyed by the introduction of watermelon and cotton fields. A series of limestone hills to the west of the Apache Mountains have a moderate cover of Zone B vegetation—sotol, agave, prickly pear, cholla, and ocotillo.

The Plateau complex includes 69 sites; 38 (55 percent) are campsites, and 21 (30 percent) are base camps. Four of the quarries—the Purple-Tan chert

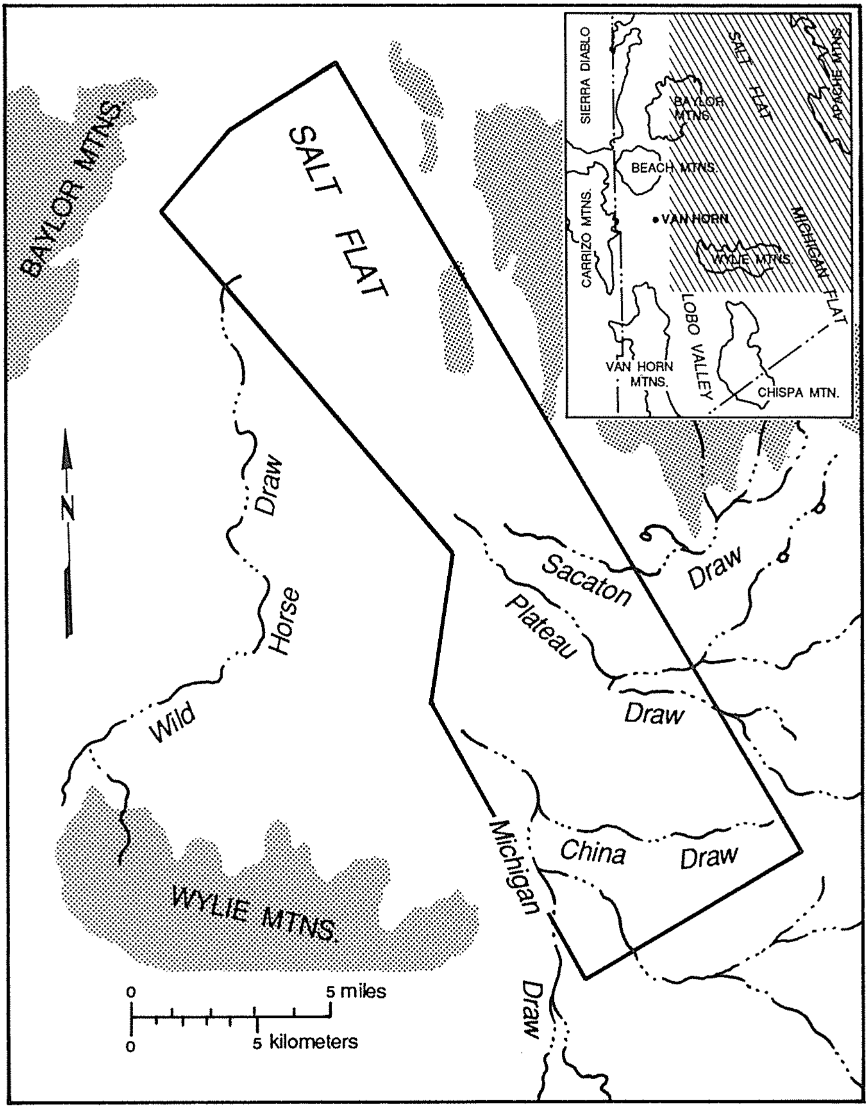

Figure 3. Map of part of Culberson County, showing Study Area 1—The Plateau Complex.

quarry (41CU449) and the white chert quarries (41CU349, CU372, CU379)—are also in the complex. The other six sites are a lithic scatter, a ring midden, an isolated hearth, a rock circle, a rock art display, and an isolated find. Most of the sites are eroded and are covered and uncovered depending on climatic conditions. This covering and uncovering has caused a mixing of components; however, the cultural remains at several of the sites have not been subjected to this erosion-caused blending.

Campsites and Base Camps

Campsite and base camp features include many multiple—sometimes overlapping—hearths, scattered burned rock, and areas of fire-blackened sand. Density of cultural debris is moderate in general and moderate to heavy around hearths.

Artifacts include chips, flakes, utilized flakes, retouched flakes, choppers, hammerstones, knives, scrapers, bifaces, cores, gravers, mano and metate fragments, and ceramics. Dart points and arrowpoints are complete, broken, and in all stages of manufacture. Most of the finer artifacts such as projectile points, chips, and flakes were made of raw material from the Purple-Tan and white chert quarries. Many larger artifacts such as choppers, large knives, and hammerstones were made of stone from the felsite quarry across the basin in Study Area 6, the Carrizo Mountains, Area 2.

Site 41CU348 is a base camp measuring 120 by 60 meters on a mesquite-stabilized dune terrace east of Michigan Draw. Features include rock hearths 50 to 80 cm in diameter, burned sand areas, and a ring midden of burned limestone 7 meters in diameter and 30 to 40 cm high. The rocks in the midden apparently were brought in from the limestone hills about 500 meters to the east. Cultural materials include chipped stone tools and debris. Fragments of ground stone tools were also noted. The site is on the edge of a draw, 500 meters from a quarry.

Site 41CU361 is a base camp measuring 275 by 80 meters on an isolated dune terrace on the edge of Michigan Draw. The terrace is apparently eroded and has become isolated from the other dune ridges. Below the mesquite-stabilized dunes is a hard-packed sand deposit that apparently was the original formation of the terraces along the draw.

Features include many isolated and overlapping hearths 50 to 80 cm in diameter in strata stair-stepped from the erosion of the dunes, and several areas of concentrated lithic debris may be work areas. Cultural debris is dense and includes chipped stone tools and debris and ground stone tool fragments.

Another base camp (41CU370), measuring 150 by 50 meters, is also on the dune terrace on the edge of Michigan Draw. The site slopes from east to west providing protection from the extensive erosion and sand movement that occur on most of the dune sand sites. Features include rock hearths, burned rock scatters, and a ring midden 7 to 8 meters in diameter. Cultural debris is dense and, in some areas, is concentrated around the hearths.

Base camp 41CU444, measuring 200 by 100 meters, is on a sand-covered limestone hill and saddle about 2 km northeast of Plateau Draw. Features include rock hearths, burned rock scatters, lithic debris, a ring midden 7 meters in diameter, and an 80-by-150-cm rock cairn. Cultural debris is dense.

Study Area 2—Central and Southern Wild Horse Draw

Spot surveys in Study Area 2—Central and Southern Wild Horse Draw (Figure 4) have been conducted near the community of Lobo and in the area east of Van Horn. Wild Horse Draw drains the western slopes of the Chispa and Wylie mountains and the eastern slopes of the Van Horn Mountains. The area is a combination of bench terraces—some with low sand dunes—and flatlands, and there is a small volcanic hill in the center of the area near Lobo. Large areas of the Lobo Valley around Wild Horse Draw are under cultivation or are abandoned fields. Vegetation in uncultivated areas includes creosote, mesquite, and grasses characteristic of Zone A.

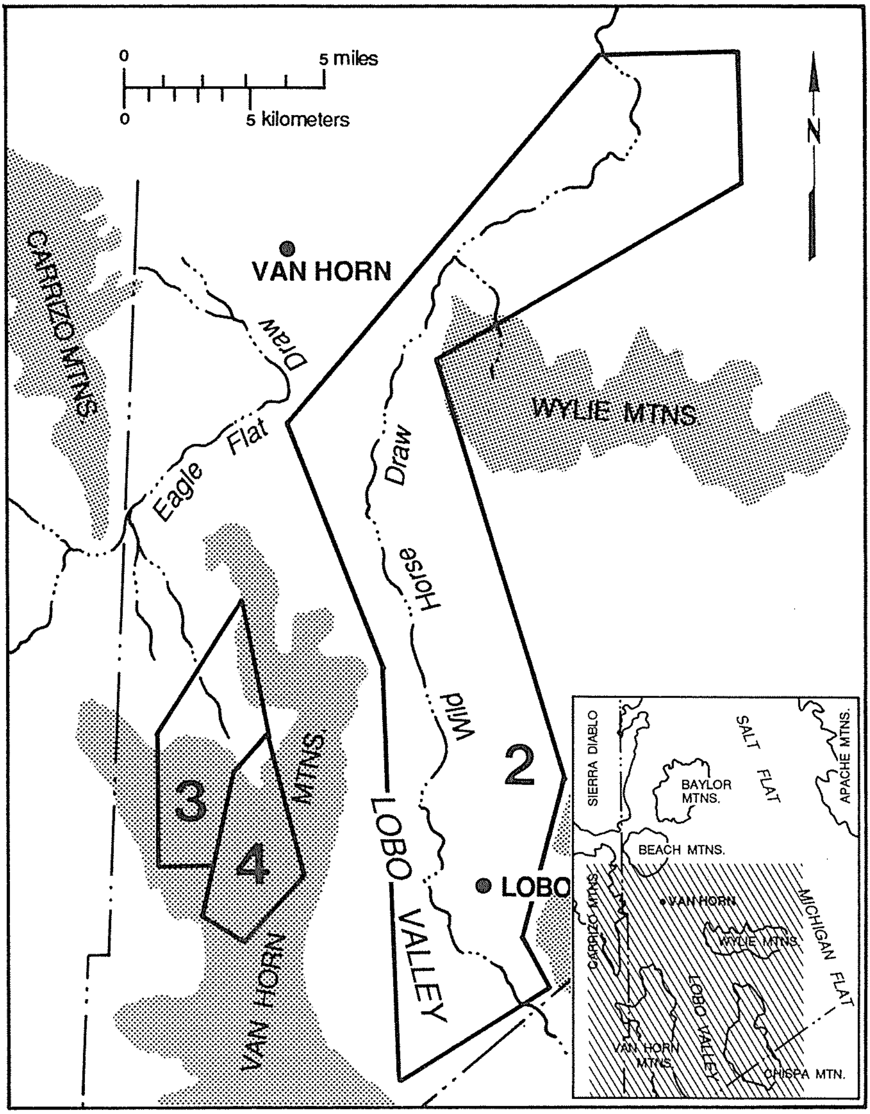

Figure 4. Map of parts of Culberson and Hudspeth Counties, showing Study Areas: 2–Central and Southern Wild Horse Draw, 3–Van Horn Mountains Area 1, and 4–Van Horn Mountains Area 2.

The 12 sites in this study area consist of seven campsites, one base camp, one lithic scatter, two isolated hearths, and one rock circle. Sites are on low dune terraces and in eroded, exposed flatlands. The cultural debris, scattered in all sites and ranging between light and moderate in density, consists of chips, flakes, hammerstones, cores, and complete and fragmentary dart points and arrowpoints. Mano and metate fragments were observed in the campsites and base camp. Some moderate concentrations were found around hearths in the base camp. Chipped stone tools are of material from a variety of sources, about half of which are identifiable.

Campsites and base camp are smaller and their concentrations of cultural materials are less dense than in sites in Study Area 1, the Plateau complex. The remaining sites are small, scattered, and isolated along the draw.

Study Area 3—Van Horn Mountains Area 1

Study area 3—Van Horn Mountains Area 1 is in the western and northern drainages of the Van Horn Mountains (Figure 4), an area that includes mountain canyons, deep arroyos, alluvial and colluvial gravel ridges and terraces, and mountain slopes. Vegetation zones vary from the agave and sotol of Zone B to oak and sumac of Zone C.

At this time, only a few parts of Study Area 3—Van Horn Mountains, Area 1 have been surveyed. Eight sites have been recorded—five campsites, one base camp, and two rockshelters. Cultural materials consist of chips, flakes, utilized flakes, bifaces, complete and fragmentary projectile points, knives, scrapers, choppers, cores, and core fragments. A predominance of heavy tools, i.e., choppers, knives, large scrapers, and large bifaces, primarily of felsite, apparently were made for food processing.

Lithic sources for the artifacts in Study Area 3—Van Horn Mountains Area 1 include felsite quarry materials, exotics such as chalcedony, agate, and jasper, and materials from unknown sources. Purple-Tan, white, and butterscotch quarry sources are represented, but much less frequently than in basin sites.

Study Area 4—Van Horn Mountains Area 2

Study Area 4—Van Horn Mountains, Area 2 (Figure 4) is on the upper plateaus and mesa tops of the central part of the mountains. Vegetation is primarily the agave, sotol, cholla, and prickly pear of Zone B with occasional oak and juniper of Zone C.

From occasional brief surveys that have been conducted in this study area, five sites—one rockshelter, one quarry, two lithic scatters, and one rock art site— have been recorded. The quarry (41CU389) and rock art site (41CU446) have been described above. Lithic samples from all sites indicate a preponderance of felsite and the spotted material from quarry site 41CU389, but lesser quantities of materials from other quarries are also present.

The rockshelter 41CU294, variously known as Lodge Cave, Lookout shelter, or Blue Finger shelter, is one of the sites that previously had been reported to the Texas Archeological Research Laboratory. It is in the conglomerate tuff formation of the central part of the Van Horn Mountains. The shelter is 25 meters across at the opening, 7.5 meters deep, and 6 meters high at the drip line. It has a large, steep, dark-colored talus-slope midden in front. The cultural deposits at both sides of the interior have been vandalized, but the central part of the shelter appears to be undisturbed. Fragments of cordage and two dart points were recovered from the surface of the disturbed area, and a dart point was recovered from the surface of the exterior talus midden.

Study Area 5—Carrizo Mountains Area 1

Study Area 5—Carrizo Mountains, Area 1 (Figure 5) encompasses the western slopes of the Beach Mountains, the basin between the Beach and Carrizo mountains, and the eastern slopes of the Carrizos. Eroded sandstone formations have formed hills, steep terraces, benches, high mesas, and deep canyons. Hackberry and Carrizo creeks form canyons and eventually flow into Three-Mile Draw. Vegetation is primarily of Zones C and D: agave, sotol, prickly pear, cholla, ocotillo, oak, sumac, white thorn acacia, and stands of juniper; mesquite, and yucca are also found.

Recorded sites are 15 rockshelters, 9 campsites, 4 ring middens, and 1 lithic scatter. At least one shelter midden has evidence of stratigraphic deposits as deep as 1.5 meters in eroded areas. Identifiable quarry resources are represented fairly evenly among the lithic samples from all sites, and there are some exotics and unknowns.

A rockshelter (41CU406) with interior cultural deposits is in a bench- or ledge-forming fracture in a contact zone in layered sandstone on the western slopes of the Beach Mountains. The shelter measures 40 meters across the opening and is 6 to 12 meters deep. Occupational areas are under the southeast-facing overhang, and apparently undisturbed cultural debris is under the overhang, across the exterior, and down the talus slope.

There are a few very faint rock art elements on the back walls of the shelter. Several red and yellow pictographs are in such poor condition that no elements are discernible, but four white pictographs appear to be anthropomorphic and zoomorphic figures.

Deer shelter (41CU408) is in a steep side canyon in the western Beach Mountains. This overhang shelter was formed by erosion and weathering of the Van Horn conglomerate sandstone formation. The overhang is 24 meters wide at the opening, 4.5 meters deep, and 2.5 meters high. There are no stratified cultural deposits, but three bedrock mortars are in the floor below the overhang, and a few flakes and chips of cultural material are scattered about.

On the ceiling of the southwest-facing shelter is what appears to be a prepared charcoal-colored background measuring 3 by 4 meters on which a tannish-white deer (Figure 6) is painted. The deer is 1.7 meters long and has a body thickness of 46 cm.; the painting is in excellent condition, showing only slight weathering. This figure conveys the sense of being early historic Indian in origin.

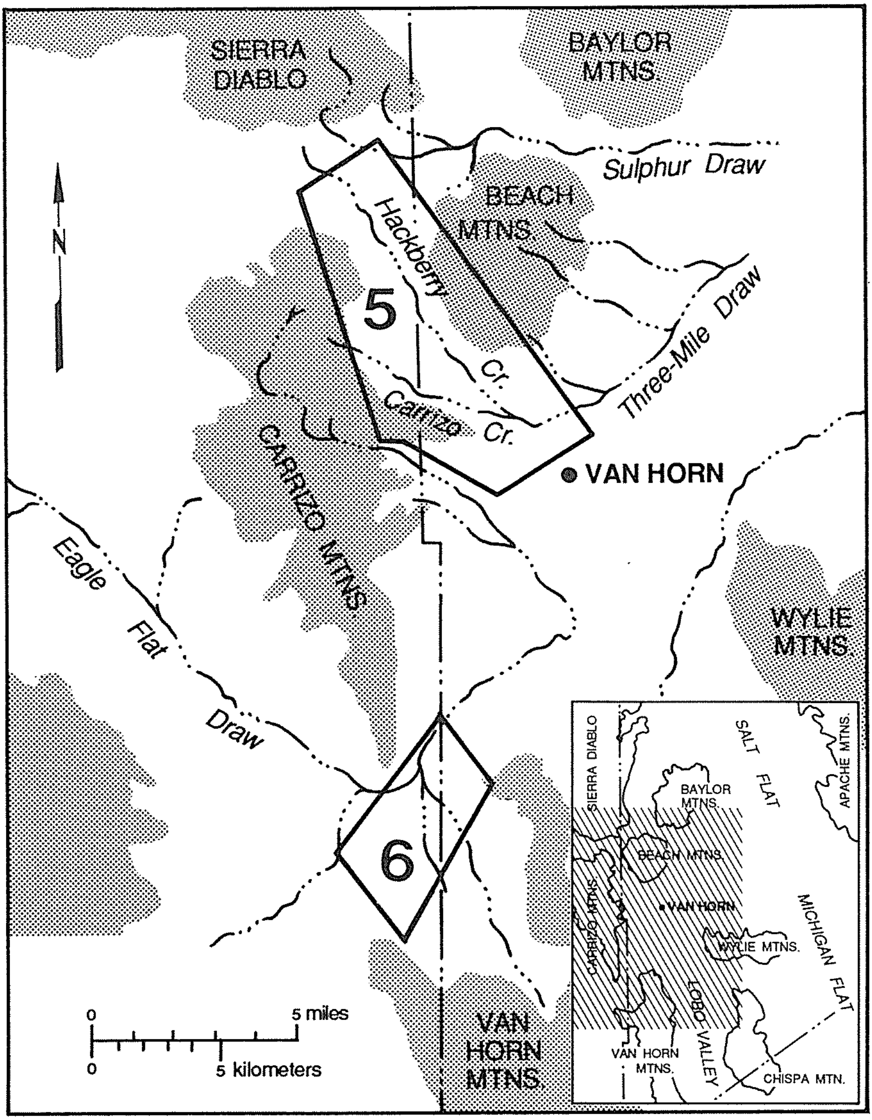

Figure 5. Map of parts of Culberson and Hudspeth counties, showing Study Area 5–Carrizo Mountains Area 1, and Study Area 6–Carrizo Mountains Area 2.

Study Area 6—Carrizo Mountains Area 2

Study Area 6—Carrizo Mountains, Area 2 (Figure 5) lies along Eagle Flat Draw between the Carrizo and Van Horn Mountains. Coarse gravel-boulder pediments form terraces cut by arroyos that expose the pediment gravel and boulders. Fragments and nodules of exotics (agate, chalcedony, petrified wood, and jasper) are abundant in the gravels, so the pediment gravel and boulders

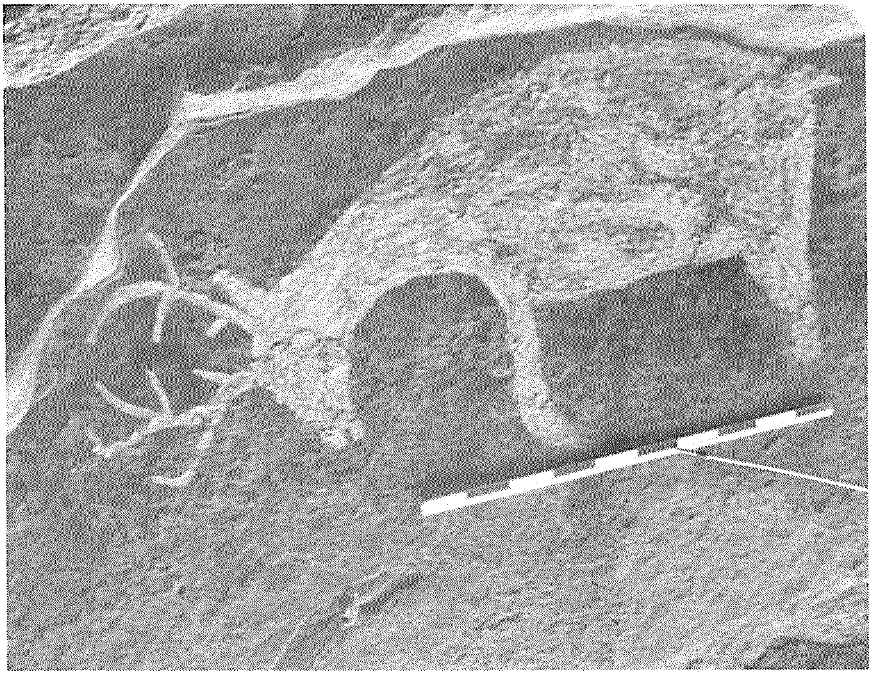

Figure 6. Photograph of the deer pictograph at site 41CU408. The scale is 1 meter long.

could be the resource area for these materials. Vegetation is primarily Zone A grassland with creosote and occasional mesquite, yucca, and ocotillo.

This study area is another that has received only superficial examination. The three felsite quarries (41HZ398, CU441, and CU443) and one cairn (41CU442), discussed earlier, are the only sites recorded.

Diagnostic Artifacts

Ceramics

Two hundred eighty-nine sherds were recorded from 55 (43 percent) of the 127 surveyed sites. The frequency ranges from a single sherd to a maximum of 39 sherds on a Plateau complex base camp. Ceramics represent a mixture of cultural associations and are found throughout the region (Table 4). Because most of the recorded sites are in the Plateau complex and Carrizo Mountains, Area 1, it is not unexpected that most of the sherds are from those two areas. Specifically, they are from the base camps and campsites of the Plateau complex and the middens associated with shelters in the Carrizo Mountains, Area 1.

Ceramics represent varied origins, primarily the Jornada Branch of the Mogollon culture and northern Mexico. They are apparently considerably less dense in the Plateau complex and the Carrizo Mountains Study Areas than in the

Table 4. Distribution of Ceramic Sherds by Study Area

(**PC,** Plateau Complex; **C/SWHD,** Central and Southern Wild Horse Draw; **VHM-1,** Van Horn Mountains, Area1; **CM-1,** Carrizo Mountains, Area 1.).

Cultural Association/Ceramic Type	Study Area PC	 C/S WHD	 VHM-1	 CM-1	TOTAL
SOUTHERN JORNADA MOGOLLON					
El Paso Brown (A.D. 400-1000)	66	6	6	61	139
El Paso Polychrome (A.D. 1000-1350)	13	-	-	9	22
Chupadero Black on White (A.D. 1150-1400)	5	2	-	7	14
NORTHERN JORNADA MOGOLLON					
Jornada Brown (A.D. 900-1200)	23	-	-	2	25
Three Rivers Red on Terra Cotta (A.D. 900-1200)	-	-	-	3	3
MIMBRES					
Mimbres Black on White (A.D. 850-1150)	-	-	2	2	4
NORTHERN CHIHUAHUA, MEXICO					
Polished tan, plain	2	2	-	1	5
Corrugated tan	11	-	-	5	16
Playas Red Incised (A.D. 1060-1340)	1	-	-	-	1
Unknown	2	-	-	6	8
CENTRAL AND NORTHERN NEW MEXICO					
Galisteo Black on White (A.D. 1300-1400)	-	-	-	2	2
Black on Red glaze	-	-	-	1	1
MIDDLE PECOS					
Middle Pecos Micaceous Brown (A.D. 900-1000)	1	-	-	-	1
UNKNOWN					
Brownware	22	-	-	1	23
Polished brown	4	1	4	16	25
TOTALS	150	11	12	116	289

Guadalupe Mountains to the north (Phelps 1974:136,147); this supports Mallouf's theory (1985:130) that "ceramics become more rare as one progresses southward."

Projectile Points

Ninety-one projectile points were recorded during the survey; 58 percent are made of local quarry material (Table 5).

Projectile points that could be assigned to recognized types include 32 arrowpoints and 28 dart points (Table 6).

Many dart points and arrowpoints made of local material do not fit into any established typology. They may be variants of recognized types or they may be undescribed types peculiar to the Trans-Pecos or a part of it.

DISCUSSION

The study region, situated as it is in a natural basin and range corridor, provides a north-south passageway from the Davis Mountains northward to the Guadalupe Mountains and Salt Basin. The density of sites and cultural debris in the region indicates that it was inhabited extensively through time; it is reasonable to presume that migrating animal and human populations followed this corridor.

Establishment of northern Chihuahua desert-shrub communities began around 8000 B.P. (Van Devender and Spaulding 1979). This provided a stable and diverse plant community in the basin, hills, slopes, and mountains—a substantial resource base for hunting and gathering. Features and artifacts reflect these activities, as well as those of tool manufacture and repair.

Salt, extensively available cherts, felsites, and other lithic resources undoubtedly contributed to the attractiveness of the corridor, and uplifted, fractured, and eroded limestone and sandstone mountain and canyon formations provided numerous shelters. Sandstone fragments were readily available as raw materials for one-handed wedge manos and basin and slab metates (Hedrick 1975).

Base camps, campsites, and shelters are situated near plant communities and lithic and water resources. Cultural materials indicate occupation from Archaic to Late Prehistoric times and therefore point to an efficient, successful adaptation to a relatively stable environment.

Resources of the quarries in the region were used extensively through time and appear in all forms of artifacts and in all parts of the area. There is evidence of preference for specific resource materials for specific tool types, i.e., felsite was used for heavier and larger tools; the finer cherts and exotics (agate, jasper, and chalcedony) were used for projectile points and smaller tools. Projectile points from the survey and private collections show this to be particularly true in all Archaic through Late Prehistoric periods.

From the density of the debitage, tools, and projectile points recorded at sites, it can be inferred that prehistoric populations occupied the area long enough to locate and make extensive use of the enormous quantities of local lithic resources.

Table 5. Projectile Points From the Study Area and Quarries From Which Their Raw Materials Came

(**PC,** Plateau Complex; **C/SWHD,** Central and Southern Wild Horse Draw; **VHM-1,** Van Horn Mountains Area 1; **VHM-2,** Van Horn Mountains Area 2; **CM-1,** Carrizo Mountains Area 1; **CM-2,** Carrizo Mountains Area 2.).

Quarry Source or Material	Study Area													
	C/SWHD		CM-1		CM-2		PC		VHM-1		VHM-2		TOTAL	
	Dart Point (DP) or Arrowpoint (AP)													
	DP	AP	DP	AP	DP	AP	DP	AP	DP	AP	DP	AP	DP	AP
41CU349, -CU372, -CU379 (White chert)	-	-	-	1	-	-	2	-	-	-	-	-	2	1
41CU389 (Spotted Chert)	-	-	-	-	-	-	-	-	-	2	-	-	-	2
41HZ397, -CU441, -CU443 (Felsite)	-	-	-	-	-	-	-	-	-	-	1	-	1	-
41CU449 (Purple-tan chert)	1	1	6	4	-	-	18	4	3	1	3	-	31	10
Butterscotch Agate	-	-	-	3	-	-	2	-	-	-	1	-	3	3
TOTAL from known sources	1	1	6	8	-	-	22	4	3	3	5	-	37	16
Exotics														
Agate, Chalcedony, Jasper	-	1	1	3	-	-	1	-	1	-	-	-	3	4
Unknown	1	1	6	10	-	-	5	2	2	1	2	1	16	15
TOTAL from unknown source	1	2	7	13	-	-	6	2	3	1	2	1	19	19
GRAND TOTAL	2	3	13	21	-	-	28	6	6	4	7	1	56	35

Table 6. Chronological Distribution of Projectile Points According to the Eastern Pecos Chronology

Period	No.	Point Type and Reference
Late Prehistoric		
ca. A.D. 1000-1500	9	Livermore (Turner & Hester 1985:181)
	7	Livermore variant (Hedrick 1986:115-127)
	7	Toyah (Kelley 1957:46)
	5	Fresno (Suhm & Jelks 1962:273, 274)
	2	Foyle flakes (Foster & Kelley 1987:36)[1]
	1	Garza (Runkles & Dorchester 1987:94)
	1	Bonham (Suhm & Jelks 1962:267-281)
Late Archaic		
ca. 500 B.C. -A.D. 1000	4	Ensor (Dibble 1967:36, 37)
	4	Ellis (Suhm & Jelks 1962:167, 168)
	4	Paisano (Suhm & Jelks 1962:227, 228)
	3	Palmillas (Suhm & Jelks 1962:229, 230)
Middle Archaic		
3000-500 B.C.	5	Langtry (Turner & Hester 1985:114, 115)
	3	Shumla (Dibble 1967:40, 41,
	1	Marcos (Dibble 1967:38, 39)
Early Archaic		
6500-3000 B.C.	1	Pandale (Suhm & Jelks 1962:231, 232)
	1	Nolan (Turner & Hester 1985:132)
	1	Bulverde (Turner & Hester 1985:73)
Late Paleo-Indian		
8000-6500 B.C.	1	Folsom (Suhm & Jelks 1962:193, 194)

SOURCE: Mallouf 1985

[1] Not included in Mallouf's Eastern Pecos Chronology; see Foster and Kelley 1987:37.

Many Livermore and Toyah arrowpoints made of local material indicate that this is a core area for Kelley's (1957) Livermore focus. There also appears to be interaction between prehistoric populations in the Late Prehistoric as evidenced by the presence of Jornada and northern Mexican ceramics. However, contact with the Jornada does not appear to have been in a settlement situation but rather in forays or trade. There simply is not enough ceramic evidence to indicate that the Jornada presence in the area was more than transient.

A large percentage of projectile points from the eastern Trans-Pecos, Big Bend, and Lower Pecos areas in both the survey and private collections are made of local materials. They provide the strongest affirmation of continuous occupation of the corridor from Paleo-Indian through Late Prehistoric times. A predominance of points of temporally diagnostic types made from local materials indicates that the area was occupied more intensely from Middle Archaic through the Late Prehistoric times and possibly into the early historic era. The highest density of occupation appears to be in the Late Archaic and Late Prehistoric periods.

APPENDIX

Key to Study Areas

1 Plateau Complex
2 Central & South Wild Horse Draw
3 Van Horn Mts Area 1
4 Van Horn Mts Area 2
5 Carrizo Mts Area 1
6 Carrizo Mts Area 2

Key to Ecological Zones

A Flatlands and/or dunes **B** Hills and/or slopes **C** Canyons and/or watercourses
D Mountains

Site No.	Elevation in Feet	Size m^2	Kind of Site	Study Area	Ecological Zone
		Culberson County			
41CU22	3920	6,000	Campsite	1	A
41CU259	4100-4200	8,000	Rock art	1	A, B
41CU294	5140	800	Rockshelter	4	B,D
41CU334	3870	11,205	Base camp	1	A
41CU335	3870	11,234	Base camp	1	A
41CU336	3850	5,617	Base camp	1	A
41CU337	3850	2,079	Campsite	1	A
41CU338	4100	3,984	Campsite	1	B
41CU339	4130	6,724	Campsite	1	B
41CU340	4140	2,700	Campsite	1	B
41CU341	3970	2,400	Campsite	1	A
41CU342	3900	24,090	Base camp	1	A
41CU343	3900	13,695	Base camp	1	A
41CU344	4080	5,400	Campsite	1	A
41CU345	4050	3,600	Campsite	1	A
41CU346	4000-4020	6,000	Base camp	1	A
41CU347	4000-4020	8,000	Campsite	1	A
41CU348	4010	7,200	Base camp	1	A
41CU349	4120-5000	4,800	Quarry	1	A,B
41CU350	3980-4000	6,000	Campsite	1	A
41CU351	3940	11,250	Base camp	1	A
41CU352	3940	7,500	Campsite	1	A
41CU353	3930-3950	4,800	Campsite	1	A
41CU354	3930-3950	6,000	Campsite	1	A

Site No.	Elevation in Feet	Size m^2	Kind of Site	Study Area	Ecological Zone
41CU355	3900	7,000	Campsite	1	A
41CU356	3900	2,500	Lithic scatter	1	A
41CU357	3920	3,750	Campsite	1	A
41CU358	3910	3,750	Campsite	1	A
41CU359	3910	12,000	Base camp	1	A
41CU360	3930	4,800	Campsite	1	A
41CU361	3950	22,000	Base camp	1	A
41CU362	3950	6,000	Campsite	1	A
41CU363	3950	6,375	Campsite	1	A
41CU364	3960	4,500	Campsite	1	A
41CU365	3960	6,000	Campsite	1	A
41CU366	3900-3920	6,000	Campsite	1	A
41CU367	3920	6,000	Base camp	1	A
41CU368	3920	5,100	Campsite	1	A
41CU369	3920	12,000	Campsite	1	A
41CU370	3940	7,500	Base camp	1	A
41CU371	3940	6,000	Campsite	1	A
41CU372	4020-4120	70,000	Quarry	1	B
41CU373	4020	625	Isolated find	1	A
41CU374	3920	10,000	Base camp	1	A
41CU375	3930	3,600	Campsite	1	A
41CU376	4010	6,000	Campsite	1	A
41CU377	4020	8,000	Campsite	1	A
41CU378	4080	2,400	Rock circle	1	B
41CU379	4025	20,000	Quarry	1	B
41CU380	4020	500	Isolated hearth	1	A
41CU381	4050	16,000	Base camp	2	A
41CU382	4050	4,500	Campsite	2	A
41CU383	4050	4,000	Isolated hearth	2	A
41CU384	4100	4,800	Rock circle	2	A
41CU385	4560	2,400	Rockshelter	3	A
41CU386	4560	200	Rockshelter	3	A
41CU387	5040	1,800	Lithic scatter	4	B,D
41CU388	5040	2,400	Lithic scatter	4	B,D
41CU389	5040	9,000	Quarry	4	B,D
41CU390	4780	2,400	Campsite	3	B,C
41CU391	4720	3,600	Campsite	3	B,C
41CU392	4160	3,600	Rockshelter	5	B,C
41CU393	4200	12,000	Rockshelter	5	B,C

Site No.	Eleva- tion in Feet	Size m^2	Kind of Site	Study Area	Ecological Zone
41CU394	4300-4500	150,000	Rockshelter	5	B,C
41CU395	5600	2,400	Rockshelter	5	B,C
41CU396	4660	1,200	Rockshelter	5	B,C
41CU397	4340	4,800	Campsite	5	B,C
41CU398	4260	600	Rock circle	5	B,C
41CU399	4260	1,500	Campsite	5	B,C,D
41CU400	4260	70	Rockshelter	5	B,C
41CU401	4430	450	Rockshelter	5	B,C
41CU402	4220	1,140	Rockshelter	5	B,C
41CU403	4400	176	Rock circle	5	B,C
41CU404	4300	1,400	Campsite	5	B,C
41CU405	4380	660	Campsite	5	B,C
41CU406	4600	480	Rockshelter	5	B,C
41CU407	4300	3,200	Rockshelter	5	B,C
41CU408	4500	108	Rockshelter	5	B,C
41CU409	4300-4380	4,800	Campsite	5	A
41CU410	4400	3,600	Campsite	5	B,C
41CU411	4400	2,400	Rockshelter	5	B,C
41CU412	3670	6,000	Campsite	1	A
41CU413	3670	12,000	Base camp	1	A
41CU414	3687	9,300	Base camp	1	A
41CU415	3800	3,200	Campsite	1	A
41CU416	4300	12,000	Rock circle	1	A,B
41CU417	3800	2,400	Campsite	1	A,B
41CU418	3796	45,000	Base camp	1	A
41CU419	3970	20,000	Base camp	1	A
41CU420	4860	4,800	Campsite	3	B,C
41CU421	4760	2,400	Campsite	3	B,C
41CU422	4660	7,200	Campsite	3	B,C
41CU423	4600	4,800	Base camp	3	B,C
41CU424	3980	2,400	Lithic scatter	2	A
41CU425	3880	1,600	Campsite	2	A
41CU426	3880	1,800	Campsite	2	A
41CU427	3880	600	Isolated hearth	2	A
41CU428	3960	2,100	Campsite	2	A
41CU429	3830	4,800	Campsite	2	A
41CU430	3840	2,400	Campsite	2	A
41CU431	3850	4,000	Campsite	2	A
41CU432	4260	2,000	Rockshelter	5	B

Site No.	Elevation in Feet	Size m^2	Kind of Site	Study Area	Ecological Zone
41CU433	4240	1,600	Campsite	5	B
41CU434	4280	2,400	Rock circle	5	B
41CU435	4260	600	Rockshelter	5	B
41CU436	4520	800	Rockshelter	5	B,C
41CU437	4260	9,000	Campsite	5	B
41CU438	4000	2,500	Campsite	1	A,B
41CU439	3990	4,200	Campsite	1	A
41CU440	4050	8,000	Campsite	1	A
41CU441	4160	8,000	Quarry	6	B
41CU442	4180	2,400	Cairn	6	B
41CU443	4200	4,000	Quarry	6	B
41CU444	3837	20,000	Base camp	1	B
41CU445	3800	6,000	Campsite	1	B
41CU446	4800	3,000	Rock art	4	B,C
41CU447	3680	6,000	Campsite	1	A
41CU448	3680	8,000	Campsite	1	A
41CU449	4250-4400	390,000	Quarry	1	B
41CU450	3910	60,000	Base camp	1	A
41CU451	3900	55,000	Base camp	1	A
41CU452	3910	45,500	Base camp	1	A
41CU453	3940	2,400	Campsite	1	A
		Hudspeth	**County**		
41HZ395	4360	3,600	Lithic scatter	5	B
41HZ396	4500	2,800	Campsite	5	B,C
41HZ397	4560	1,600	Rock circle	5	B,C
41HZ398	4180	12,000	Quarry	6	B

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REFERENCES CITED

Betancourt, Julio, and R. W. Ralph

1981a Preliminary Reconnaissance of Archeological Resources in the Southern Quitman Mountains Hudspeth County, Texas. In: *Five Archeological Investigations in the Trans-Pecos Region of Texas.* Texas Antiquities Committee Permit Series 6.

1981b Preliminary Reconnaissance of the Archeological Resources in the Lower Hueco Mountains El Paso and Hudspeth Counties, Texas. In: *Five Archeological Investigations in the Trans-Pecos Region of Texas.* Texas Antiquities Committee Permit Series 6.

Boisvert, Richard

1980 A Technical Analysis of Lithic Assemblages from the Guadalupe Mountains National Park. M.A. Thesis, Anthropology, Texas A & M University.

Clark, John

1974 Rock Art of the Guadalupe Mountains National Park. *Bulletin of the Texas Archeological Society* 45:97-120.

Cliff, M. B., and Terrence Fifield

1980 *An Archaeological Evaluation of the Floodwater Diversion in the Three-Mile and Sulphur Draw Watershed, Culberson County, Texas.* Environmental Consultants, Inc., Dallas.

Creel, Darrell

1981 An Archeological Reconnaissance in the Eagle Mountains Hudspeth County, Texas. In: *Five Archeological Investigations in the Trans-Pecos Region of Texas.* Texas Antiquities Committee Permit Series 6.

Dibble, D. S.

1967 *Excavations at Arenosa Shelter, 1965-66.* Texas Archeological Salvage Project, The University of Texas, Austin. Division of Natural Resources and Environment, The University of Texas at Austin.

1975 *Mount Livermore and Sawtooth Mountain: A Natural Area Survey.* Division of Natural Resources and Environment. The University of Texas at Austin.

Foster, M. S., and J. C. Kelley

1987 *Archaeological Investigations of Portions of Eight Sites Within the Proposed Floodwater Diversion Three- Mile and Sulphur Draw, Three-Mile and Sulphur Draw Watershed, Culberson County, Texas.* Jornada Anthropological Research Association, El Paso.

Gerald, R. E.

1978 Report on a Preliminary Archeological Survey of the Revised Location of a Floodwater Diversion in Three-Mile and Sulphur Creeks Watersheds, Culberson County, Texas. Report submitted to Soil Conservation Service, U.S. Department of Agriculture, Temple.

Greer, John W.

1968 Notes on Excavated Ring Midden Sites, 1963-1968. *Bulletin of the Texas Archeological Society* 38 (for 1967):39-44.

Hedrick, J. A.

1968 Plateau Station Area Survey (EPAS-68). *The Artifact* 6(1): 1-16.

1975 Archaeology of the Plateau Site, Culberson County. *The Artifact* 13(4):45-82.

1986 Five Arrowpoint Types from the Plateau Complex, Van Horn, Texas. *Transactions of the Twenty-Second Regional Archeological Symposium for Southeastern New Mexico and Western Texas*:15-27.

Henry, C. D., and J. G. Price

1986 *The Van Horn Mountains Caldera, Trans-Pecos Texas: Geology and Development of a Small (10km2) Ash-Flow Caldera.* Bureau of Economic Geology, Austin.

Jackson, A. T.

1938 *Picture-writing of Texas Indians.* University of Texas Publication 3809.

Katz, P. R., and P. D. Lukowski

1981 Results of Archaeological Survey in the Salt Flat Locality of Northern Hudspeth County, Texas. In: *Five Archeological Investigations in the Trans-Pecos Region of Texas.* Texas Antiquities Committee Permit Series 6.

Katz, S. R.

1983 Late Prehistoric Period Environment and Economy of the Southern Guadalupe Mountains, Texas. Ph.D. dissertation, University of Kansas.

Katz, S. R., and Paul Katz, editors

1987 Advances in Middle Pecos Archaeology. *Proceedings of a Symposium Held at the Fourth Jornada Mogollon Conference*, Tularosa, New Mexico, on October 12, 1985.

Kelley, J. C.

1947a The Lehmann Rock Shelter: A Stratified Site of the Toyah, Uvalde, and Round Rock Foci. *Bulletin of the Texas Archeological and Paleontological Society* 18.

1947b The Cultural Affiliations and Chronological Position of the Clear Fork Focus. *American Antiquity* XIII(2):97-109.

1957 The Livermore Focus: A Clarification. *El Palacio* 64(1-2):44-52.

Lehmer, D. J.
1958 A Review of Trans-Pecos Texas Archeology. *Bulletin of the Texas Archeological Society* 29:109-144.

Mallouf, R. J.
1985 A Synthesis of Eastern Trans-Pecos Prehistory. Masters thesis, Department of Anthropology, University of Texas at Austin.

1987 *Las Haciendas: A Cairn-Burial Assemblage from Northeastern Chihuahua, Mexico.* Office of the State Archeologist Report 35, Texas Historical Commission, Austin.

McNatt, Logan
1981 An Archeological Reconnaissance of the Lower Pecos River Crockett, Terrell and Val Verde Counties, Texas. In: *Five Archeological Investigations in the Trans-Pecos Region of Texas.* Texas Antiquities Committee Permit Series 6.

Phelps, A. L.
1974 An Analysis of the Ceramics of the Guadalupe Mountains National Park. *Bulletin of the Texas Archeological Society* 45:121-150.

Price, J. G., C. D. Henry, D. F. Parker, and D. S. Barker, Editors.
1986 *Igneous Geology of Trans-Pecos Texas: Field Trip Guide and Research Articles.* Bureau of Economic Geology, Texas Mining and Mineral Resources Research Institute, The University of Texas at Austin.

Rock Color Chart Committee
1984 Rock Color Chart. Originally published 1948. Distributed by the Geological Society of America.

Runkles, F. A., and E. D. Dorchester
1987 The Lott Site (41GR56): A Late Prehistoric Site in Garza County, Texas. *Bulletin of the Texas Archeological Society* 57 (for 1986).

Suhm, D. A., and E. B. Jelks
1962 *Handbook of Texas Archeology: Type Descriptions.* Texas Archeological Society Special Publication 1 and Texas Memorial Museum Bulletin 4, Austin.

Turner, E. S., and T. R. Hester
1985 *A Field Guide to Stone Artifacts of Texas Indians.* Texas Monthly Press, Austin.

Van Devender, T. R., and W. G. Spaulding
1979 Development of Vegetation and Climate in the Southwestern United States. *Science* 204:701-710.

Long-Bone Implements from Some Prehistoric Sites in Texas: Functional Interpretations Based on Ethnographic Analogy

Grant D. Hall

ABSTRACT

Alternative functions are proposed for certain implements made from the long bones of deer, antelope, or bison found at several prehistoric sites in Texas. These long-bone implements are often identified as awls or hairpins, but their use as head scratchers, louse crushers, or sweat scrapers is hypothesized here. These functional interpretations are based on analogies drawn from the ethnographic literature of the American Southwest and California. Variations in the geometric design patterns incised on the surfaces of some of these implements suggest that the patterns may have been unique to their prehistoric owners or perhaps to particular bands or lineages. If this is true, future tracking of the occurrence of the decorative patterns from site to site in Texas may yield information on the movements of individuals and bands, the social organization of bands, and intergroup relationships.

INTRODUCTION

Because of their shapes, long bones from deer, antelope, and bison are particularly well suited for the manufacture of certain artifacts, most commonly ones called awls or awllike tools by archeologists. As Hough (1907:120) has noted concerning the function of awls,

> the awl was used to make perforations through which thread of sinew or other sewing material was passed when skins for moccasins, clothing, tents, etc., were sewed, and in quillwork, beadwork, and basketwork. Other uses for awls were for making holes for pegs in woodwork, as a gauge in canoe-making, for shredding sinew, for graving, etc. Various awllike implements that were used by the Indians in weaving and making pottery, as pins for robes, as head-scratchers, pipe-picks, blood pins for closing wounds in game to save the blood, marrow-extractors, forks, corn-huskers, etc., have sometimes been classed as awls.

Prehistoric people in many areas of Texas worked long bones into a variety of implements and ornaments. This study is concerned with long-bone artifacts that are often called awls, hairpins, or basket- or mat-weaving tools and especially with one class of these artifacts, which have relatively blunt tips. There may have been other functions for these blunt-tipped tools.

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DESCRIPTION OF THE IMPLEMENTS

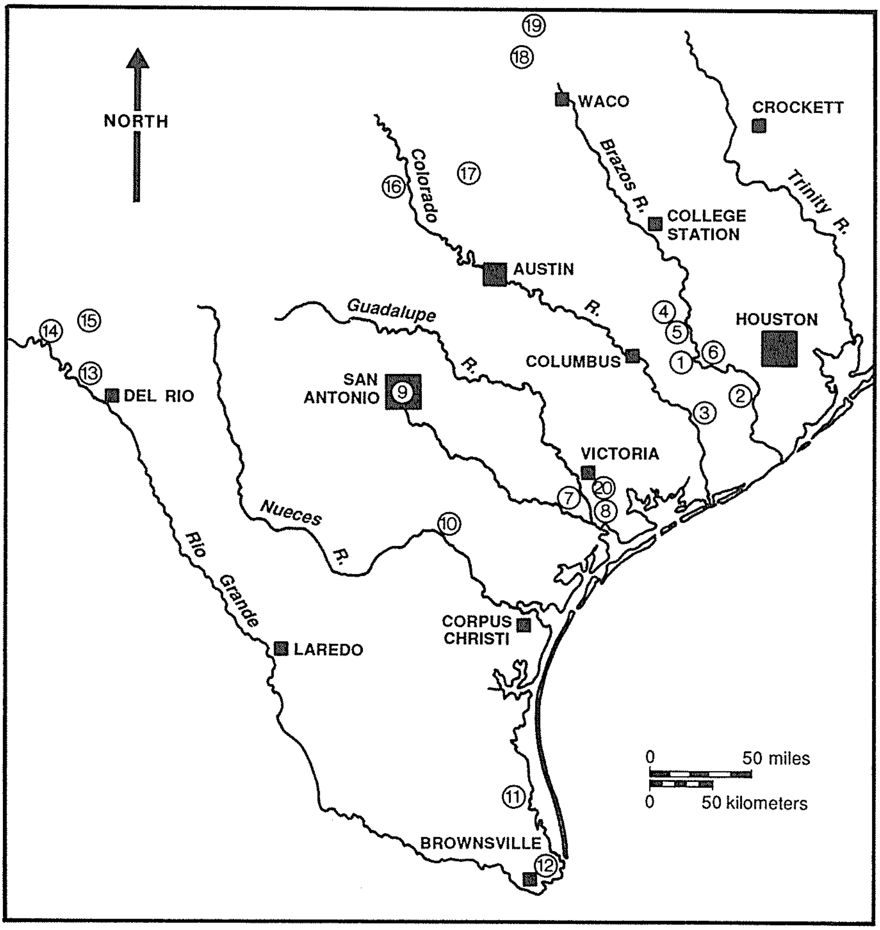
Most of the specimens in this study are made from metapodial bones of deer, but antelope or bison also may be represented. All of the implements discussed here were made by splitting long bones into two symmetrical pieces that were then worked by abrasion into long, tapering artifacts. In horizontal cross section, these implements vary from essentially flat, to gently planoconvex, to subcircular, depending on the intended function and the location on the tool of the cross section. The proximal end of the split long bone is usually only lightly modified. The proximal articular surface is usually ground down to some extent, but its original contours remain apparent. The distal end is worked into a tip that ranges between very sharply pointed and rounded. Reflecting the morphology of the long bone, the tip is sometimes slightly upturned, but, except for this, all signs of the articular surface are completely obliterated. The specimens are between 8 and 22 cm long, between 1 and 3 cm wide, and between 0.5 and 1 cm thick. Some of the implements are perforated at the broader proximal end, and some are decorated on the exterior (convex) surface with incised geometric designs.

INFERRED FUNCTIONS

In the Texas archeological literature, artifact functions have most often been inferred from their shapes, supported (usually tacitly) by ethnographic analogy, and, to a lesser extent, by context. Specimens with sharp, slender points would be useful for punching holes and are, not unreasonably, called awls. Polished areas or striations, presumably signs of wear resulting from use, are sometimes detectable and reinforce the notion that some of the implements did indeed function as awls. However, long-bone implements found near skulls in graves provide contextual evidence for an alternative view that the artifacts functioned as hairpins. A third hypothesized function—supported mainly by ethnographic analogy—is for weaving baskets or mats.

LONG-BONE IMPLEMENTS FROM TEXAS SITES

A representative sample comprising 118 complete long-bone implements from sites in Texas (Figure 1) has been sorted according to morphological characteristics, contextual information, or postulated function. The specimens are categorized as implements with the sharp, slender points characteristic of awllike tools (Table 1), a smaller group that were thought to have functioned as hairpins based on their locations in the graves from which they were recovered (Table 2), and the largest group of artifacts, with tips that vary from narrow and pointed to rounded (Table 3). These specimens differ from most of those in Table 1 in that the tips are flat or convex in cross section, and, although it is technically accurate to describe them as pointed, their tips are not nearly as slender or sharp as those of the awllike tools (Table 1). The bluntness of the tips of these tools did not result from use wear; they were intentionally worked into this shape (Figures 2 to 7).



Key to Sites

1-Ernest Witte
2-Albert George
3-Crestmont
4-Goebel
5-Brandes
6-Konvicka
7-TWI
8-Green Lake
9-Olmos Dam
10-Loma Sandia
11-41WY50
12-Unland
13-Centipede Cave
14-Shumla Caves
15-Baker Cave
16-Fall Creek
17-McCann
18-Brawlwy's Cave
19-Kyle
20-Blue Bayou

Figure 1. Map of Central and South Texas showing the prehistoric sites in which bone implements have been found.

Table 1. Bone Implements With Sharp, Slender Points from Some Prehistoric Sites in Texas.

No. of Speci-mens	Site	County	Reference	Stated Function
1	Fall Creek	Llano	Jackson 1938:104-5	Awl
1	McClure Mound	Williamson	Jackson 1938:104-5	Awl
*3	Shumla Caves	Val Verde	Schuetz 1961:191-2	Awls
3	Kyle	Hill	Jelks 1962:62-4	Awls
2	Centipede Cave	Val Verde	Epstein 1963:81-2	Awls
5	Jim Arnold	Hall	Tunnell 1964:85-92	Awls
6	Brawley's Cave	Bosque	Olds 1965:136-9	----
*3	McCann	Lampasas	Preston 1969:188	Awls?
2	Baker Cave	Val Verde	Word and Douglas 1970:91-3	Awls
1	Loma Sandia	Live Oak	Highley in press	----

*Implements from the Shumla Caves and the McCann site have incised decorations but are not illustrated here. The three decorated Shumla Cave specimens have simple diagonal lines or criss-crossed lines incised over small areas of their proximal (broad) ends. The specimen from the McCann site has a simple zig-zag line pattern running most of its length. The scale published with the illustration of the McCann specimen indicates that it is only about 7 cm long, but it is possible that the scale is incorrect.

Table 2. Bone Hairpins from Some Prehistoric Sites in Texas.

No. of Speci-mens	Site	County	Reference	Stated Function
1	Unland	Cameron	Mallouf and Zavaleta 1979:18,21	Hairpin or weaving imple-ment
1	41 WY 50	Willacy	Day, Laurens-Day, and Prewitt 1981:333, 336	Hairpin
1	Loma Sandia	Live Oak	Highley in press	Hairpin

Table 3. Bone Implements with Blunt Tips from Some Prehistoric Sites in Texas.

No. of Speci-mens	Site	County	Reference	Stated Function
1	Fred Acree Farm	Coryell	Jackson 1938:104-105	Awls
2	Amistad Reservoir	Val Verde	Collins 1969:73-75	Awls
23±	Albert George	Fort Bend	Walley 1955:218-234 Duke 1970	Hairpins or weaving tools
1	Green Lake	Calhoun	Wingate and Hester 1972:119-126	-
72[a]	Ernest Witte	Austin	Hall 1981:225-230	-
2[b]	Leonard K	Austin	Hall 1981:107, 241	-
2	Goebel	Austin	Duke 1970:7; 1982:6	Awls
?	Crestmont	Wharton	Joe Hudgins (pers. com.)	-
1	Konvicka	Fort Bend	Patterson and Hudgins 1987	-
2+	TWI	Victoria	Birmingham and Huebner n.d.	-
1	Brandes	Austin	Highley et al. 1988	Hairpin
2	Olmos Dam	Bexar	Lukowski 1988	Hairpin
1	41BX36	Bexar	Lynn Highley (pers. com.)	-
1[b]	Blue Bayou	Victoria	Huebner 1988:97-99	Awl

[a] The total of 72 does not take into account 40 implements represented by fragments (Hall 1981:235-236).

[b] Decorated implements from the Leonard K and Blue Bayou sites are not illustrated here. The two specimens from the Leonard K site have elaborate design patterns, but are too decomposed to be drawn accurately. The Blue Bayou specimen has one line incised across its proximal (broad) end.

ETHNOGRAPHIC CORRELATES

The inferred identifications of the awls (Table 1) are accepted here as correct. However, the relatively blunt tips of other specimens (Tables 2 and 3) rendered them useless for piercing holes in tough materials such as hide, leather, or plant fiber. In pursuing the idea that long-bone implements, especially those with fairly blunt tips (Table 3), may have functioned as hairpins or mat- or basket-weaving tools, a survey of the *Handbook of North American Indians* (Heizer 1978, Ortiz 1983, D'Azevedo 1986) and several other ethnographic sources indicated that the tool most often used in basket-making has a sharp, slender point capable of perforating the fiber coils of baskets (Spier 1978:475, Bowen 1983:241, Roessel 1983:601, Aikens and Madsen 1986:156, Cain and Farmer 1981:84). The tools illustrated in these sources are of bone and are shaped much like awllike artifacts (Table 1). Cactus spines (Fowler and Dawson

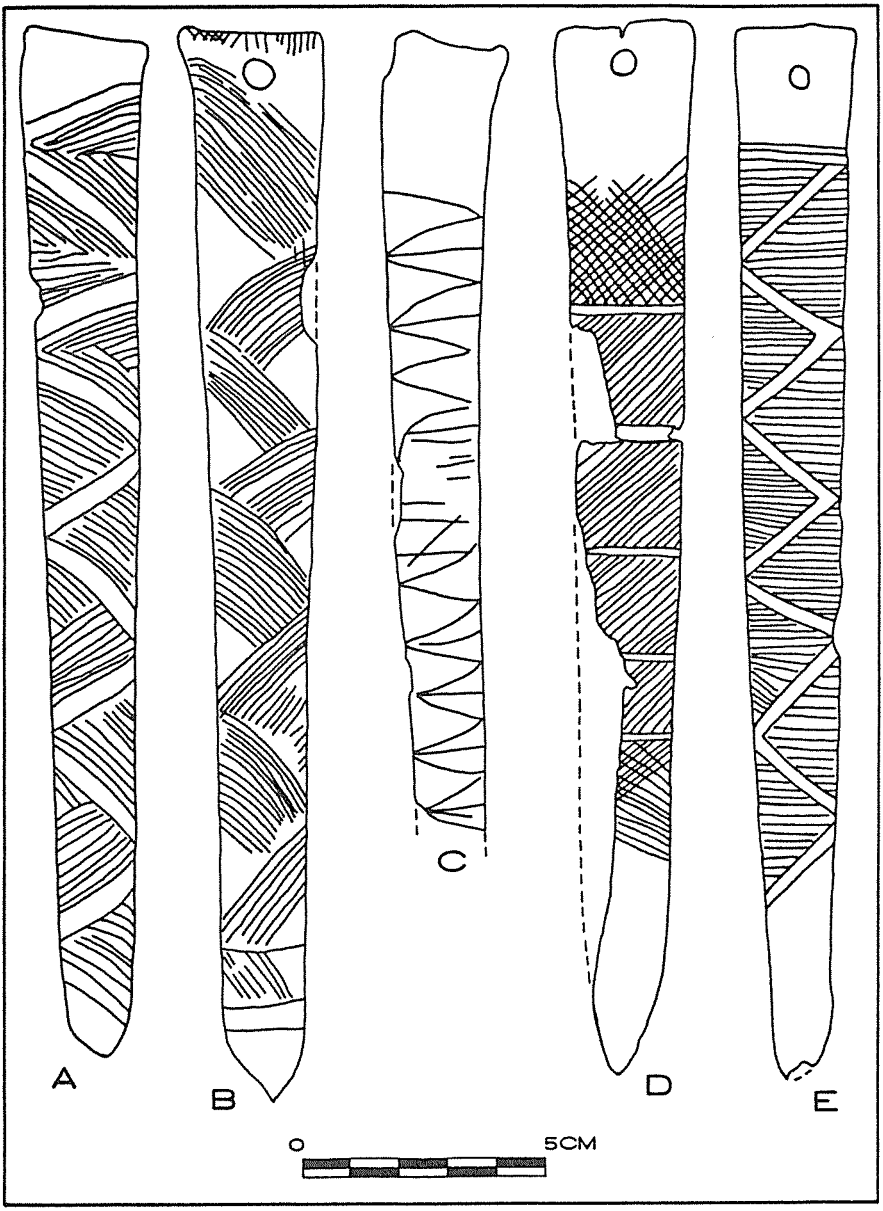


Figure 2. Drawings of incised bone implements from the Albert George site. (Redrawn from Walley 1955:Pl 36 and 37, *Bulletin of the Texas Archeology Society* 26.)

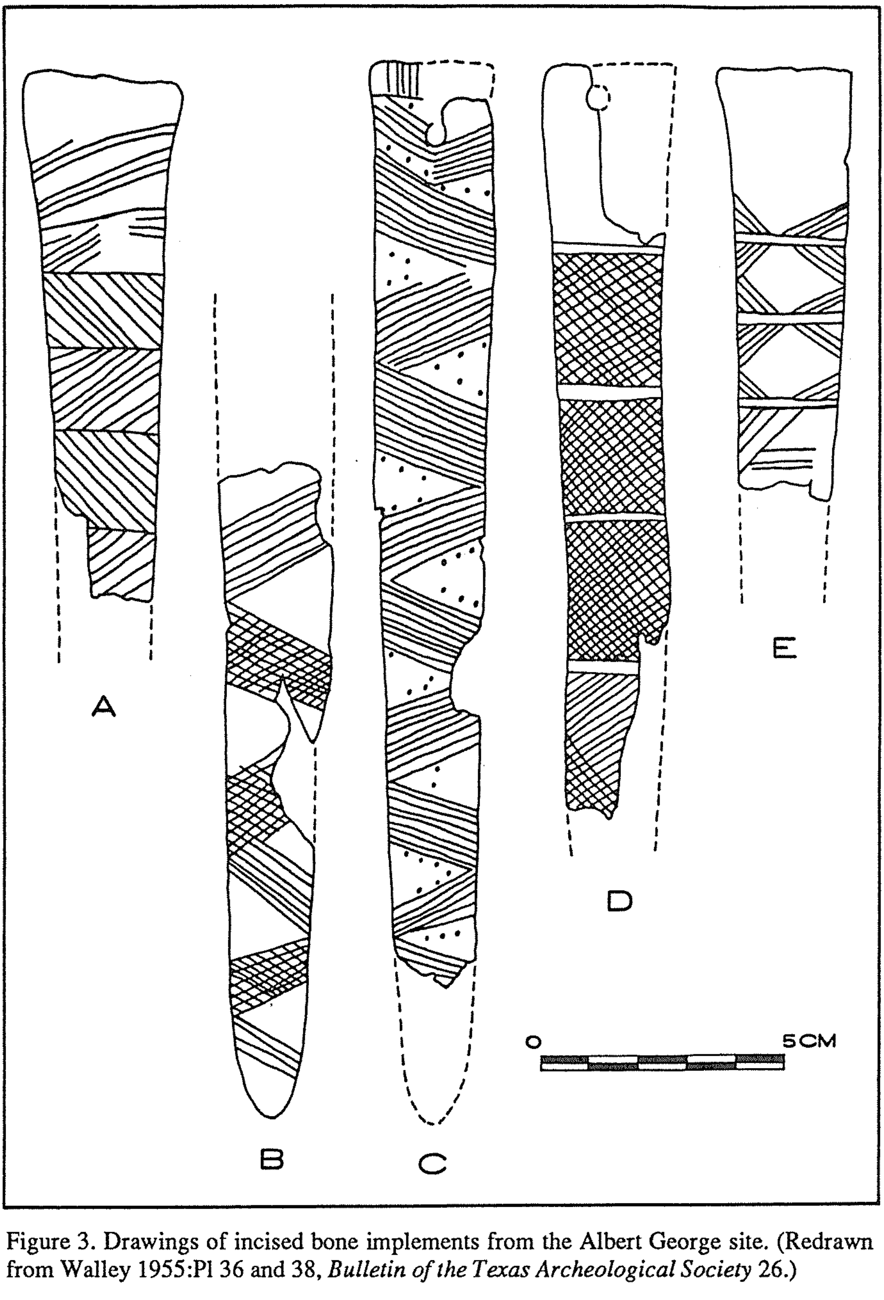


Figure 3. Drawings of incised bone implements from the Albert George site. (Redrawn from Walley 1955:Pl 36 and 38, *Bulletin of the Texas Archeological Society* 26.)

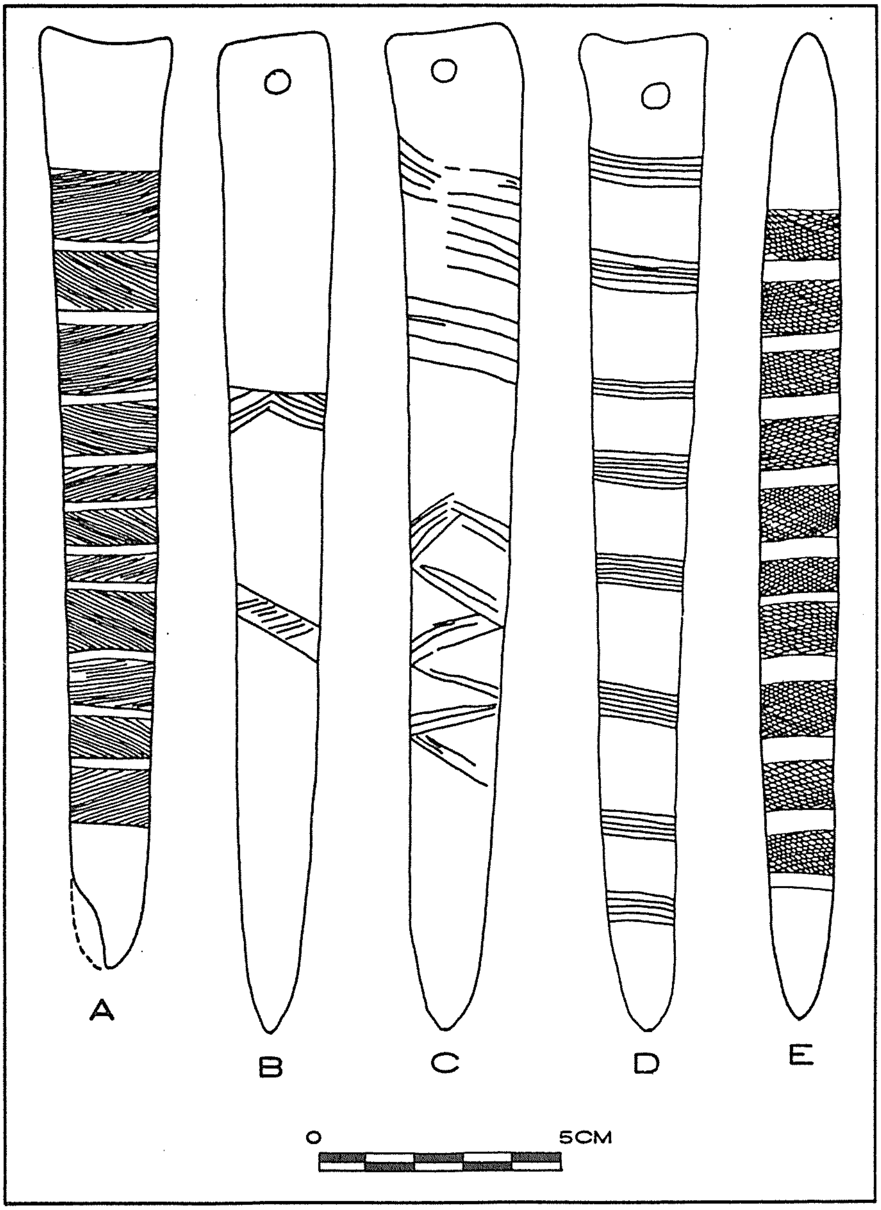


Figure 4. Drawings of incised bone implements from the Ernest Witte site. (Redrawn from Hall 1981:Figures 50 and 51, courtesy of the Texas Archeological Research Laboratory, The University of Texas at Austin.)

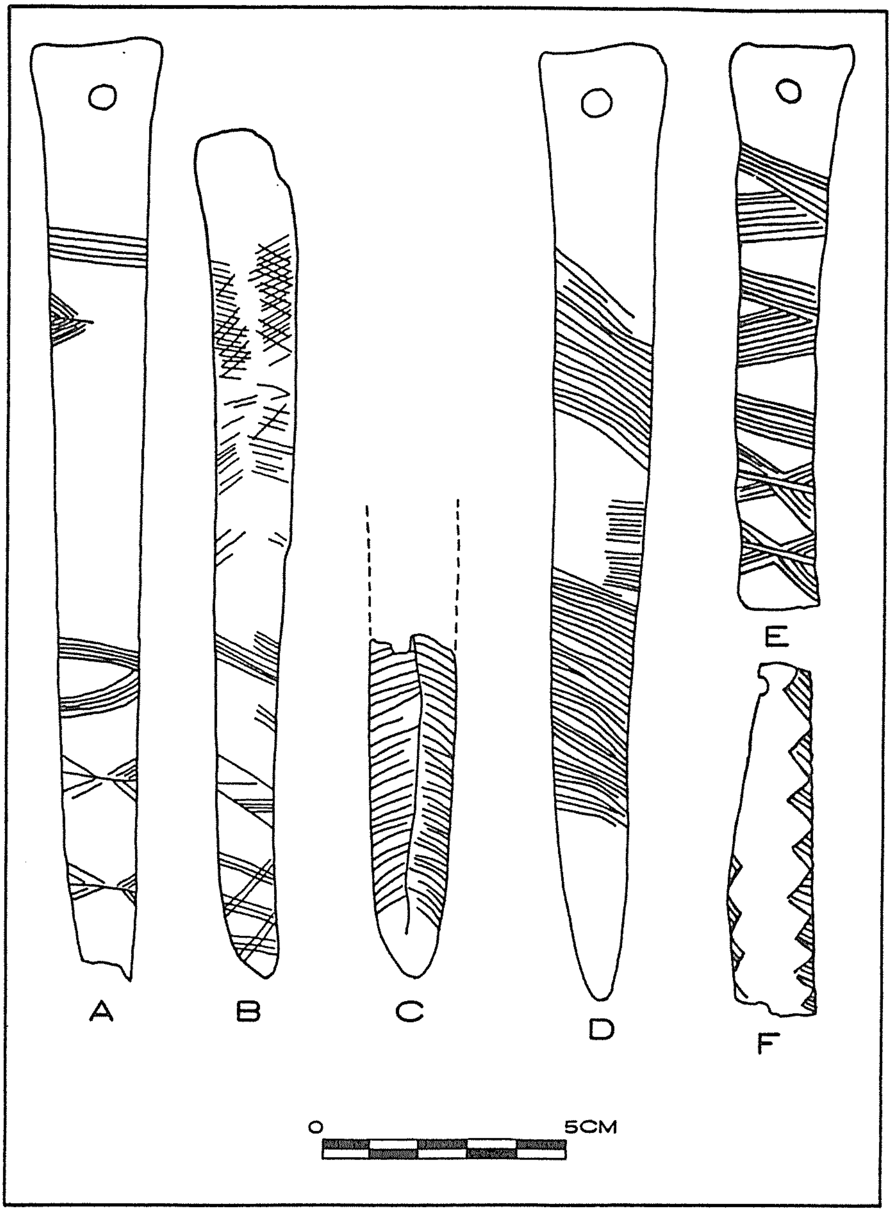


Figure 5. Drawings of incised bone implements: A-D, from the Ernest Witte site; E, from the Albert George site; F, from the Konvicka site. (A-D redrawn from Hall 1981:Figures 50 and 51, courtesy of the Texas Archeological Survey, The Universtiy of Texas at Austin; E , redrawn from Duke 1970, courtesy of Alan R. Duke: F redrawn from Patterson and Hudgins 1987, courtesy of Leland W. Patterson and Joe D. Hudgins.)

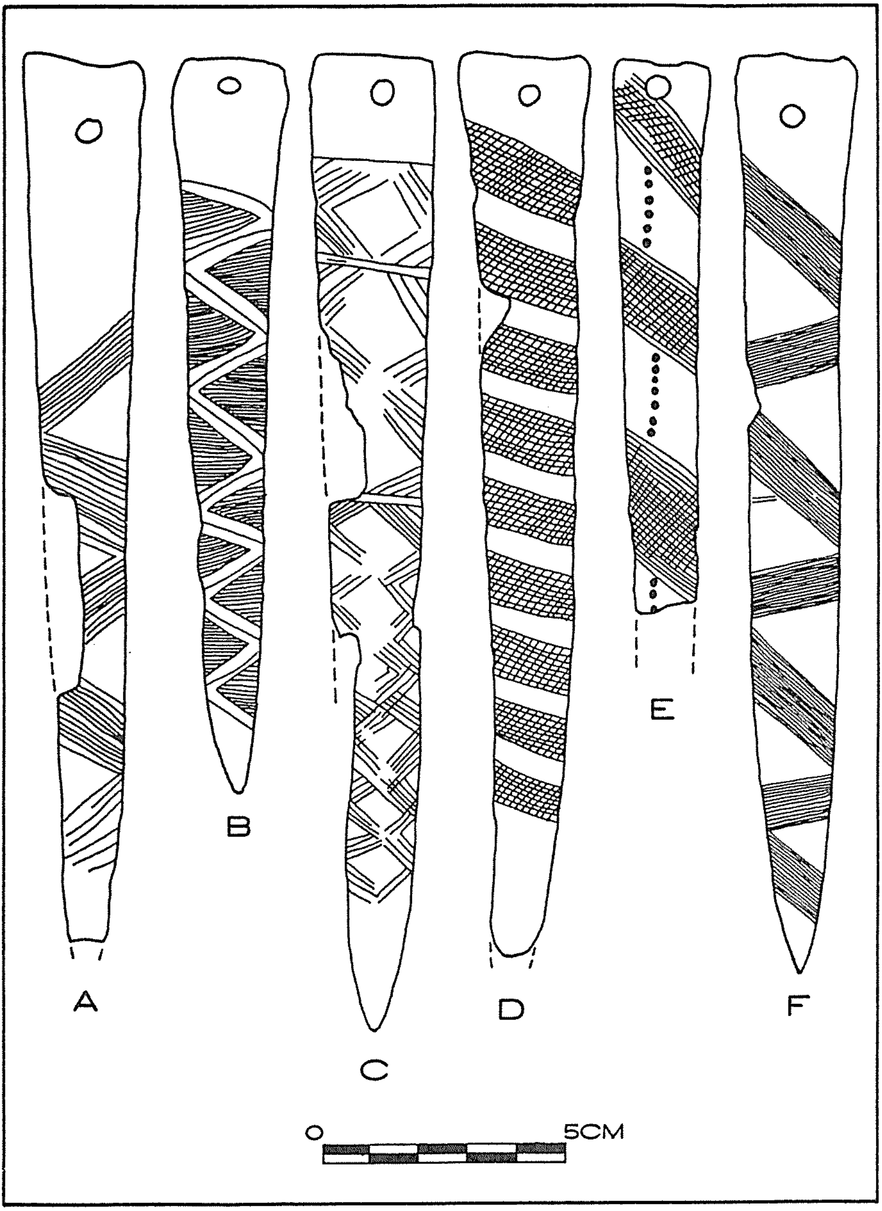


Figure 6. Drawings of incised bone implements from the Crestmont site. (Courtesy of Joe D. Hudgins.)

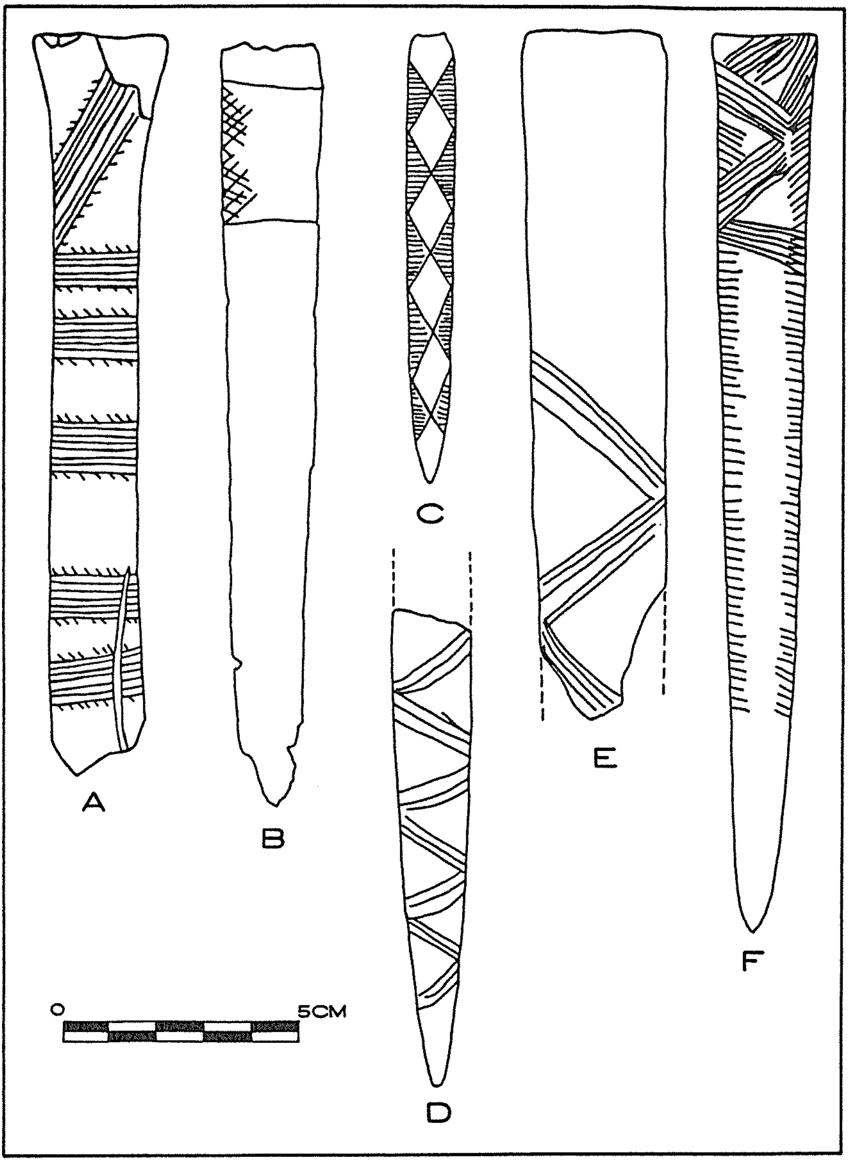


Figure 7. Drawings of incised bone implements. A, from the Green Lake site; B, from the Loma Sandia site; C and D, from the TWI site; E, from 41BX36; F, from the Brandes site. (A is redrawn from Wingate and Hester 1972, courtesy of Thomas R. Hester; B is redrawn from Highley, in press, courtesy of A. J. Taylor, Lynn Highley, and the Texas State Department of Highways and Public Transportation; C and D are redrawn from Birmingham and Huebner, n.d., courtesy of William W. Birmingham and Jeffery A. Huebner; E, courtesy of Lynn Highley and the Center for Archaeological Research, The University of Texas at San Antonio; F, redrawn from Highley et al. 1988, courtesy of Lynn Highley.)

1986: 720) and metal awls (Cain and Farmer 1981: 84) are also documented for the same purpose. In their mention of bone awls, Aikens and Madsen (1986:156) note that these are suitable for perforating both leather and basketry coils.

A specimen very similar to the blunt-tipped tools (Table 3) is illustrated in Volume 10 of the *Handbook of North American Indians* (Schwartz 1983:21). Made from a long bone, it is decorated on one face with geometric, anthropomorphic, and zoomorphic designs. The reverse is decorated only with geometric designs. The specimen is perforated at the proximal end and a leather thong is knotted through the hole. Collected from a Yuman group in the Southwest, the specimen is identified as a scratcher.

Other bone implements identified as head scratchers, louse crushers, hairpins, hair ornaments, or sweat scrapers are described and illustrated in other ethnographic and archeological sources for the Southwest and California (Wallace 1978:173; Loud 1918:Plate 20; Heye 1921:3, 94-97; Gifford 1940; Ragir 1972:66-67; Hester 1974:Figure 6). Although these specimens vary considerably from bipointed to subrectangular, some are shaped much like the blunt-pointed specimens in this study (Table 3) (see especially Heye 1921). The subrectangular to rectangular specimens illustrated by Heye and identified as louse crushers are reminiscent of bone implements found at several Late Prehistoric sites in Texas; Huebner (1987:6-15) has suggested that such rectangular bone implements functioned as fleshing tools. Hester (1974) has reported on a decorated long-bone implement from western Nevada, which he speculates may have functioned as a sweat scraper, or strigil. Ragir (1972:66) illustrates a similar specimen, also identified as a sweat scraper, from a site yielding Archaic remains in California.

Wing and Brown (1979:104-105) discuss bone implements called husking pins that were used by prehistoric and early historic farming peoples in North America and Mesoamerica for shucking corn. The specimens illustrated by Wing and Brown are in some cases identical to the blunt-tipped artifacts in this study (Table 3), except that they lack decoration.

Most striking is the fact that many of the specimens illustrated in these sources have incised geometric designs on the convex faces and are perforated at one end. The sources specifically mention that females, both those involved in menarche rituals (Teit 1900:311-14; Swanton 1910:314-15; Elsasser 1978:196; Wallace 1978:172-3; Loud 1918:383) and postpartum females (Kelly 1978: 421) used bone head scratchers to touch their bodies (when scratching, eating, etc.) in compliance with taboos against touching themselves with their fingers at these times. These were apparently items that everyone would need now and again, but the sources do not specifically state that everyone was equipped with a head scratcher or louse crusher.

TEXAS LONG-BONE IMPLEMENTS AS HEAD SCRATCHERS OR LOUSE CRUSHERS

On the basis of the ethnographic data from the Southwest and California, it is proposed that use as head scratchers or louse crushers be added to the list of possible functions for the blunt or flat-tipped long-bone implements (Tables 2 and 3). These newly proposed functions do not preclude concurrent service of long-bone implements as hairpins or sweat scrapers, since both of these functions are also indicated for such tools in the ethnographic record.

Considering the presumed hunter-gatherer subsistence orientation of prehistoric peoples represented by the long-bone specimens in this study, it is not likely that they used the implements for husking maize.

Referring back to the blunt and flat-tipped specimens (Tables 2 and 3), how do the proposed functions agree with the available contextual information? All three of the long bone implements listed in Table 2 were found in burials beside or beneath the skulls, and, as already noted, are suggested by their respective analysts to be hairpins or, in one case, a weaving implement. Most of the flat-tiped specimens listed in Table 3 also came from burial contexts. This is largely because many specimens were recovered from Late Archaic cemeteries in Texas, especially at the Albert George and Ernest Witte sites.

At the Albert George and Ernest Witte sites, which together yielded at least 95 specimens, the contextual distribution is decidedly postcranial. Only three burials at Ernest Witte had long-bone implements positioned around the skulls. Further confounding the issue, such implements, together with other types of bone artifacts made from limb bones, were found in stacks or side-by-side in echelon. All of the Albert George site specimens were found together in one such cache (Walley 1955:233), and at the Ernest Witte site, seven stacks of bone implements were found and account for most of the recovered specimens (Hall 1981:225-30). The graves of at least 14 individuals in the Group 2 component at the Ernest Witte site were furnished with long-bone implements. Of further significance is the fact that all long-bone artifacts (in fact, *all* bone artifacts) in the Group 2 Ernest Witte component were associated with individuals more than 20 years old. An analysis of the Crestmont burials revealed that the grave of one individual 13 to 14.5 years old was furnished with bone implements (Vernon, in press). At Green Lake (Wingate and Hester 1972), Brandes (Highley et al. 1988), and Olmos Dam (Lukowski 1988), long-bone implements were found around the skulls.

The contextual data from many of the sites therefore support the hairpin or head scratcher functions proposed for the long-bone implements. However, the strong contextual information from the Albert George and Ernest sites does not. Is it possible to reconcile the contextual data with the hypothesized hairpin/head scratcher/louse crusher functions? Single specimens with perforated ends found in the upper torso areas of skeletons may have been attached to clothing or suspended from the neck so that they would have been close at hand when head scratching or louse crushing needs arose. Stacks of long-bone implements may represent personal tool kits containing different types of tools intended for a variety of functions. Alternatively, the stacks may be aggregates of individual memorial tokens contributed as grave furnishings by survivors participating in the funeral ceremonies. The last two alternatives neither confirm nor deny the functional speculations made about the implements.

DECORATIONS ON LONG-BONE IMPLEMENTS

Geometric designs are incised into about 10 percent of the long-bone implements from 10 prehistoric sites in Texas (Figures 2 to 7); they comprise almost all of the incised specimens known to the author. Remarkably, no design pattern is repeated among the 36 known specimens, but variations on certain decorative themes are apparent. It is possible that study of the design elements and themes on the decorated specimens will yield insights into social relationships among the individuals or bands responsible for their manufacture. For example, did certain kin groups use variations on a particular geometric theme? If so, a study similar to the work done with designs on Arikara pottery in the Northern Plains (Deetz 1965) might prove fruitful.

As an example of how such a study of decorative themes might proceed, attention is called to three sets of design patterns found at the Albert George, Ernest Witte, and Crestmont sites (Figure 8). One group of similar patterns—a zigzag, or lightning bolt—is represented by specimens from the Albert George (Figure 2: A, E) and Crestmont (Figure 6: B) sites. A second group—the diamond pattern (Figures 3, E and 6, C)—also involves the same two sites. A third style of design links the Albert George and Ernest Witte sites (Figures 3, A and 4, A) and could be described as a band/crisscross pattern. It is suggested that tracking of the occurrence of these patterns as new specimens are found in the future will yield useful insights into the movements and social structure of the band represented by the specimens.

Not all of the long-bone implements have incised decorations; this observation may be significant. At the Ernest Witte site, only about 10 percent of the implements have the incised decorations. Did a person need to reach a certain age, achieve a certain status, or accomplish some other milestone in life to be eligible for a personalized design pattern? The ritual/ceremonial uses recorded for head scratchers in the Southwest suggest that the implements, with or without designs, may be symbolic of particular conditions or status rather than purely functional objects. At the Ernest Witte site, bone implements were distributed about equally between males and females. As previously noted at the Ernest Witte site, there was a definite lower age limit for association with bone implements as grave furnishings. All those who had them were over 20 years old at the time of death. This strong age-discriminant pattern is slightly confounded by the findings at the Crestmont site, where a teenager was accompanied by such artifacts. If the implements were indeed contributed by survivors, the tools and their characteristics may be saying more about the survivors than about the deceased.

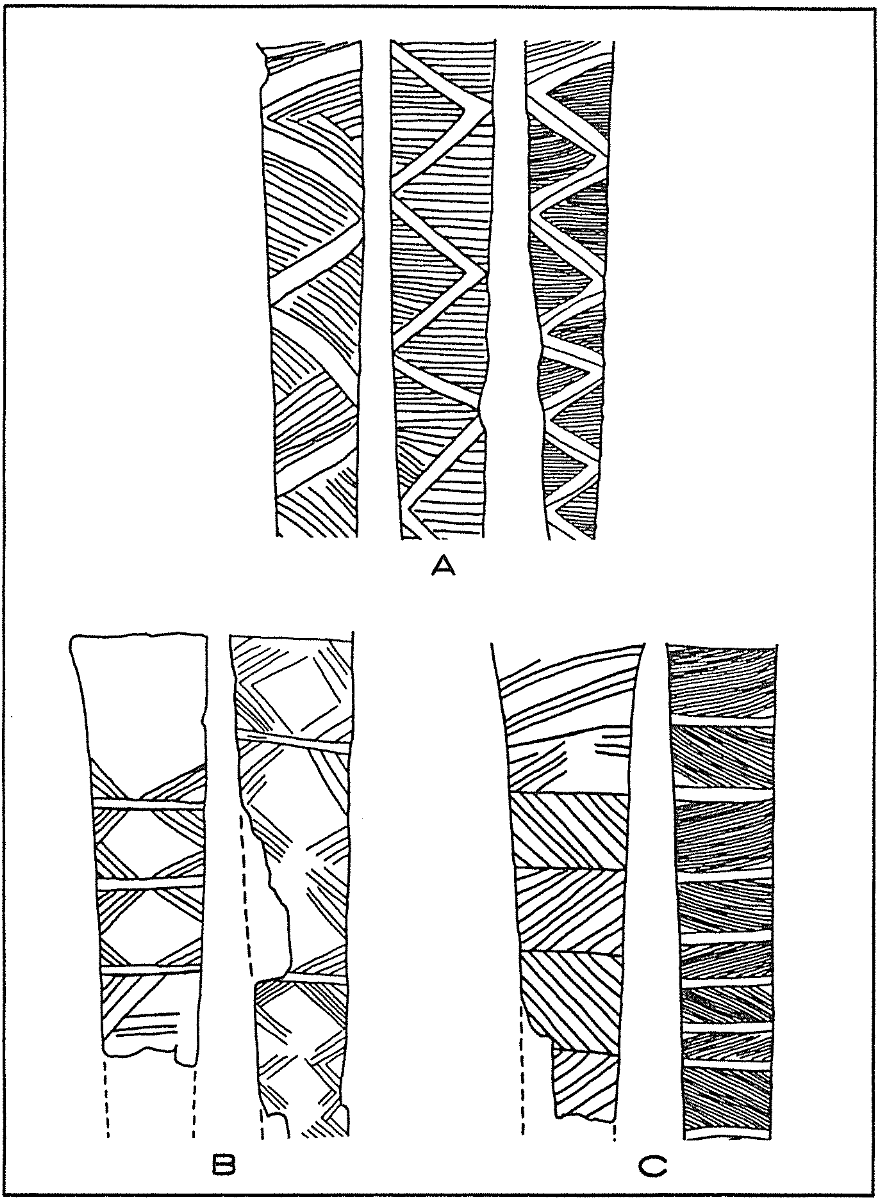


Figure 8. Drawings showing comparison of design patterns. A, zigzag or lightning bolt patterns from the Albert George and Crestmont sites (see Figures 2, A, E and 6, B); B, diamond paterns from the Albert George and Crestmont sites (see Figures 3, E and 6, C); C, band/crisscross patterns from the Albert George and Ernest Witte sites (see Figures 3, A, and 4, A).

CONCLUSION

The ethnographic data reviewed here support the contention that the sharply pointed long-bone implements (Table 1) were used as awls. In this capacity they could have served several hole-punching needs, including the perforation of fiber coils in basket making. The blunt- or flat-ended specimens (Tables 2 and 3) are too dull to have functioned well as awls and were more likely to have been used principally as hairpins, head scratcher/louse crushers, or sweat scrapers

In addition to the proposal concerning some other functions, there is a possibility of exclusivity in the usage of design patterns on the long-bone implements. The data suggest that ownership (or, at least, inclusion as burial furnishings) was restricted to adults and, possibly, later adolescents, suggesting that social identity developed late in the second decade of life for these groups. Finally, it is speculated that the design patterns may have been band-, lineage-, or person-specific and that the use of these patterns survived the individuals who commissioned them. The contention that design patterns are specific to persons or bands is the most tenuous of the propositions presented here, but it can be tested when additional data are recovered.

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REFERENCES CITED

Aikens, C. M., and D. B. Madsen

1986 Prehistory of the Eastern Area. In: D'Azevedo,Warren L. (Volume Editor). Great Basin. *Handbook of North American Indians* 11. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Birmingham, W. W., and J. A. Huebner

n.d. Incised Bone and Conch Shell Artifacts from the Texas West Indies Ranch Site (41 VT 9), Victoria County, Texas.

Bowen, Thomas

1983 Seri. In: Ortiz, Alfonso (Volume Editor). Southwest. *Handbook of North American Indians* 10. Williams C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Cain, W. C., and J. F. Farmer
1981 Materials, Techniques, and Styles. In: Lopez, Raul A. and Christopher L. Moser (editors). *Rods, Bundles, and Stitches - A Century of Southern California Indian Basketry*. Riverside Museum Press. Riverside, California.

Collins, M. B.
1969 Test Excavations at Amistad International Reservoir, Fall, 1967. The University of Texas at Austin. *Papers of the Texas Archeological Salvage Project* 16.

Day, D. W., Jane Laurens-Day, and E. R. Prewitt
1981 Cultural Resources Surveys and Assessments in Portions of Hidalgo and Willacy Counties, Texas. *Prewitt and Associates, Inc., Reports of Investigations* 15. Austin.

D'Azevedo, W. L. (Volume Editor)
1986 Great Basin. *Handbook of North American Indians* 11. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Deetz, James
1965 *The Dynamics of Stylistic Change in Arikara Ceramics*. Urbana: University of Illinois Press.

Duke, A. R.
1970 Indian Artists of the Gulf Coast. *Newsletter of the Houston Archeological Society* 31:3-7.

Elsasser, A. B.
1978 Mattole, Nongatl, Sinkyone, Lassik, and Wailaki. In: Heizer, Robert F. (Volume Editor). California. *Handbook of North American Indians* 8. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Epstein, J. F.
1963 Centipede and Damp Caves: Excavations in Val Verde County,Texas, 1958. *Bulletin of the Texas Archeological Society* 33 (for 1962): 1-129.

Fowler, C. S., and L. E. Dawson
1986 Ethnographic Basketry. In: D'Azevedo, Warren L. (Volume Editor). Great Basin. *Handbook of North American Indians* 11. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Gifford, E. W.
1940 Californian Bone Artifacts. *Anthropological Records* 3(2): 153-237. University of California Press. Berkeley.

Hall, G. D.
1981 Allens Creek: A Study in the Cultural Prehistory of the Lower Brazos River Valley, Texas.*Texas Archeological Survey. The University of Texas at Austin Research Report* 61.

Heizer, R. F. (Volume Editor)

1978 California. *Handbook of North American Indians* 8. Williams C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Hester, T. R.

1974 Archaeological Materials from Site NV-Wa-197, Western Nevada: Atlatl and Animal Skin Pouches. In: Four Papers on Great Basin Anthropology. *Contributions of the University of California Archaeological Research Facility No.* 21. University of California, Department of Anthropology, Berkeley.

Heye, G. G.

1921 Certain Artifacts from San Miguel Island, California. *Museum of the American Indian, Heye Foundation, Indian Notes and Monographs* 7(4).

Highley, C. L.

In Press Bone and Antler Artifacts. In: Taylor, A. J., and Cheryl Lynn Highley, Archaeological Investigations at the Loma Sandia Site (41 LK 28): A Prehistoric Cemetery and Campsite in Live Oak County, Texas. *Texas State Department of Highways and Public Transportation Publications in Archaeology, Highway Design Division.*

Highley, C. L., Jeffery A. Huebner, J. H. Labadie, R. J. Leneave, and R. R. Harrison

1988 Salvage Archaeology at the Brandes Site (41 AU 55), Austin County, Texas. *La Tierra* 15(3):6-19.

Hough, Walter

1907 Awls. In: Handbook of American Indians North of Mexico. F. W. Hodge, Editor. *Bureau of American Ethnology Bulletin* 30, Pt. 1. Washington, D. C.

Huebner, J. A.

1987 A Toyah Horizon Tool from Victoria County. *La Tierra* 14(4):6-15.

1988 The Archaeology of Blue Bayou: A Late Prehistoric and Archaic Mortuary Site, Victoria County, Texas. Unpublished Master's Thesis. The University of Texas at San Antonio.

Jackson, A. T.

1938 The Fall Creek Sites. *The University of Texas Publication* 3802. Austin.

Jelks, E. B.

1962 The Kyle Site - A Stratified Central Texas Aspect Site in Hill County, Texas. *Department of Anthropology, The University of Texas at Austin Archeology Series* 5.

Kelly, Isabel

1978 Coast Miwok. In: Heizer, Robert F. (Volume Editor). California. *Handbook of North American Indians* 8. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Loud, L. L.
1918 Ethnogeography and Archaeology of the Wiyot Territory. *University of California Publications in American Archaeology and Ethnology* 14(3):221-436. Berkeley.

Lukowski, P. D.
1988 Archaeological Investigations at 41BX1, Bexar County, Texas. *Center for Archaeological Research. The University of Texas at San Antonio Archaeological Survey Report 126.*

Mallouf, R. J., and A. N. Zavaleta
1979 The Unland Site. *Office of the State Archeologist Special Report* 25. Texas Historical Commission. Austin.

Olds, Doris L.
1965 Report on Materials from Brawley's Cave, Bosque County, Texas. *Bulletin of the Texas Archeological Society* 36:111-152.

Ortiz, Alfonso (Volume Editor)
1983 Southwest. *Handbook of North American Indians* 10. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Patterson, L. W., and J. D. Hudgins
1987 The Konvicka Collection (41 FB 95), Fort Bend Co., Texas. *Journal of the Houston Archeological Society* 89:11-18.

Preston, N. E.
1969 The McCann Site. *Bulletin of the Texas Archeological Society* 40: 167-192.

Ragir, Sonia
1972 The Early Horizon in Central California Prehistory. *Contributions of the University of California Archaeological Research Facility Number* 15. University of California, Department of Anthropology, Berkeley, California.

Roessel, Ruth
1983 Navajo Arts and Crafts. In: Ortiz, Alfonso (Volume Editor). Southwest. *Handbook of North American Indians* 10. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Schuetz, M. K.
1961 An Analysis of Val Verde County Cave Material: Part II. *Bulletin of the Texas Archeological Society* 31 (for 1960): 167-205.

Schwartz, D. W.
1983 Havasupai. In: Ortiz, Alfonso (Volume Editor). Southwest. *Handbook of North American Indians* 10. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Spier, R. F. G.

1978 Foothill Yokuts. In: Heizer, Robert F. (Volume Editor). California. *Handbook of North American Indians* 8. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Swanton, J. R.

1910 Puberty Customs. In: Handbook of American Indians North of Mexico. F. W. Hodge, Editor. *Bureau of American Ethnology Bulletin* 30, Pt. 2. Washington, D. C.

Taylor, A. J., and C. L. Highley

In Press Archaeological Investigations at the Loma Sandia Site (41 LK28): A Prehistoric Cemetery and Campsite in Live Oak County, Texas. Texas *State Department of Highways and Public Transportation, Highway Design Division, Contract Reports in Archaeology.*

Teit, J. A.

1900 The Thompson Indians of British Columbia. In: Boas, Franz (Editor), Jesup North Pacific Expedition. *Memoirs of the American Museum of Natural History 2, Anthropology* 1(4). New York.

Tunnell, C. D.

1964 Two Burials from the Jim Arnold Site in Northwest Texas. *Bulletin of the Texas Archeological Society* 35: 83-93.

Vernon, C. R.

In Press The Prehistoric Skeletal Remains from the Crestmont Site, Wharton County, Texas. *Studies in Archaeology* No 1. Texas Archeological Research Laboratory, The University of Texas at Austin.

Wallace, W. J.

1978 Hupa, Chilula, and Whilkut. In: Heizer, Robert F. (Volume Editor). California. *Handbook of North American Indians* 8. William C. Sturtevant, General Editor. Smithsonian Institution. Washington, D. C.

Walley, Raymond

1955 A Preliminary Report on the Albert George Site in Fort BendCounty. *Bulletin of the Texas Archeological Society* 26: 218-234.

Wing, E. S., and A. B. Brown

1979 *Paleonutrition.* Academic Press, New York.

Wingate, R. J., and T. R. Hester

1972 Ten Burials from Green Lake, Texas. *Florida Anthropologist* 25(3):119-127.

Word, J. H., and C. L. Douglas

1970 Excavations at Baker Cave, Val Verde County, Texas. *Texas Memorial Museum Bulletin* 16, Austin.

Exploring The Possibilities of Acorn Utilization in the Burned Rock Middens of Texas

Ellen Sue Turner

ABSTRACT

This paper examines the possibility of a correlation between acorn processing and some types of burned rock middens in Texas, using known interrelationships between North American aboriginal culture and the technology of acorn gathering and utilization. The acorn industry, as reported in ethnographic records and reconstructed through archeological excavations, is reviewed, and the processing of acorns in the Texas environment is considered.

INTRODUCTION

Many burned rock midden sites of varying forms or types are found in Central Texas along the east edge of the Edwards Plateau (Hester 1980:63). In addition to an abundance of fire-cracked rocks, some middens typically yield large amounts of sandstone, chert, ash, and baked clay, indicating that prehistoric people camped on and around them. Other types of burned rock middens comprise little else but burned rock and some ashy soil. There is much controversy over the nature and function of the different kinds of burned rock middens, but some may have been specialized food-cooking or plant-processing areas (Hester 1980:63).

ETHNOGRAPHIC RECORDS OF ACORN UTILIZATION

Some of the highest population densities for North American Indians were among the acorn-gathering groups of California and the sedentary Pueblo farmers of the Southwest. The native culture of central California followed a hunting-and-gathering-based subsistence pattern in an unusually rich environment. In most cases, the basic staple was acorns, which were consumed annually in vast quantities, indicating their high food value in that culture. The hunting-and-gathering culture of central California reached ecological stability around 2000 B.C.; later changes were primarily in artifact styles (Sanders and Price 1968:85-86).

Sweet acorns were eaten by the Omahas and the Delawares of the midwestern prairies (Hecklewelder 1882), and by the Tonkawas, Coahuiltecans, and Karankawas of Texas (Newcomb 1973:139). In the Southeast, the Choctaw of Louisiana also ate acorns (Merriam 1918). In the Northeast, the Algonquins, Iroquois, Hurons, and other tribes stretching from Canada to the Gulf of Mexico included acorns in their diets (Merriam 1918).

There are some 60 species of oaks in North America (genus *Quercus*), and acorns of 27 species are known to have been eaten by the Indians. At least half of the Indian tribes in the United States ate acorns, but they were a staple food only in California, where they were eaten in greater quantity than any other food-animal or vegetable (Driver 1975:91).

In California, wherever tan oak acorns (*Quercus densiflora)* were obtainable, they and *Quercus kelloggii* were most preferred overall. *Quercus kelloggii* was preferred by the Southern Maidu or Nisenan, Miwok, Shasta, and Luiseno, *Quercus dumosa* by the Cahuilla, *Quercus gambeli* by the Southern Maidu, *Quercus kelloggii, Quercus chrysolepis,* and *Quercus wislizenii* by the Northern Maidu, and *Quercus agrifolia* by the Pomo (Gifford 1936:240).

The nuts of the bur oak, *Quercus macrocarpa,* which grows in moist forests along streams in East and Central Texas, eastward to the Atlantic Ocean, and northward to New Brunswick and Saskatchewan (Correll and Johnston 1970:472), were gathered in late autumn by the Ojibwa and buried for winter or spring use (Densmore 1928:320). The red oak, *Quercus rubra,* was used by the Ojibwa and the Iroquois. The Potawatomi used all kinds of acorns (Smith 1932:369, 1933:100, Waugh 1916:123). The white oak, *Quercus alba,* grows in moist forests in the timber region of East Texas, eastward to the Atlantic Ocean, and northward to Canada (Correll and Johnston 1970:473). The Ojibwa depended on the nuts for soup stock. The tree is common in lower Michigan and was also used by the Menomini, the Sauk-Fox, and the Iroquois (Smith 1923:66, 1932:401, Waugh 1916:123).

Acorn Gathering and First Fruit Rites

Collecting acorns was a simple annual event in almost all California native groups, initiated with a First Acorn Ceremony in the fall. The community was organized for the collection and distribution of acorns by the shaman, moiety chief, or secret society headman (Swezey 1975:14), and harvesting or eating of acorns before the rite was a strict ritual prohibition (Voegelin 1942:175). There were many varieties of regulatory rites, all emphasizing the central position of ritual specialists in the direction of the work of the fall harvest (Swezey 1975:15).

Acorns matured and were gathered in the late autumn and early winter. Rapid and efficient gathering simultaneously with the onset of the mature crop was essential; natural competition from birds, mammals, and insects was an ever-present factor that threatened to reduce the harvest (Wolf 1945:19). In times of shortage, the trees in which the California woodpecker had drilled holes and stored acorns were examined, and the fresh acorns were pried out with a pointed instrument (*welup*) of deer antler (Barrett and Gifford 1933:143). Both men and women engaged in acorn-gathering; the men climbed the trees to shake the nuts down, and the women retrieved the falling and already fallen acorns. The men and boys shook down or dislodged the nuts with long poles (Spencer, Jennings, et al. 1968:243). "The acorn harvest lasted many days, perhaps as long as a month" (Gayton 1948:178), "until enough nuts had been picked up to last over the winter when food was scarce" (Baumhoff 1963).

Acorn Processing

The acorns were gathered in large conical burden baskets, each large enough to hold a bushel or two (Spencer, Jennings, et al. 1968:233). Two methods of removing the hulls have been reported; the first engaged all the family—men, women, and children—who removed the hulls with their teeth, but the more common method was to crush the acorns with a hand-held stone and a rock platform. Sometimes unworked flat stones were used as anvils, but frequently special stones with several small pecked cuppings were used.

After hulling, the plump meats were placed on a bedrock mortar and ground into meal. The bedrock mortars were merely flat outcroppings of the bedrock of the region. Development of the basket- or hopper-mortar was particularly important. It was a special stone mortar, provided with a conical basket hopper stuck to the rim with asphalt for use in the processing (Snow 1976:162). If the acorns were too oily, Spanish clover was pounded with them to absorb some of the oil, and roots of pond lilies, or sometimes rattails, were mixed with the meal that was intended for bread (Barrett and Gifford 1933:144-145).

Many procedures were involved in the preparation of acorns for consumption. The striking thing about the California Indians was their almost universal knowledge of leaching (Barrett and Gifford 1963:250). Boiling was practiced in the eastern Woodlands, but no other areas are known to have developed the acorn industry (except for sweet acorns) to the magnitude reached by the California Indians.

Various methods were used to leach the tannin from the acorns. In one method, a shallow basin about a meter in diameter was scooped out in the sand. The ground meal was placed in the basin and water was poured over it. "As the water soaked through the fine meal, it dissolved out the acid and leached it down through the porous sand" (Barrett and Gifford 1933:145). In other methods, leaves were put in the bottom of a hole, and bark was put on the sides and over the top. Green acorns were pounded and leached in the same way as dried acorns or, in some cases, were simply boiled whole and eaten. Green (undried) acorns were sometimes placed in long cylindrical openwork baskets that were laid across the flow of a stream until the shells cracked open. Often acorns were buried for at least a year (Kroeber et al. 1937:382); caches of acorns that have lain in cold boggy places for more than 30 years have been turned up by farmers' plows. The acorns were black, but still good (Merriam 1918). The Yurok considered the quantity of acorns they had buried in the mud a partial measure of a family's wealth and prestige; a good family had at least a year's supply. One informant told that his buried acorns were not ripe after three years in the ground because he had forgotten to bite a rotten branch, which was part of the burial ritual (Kroeber et al. 1937:381). When smaller amounts of meal were to be processed, the meal was placed in a sifting basket, which was lined with a layer of leaves to keep the ground meal from leaking out. The meal was then leached as in the leaching pit (Barrett and Gifford 1933:146).

The Algonquins, Iroquois, and Hurons used all available species of acorns and removed the tannin by soaking or boiling them in hot wood ash lye water (Smith 1932:402). The Omaha boiled the acorns until the water was almost gone, then added fresh water and ashes. They boiled the nuts again until they turned black, threw out the water and ashes, and added more fresh water until they were clean; then they cooked them until they were soft. The Delaware Indians prepared the *Q. stellata* (post oak) acorns in a similar way, then mixed them with hominy (Heckewelder 1882). In the Southeast, acorns were boiled whole, and the valuable oil was skimmed off the top of the hot liquid (Merriam 1918).

The acorns were either dried before processing or processed green. The hulled green acorns were put into "large, flattish, circular receptacles of basket work which were placed on top of a high frame over the fire in the house so that the heat in rising dried them" (Merriam 1918). They were also spread out in the sun to dry.

Cooking and Preparation

One common method of preparation of acorn meal was by stone-boiling in baskets. To prevent the basket from burning, the meal was stirred with a wooden paddle or a looped stick with string binding. The meal became a thin gruel soup, or, if the consistency was thicker, it was mush—a thick, glutenous porridge (Barret and Gifford 1933:141). Acorn bread was made by dipping out the hot mush into a special basket and turning it out into a cold running stream where the cold water caused the loaves to contract and harden. They were then placed on racks to dry, and, when hardened, they could be carried for weeks. The naturalist John Muir often carried the dry acorn bread of the Indians on his field trips into the California mountains and claimed that this slightly sour-tasting bread was the most compact and strength-giving food he had ever used (Merriam 1918). Another way to make bread was to mix the meal with red clay, one part clay to twenty parts meal, then to wrap it in leaves to bake overnight on hot stones either in the ground or covered with earth and hot stones.

> When removed the next morning, the bread previously mixed with clay is as black as jet, and while still fresh has the consistency of rather soft cheese. In the course of a few days it becomes hard . . . the sweet taste is very evident [Merriam 1918].

Algonquin tribes of the northeast used acorns for bread and for oil, and mixed the boiled acorns with their fish and meat. The Iroquois pounded the nuts and boiled them slowly in water. Then they skimmed off the oil and seasoned it with salt to be used with potatoes, squash, pumpkins, and other foods. They mixed the nut meats with mashed potatoes or added them to hominy and corn soup to enrich them (Merriam 1918).

In the New World and the Old World, the use of acorns as food for men and beasts dates back to prehistoric times. In England, France, and Italy, boiled acorns were used for bread in times of scarcity, and in most Mediterranean countries the sweet fruit of *Quercus esculenta* was prized. In Algeria and Morocco, the large acorns of an evergreen oak were eaten both raw and roasted; in Spain those of the Gramont oak were considered superior to chestnuts. In Spain and Italy in the early part of this century, as much as 20 percent of the total food of the poor consisted of sweet acorns (Merriam 1918).

ARCHEOLOGICAL EVIDENCE

From the beginning of the Archaic, nuts and acorns have been an important food resource in the diet of North American Indians (Yarnell 1970). Oak trees grow throughout the continent, and acorns have been found in archeological sites from Canada to Mexico.

Two charred acorn fragments were found at the Holdsworth III site in the Tortugas Creek drainage east of Crystal City, Texas (Hester and Hill 1975:160), and acorn fragments were also found at the Davis site in Cherokee County, Texas (Yarnell 1970). Acorn hulls decompose, and when they are burned they make a hot and lasting fire. Evidence of their use will be difficult to find in the typical open sites of Central Texas, but not all of the shells would have been completely burned; charcoal remains of such acorn shells might be found by flotation of soil samples in these areas.

Ethnohistorical sources indicate that although acorns were used extensively by Woodland groups, they were more often regarded as an emergency food to be used in the event that more usual and desirable food sources failed. They probably were gathered by groups to supplement the more reliable and staple foods and to add variety to the diet, but they probably were not regarded as a major resource (Betteral and Smith 1973:129).

Sites where acorns have been documented archeologically are the Koster site in Illinois (Asch, Ford, and Asch 1972) (the report on which is one of the best studies showing evidence of acorn use) the Fisher site in northeastern Illinois (University of Michigan Museum of Anthropology, Ethnobotanical, and Archeological Records, Report 75, as cited in Yarnell 1970), the McGraw Hopewell site in Ohio and Moccasin Bluff (Yarnell 1970:70), the Franks, Feurt, and Ash sites in Ohio, Richmond Mills (Parker 1918:29), Westfield (Guthe 1958:39), Silverwheels (Parker 1910:Pl. 31), and the Iroquoian sites—the Bates and Castle Creek Owasco sites, Vine Valley site (Ritchie 1959:11, 1944:64, 187), the Frontenac Island Archaic site (Ritchie 1945:8), the Lawson site in New York (Wintemberg 1939:6), the Alway site (Jury 1937:2), the Sidney-Mackay site (Wintemberg 1946:55), and a site in Ontario near Aylmer (University of Michigan Museum of Anthropology, Ethnobotanical and Archeological Records, Report 176, as cited in Yarnell 1970).

Acorns also have been identified in five localities at the Feeheley site, the Stroebel site, the Verchave II site (20MB181), three localities at the Juntunen site and the Hopewell site in Michigan (Yarnell 1970:70). Montet-White (1968:19) reported that the most abundant plant foods of the Middle Woodland cultures of the Illinois Valley were acorns and nuts. They were found at the Stillwell, Snyder, and Apple Creek sites (Streuver 1962). "Between 7840 and 6910 B.C. (as estimated on the basis of radiocarbon determinations) the Indians who camped seasonally in Guila Naquitz Cave in Mexico collected acorns, pinyon nuts, mesquite beans ... all of which were preserved within the cave by desiccation" (Flannery et al. 1970).

Quercus L. Oak In Texas

The Edwards Plateau, 59 million ha (24 million acres) that comprise the Hill County in west-central Texas, is predominantly rangeland, with usually shallow soils underlain on the Plateau proper by limestone or caliche and in the central basin by granite or gneiss (Correll and Johnston 1970:9). On the east and south, the plateau ends at the Balcones Escarpment, but on the north and west it extends into and interfringes with other regions (Correll and Johnston 1970:9). The rough rocky areas of the plateau typically support a tree cover primarily of live oak, Texas oak, shinnery oak, junipers, and mesquite (Correll and Johnston 1970:9). Some species of oak whose acorns conceivably could have been used by the Texas Indians in the Edwards Plateau area are described briefly below.

Quercus Drummondii (Post Oak) Small or moderate-sized trees found in the deep sand belts of Central Texas eastward; bears acorns annually (Correll and Johnston 1970:477).

Quercus glaucoides Varies from shrubs to moderate-sized trees, on limestone surface and in canyons of the Edwards Plateau in Central Texas; also in northeastern Mexico; small acorns produced annually (Correll and Johnston 1970:474).

Quercus Havardii (Shin Oak or Shinnery Oak) Very low shrubs spreading by rhizomes, or small trees. Found in deep sand across the southern Panhandle Plains; fruit annual, very polymorphic and very variable in size (Correll and Johnston 1970;477-478).

Quercus macrocarpa (Bur Oak) Large trees with coarse twigs found in moist forests along streams in East and Central Texas; fruit annually (Correll and Johnston 1970:472).

Quercus Margaretta (Sand Post Oak, Runner Oak) Low or moderate-sized shrubs branched from the base; found in deep sandy soil in low woodlands of Central and East Texas; fruit annually (Correll and Johnston 1970:477).

Quercus marilandica (Blackjack Oak) Small trees as much as 10 meters tall, with short trunks and very roughly furrowed hard black bark; abundant on sand or on clay and gravel hills in Central Texas; fruit biennially (Correll and Johnston 1970:490-491).

Quercus Mohriana (Scrub Oak) Shrubs or small trees that grow on limestone hills and mountains at low elevations in West and west-Central Texas, northward into the Plains and also southward into Coahuila, Mexico. Fruit annually (Correll and Johnston 1970:479).

Quercus Muehlenbergil (Chinkapin Oak) Moderate-sized or large trees found in calcareous upland forests of northeastern, Central, and West Texas; small fruit produced annually (Correll and Johnston 1970:473-474).

Quercus Shumardii (Shumard Red Oak, Southern Red Oak) Large trees as much as 18 meters tall with straight trunks and hard, furrowed black or plated-gray bark; found in moist forests in the timber region of East Texas and westward along waterways to the escarpment of the Edwards Plateau; fruit biennially (Correll and Johnston 1970:488-489).

Quercus sinuata (Bastard Oak) Large trees as much as 20 meters or more high, found in moist forests in the timber region of East Texas and westward along the river courses to the escarpment of the Edwards Plateau; fruit annually (Correll and Johnston 1970:481).

Quercus stellata (Post Oak) Moderate-sized trees, found in dry upland woods, frequently on sandy soil in Central Texas (one of the dominant species of the Cross Timbers region) and the timber region of East Texas; fruit annually. *Q. stellata x Q. sinuata var. breviloba* is found with both parents on mixed gravel and limestone banks (Correll and Johnston 1970:475-476).

Quercus texana (Texas Red Oak, Spanish Oak) Moderate or small trees as much as 10 meters tall, with hard rough furrowed black or smooth gray bark; peculiar to rocky limestone slopes of the Central Texas uplands; fruit biennially (Correll and Johnston 1970:489).

Quercus virginiana (Live Oak) Small or very large spreading trees; several natural hybrids occur sporadically in Texas; usually found in sandy loan but also may occur in heavy clay; fruit annually (Correll and Johnston 1970:482).

Productivity in the various species of oaks is determined by many factors and varies greatly in each region. Some oaks require two to three years to mature whereas others (such as the white oak) mature in a year but have heavy yields only every three years, with light crops intervening. The acorns of the Emory oak ripen from June to September; those of the post oak mature from September to November. White-tailed deer, squirrels, wild turkeys, prairie chickens, and peccaries eat the acorns and would have competed with the Indians for the harvest. Weir (1976:125) states that "nut collection and deer hunting go hand and hand . . . great quantities of the functionally specific artifact—the projectile point—are found within the first type of midden" (middens with sufficient occupational debris to indicate that prehistoric peoples camped on or around them). The wide diversity and range of Texas oaks would have been an abundant food source for the prehistoric hunters and gatherers.

BURNED ROCK MIDDENS OF CENTRAL TEXAS

Climatic conditions today approximate those of about 5,000 years ago, when there was an apparent expansion in population together with a greater density of oak and the development of the diagnostic burned rock midden (Weir 1976:125). There is no ethnographic record of an acorn industry in Texas, but in comparing processing procedures in other parts of the country, significant similarities suggest a possible correlation of acorn processing with some types of burned rock middens.

Burned rock middens are the most characteristic Archaic sites in Central Texas. One type is a low mound of cracked and burned limestone rocks varying in depth from a few centimeters to as much as 2.14 meters (7 feet). This type ranges in size between 4.5 meters (15 feet) and as much as "an acre [0.40 ha] in diameter" (Schuetz 1971:131). Along the Balcones Escarpment these middens are on bedrock or on residual soil near streams and springs and are also found on alluvial terraces of spring valleys. The assemblages found in these middens reflect hunting economies, sometimes with projectile points, bone, shell, and faunal remains (Weir 1976:39).

Another type of burned rock midden, which dates from the late Archaic (Weir 1976:39), has a central pit extending to bedrock; (sometimes bedrock slabs have been removed from the center of the pit for greater depth [Jarvis and Crawford 1974]). The middens are surrounded by massive concentrations of burned rock fragments; they contain few or no diagnostic artifacts, but charred remains of plant foods are often found in them (Weir 1976:39).

Burned rock middens of still another variety, found on the western periphery of Central Texas, were described by Wilson (1930) as circular piles or mounds of burned rocks that are smaller than a doubled fist. The mounds vary in circumference from 4.88 to 15.24 meters (16 to 50 feet), and they are from a few centimeters to as much as 0.91 meters (3 feet) deep in the center; the base of the mound proper always extends into the ground. All of the rocks in the mounds show the effect of thorough, but not excessive, burning. They contain ashes and dirt and, as a rule, are some distance from the campsites. Thousands of these mounds are scattered over west-central Texas in Menard, Edwards, and Kimble counties and westward from there toward the Pecos River, always near a wet-weather water hole, stream, or lake. The streams of this area are bordered with pecan trees, and the tops of the hills are covered with live oaks (Wilson 1930).

Wilson (1930:62) believes the mounds were hearth ovens for baking sotol roots. F. W. Buckelew, who was captured by the Indians in 1886, related the following eyewitness account to Wilson.

> A large circular hole was then dug three or four feet deep and several feet in diameter. In this hole they would place a large pile of wood and rock in such a way that the rocks would become thoroughly heated by the time the wood was consumed. The rocks were then replaced in such a way that the sotol could be placed on and around them. When this was completed, brush and leaves were placed next to the sotol and the entire heap covered over with dirt so as to make it airtight. This was allowed to remain several days during which time the heat from the rocks would penetrate the sotol and thoroughly cook it . . . The bulbs were then spread out in the sun where they could dry [Wilson 1930:62, 63].

Hearths similar to those described by Buckelew often are associated with burned rock middens, most commonly with those on open terrace sites. These basin-shaped pits are no more than 30.48 cm (1 foot) deep and are filled with limestone cobbles or ashy soil and contain little or no burned rock. Kelley and Campbell (1942) believe that burned rock mounds came about as a byproduct, or dump area, from the use and reuse of favored areas for the building of stone-lined hearths. In addition to the stone-lined hearths, another variety was made by scooping out a small cavity in the silt and sand and surrounding it with large stones to hold the fire. In some instances stones were put into the fire, suggesting that they might have been used for stone boiling.

W. Max Witkind conducted "An Experiment in Stone Boiling" (Gunn and Mahula 1977:205) using dolomite stream cobbles and pieces of tabular limestone fired on a campfire of oak wood. Prefiring and postfiring weights were measured, and they were boiled in a 15-quart plastic dishpan. Changes in color were obvious (Gunn and Mahula 1977:207). Fracture lines and a proclivity to fragment after several heatings suggest that there must have been only limited reuse of both boiling- and cooking-pit stones and that each stone could be used only several times before it was discarded on a nearby midden. Stones discarded by people who visited the same location repeatedly for extended periods of time could could have made the many and sometimes massive burned rock middens.

Courtenay J. Jones performed "A Further Experiment in Stone Boiling: A Calcining Process for Acorns" (Jones 1980), in which he also determined the prefiring and postfiring weights and colors of the cobbles used. In a mesquite wood fire, Jones first rotated the limestone cobbles between a fire and a cooking vessel; later, he rotated the cobbles between the fire and a vessel containing water until they fractured. He then put ground acorn meal and water into the cooking vessel and added the fractured cobbles to the thin gruellike mixture one at a time until the mixture boiled. He took colorpHast readings, and the neutralization of the increased acidity (caused by the addition of the acorns, which increased the acidity one hundredfold) suggested to Jones that

> knowledge of the benefits of using limestone rocks in acorn processing (eliminating the need for a leaching process to remove the acid prior to cooking) could easily have been gained by aboriginal peoples without requiring an understanding of the mechanics of calcination [Jones 1980:35].

Jones also noted a sizable amount of fatty, oily substance on the surface of the water after boiling the acorn meal. Since the matrix in some middens is greasy, this observation may be of some significance.

The possibility that the Indians used heated limestone cobbles to boil or steam acorns or other plant foods could also account for the relative absence in South Texas of acorn-leaching pits like those that are described above for the acorn-gathering peoples of California.

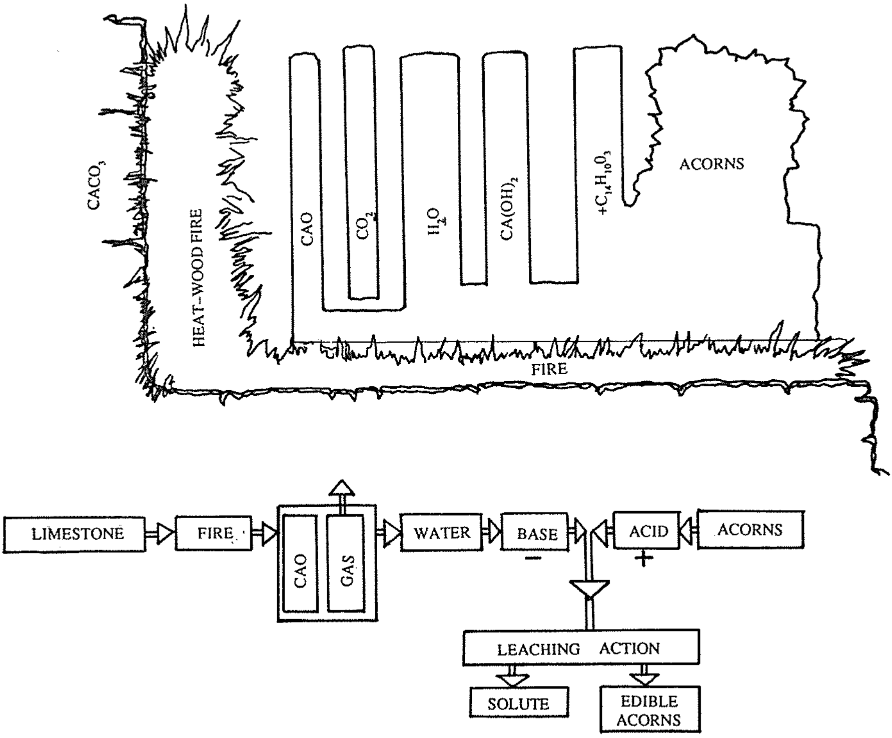

Figure 1. Pictorial (top) and diagrammatic (bottom) representations of the chemical interactions in acorn–processing. On the introduction of fire and water, limestone ($CaCO_3$) decomposes into its components CAO and CO_2 to produce a base (CaO_2H_2), which neutralizes and leaches the tannic acid from the acorns.

DISCUSSION

Many hypotheses have been proposed to solve the burned rock midden mystery of Central Texas. Exploration of areas surrounding the burned limestone rock accumulations (Hester 1971, Suhm et al. 1954) indicate that the burned rock middens are functionally specific intrasite features (Hester 1973). Hester further states that it "may be no coincidence that some of the major sites are located among, or in the immediate vicinity of, large groves of oaks." Weir (1976) suggests that the middens may have come about as a result of specialized nut processing, including the leaching and cooking of acorn bread.

Limestone is composed of the mineral calcite ($CaCO_3$), which has been deposited by either inorganic or organic processes. The rocks are soft, and moistening them with dilute acid produces vigorous effervescence caused by the liberation of copious amounts of carbon dioxide gas. When heated in a hearth pit with burned wood, limestone breaks down into calcium oxide (CaO) and carbon dioxide (CO_2), and the addition of water makes calcium hydroxide (CaO_2H_2) or

$Ca(OH)_2$, a base that would neutralize and serve as an excellent leaching agent for the bitter tannic acid ($C_{14}H_{10}O_3$) in the acorns (Figure 1).

There are 75 carbon atoms in the complex molecular structure of tannic acid ($C_{14}H_{10}O_3$). It is a sacroid glucosinate whose ingredients include phenolics, which give it its acidity. The ability of tanninates to extract water and combine with the base $Ca(OH)_2$ is low, but the wood burned to heat the limestone rocks in the pit would have produced sodium ash, which is even more effective as a leaching agent. When galls (made by wasps) are burned with the branches they are attached to, the sodium ash leaches out their tanninates and leaves the galls palatable.

Heating the limestone rocks or using them as boiling stones with water for processing acorns and other plant foods would have left the limestone fragments chemically altered, so reuse of the stones as either boiling stones or cooking–pit stones would have been limited. Therefore, the burned rock middens that are so common in Central Texas might be explained, in accordance with the Aboriginal Dump Theory of Hester (1971) and Sorrow (1969), as accumulations of discarded altered stones.

REFERENCES CITED

Asch, N.B., R.I. Ford, and D.L. Asch
1972 Paleo Ethnobotany of the Koster Site. *Illinois State Museum Reports of Investigation* 24.

Barrett, S. A., and E. W. Gifford
1933 Miwok Material Culture. *Bulletin of the Public Museum of the City of Milwaukee* 2:117–376.

Baumhoff, M. A.
1963 Ecological Determinants of Aboriginal California Populations. *University of California Publications in American Archaeology and Ethnology* 49:155-236.

Betteral, R. L., and H. G. Smith
1973 The Moccasin Bluff Site and the Woodland Cultures of Southwestern Michigan. *Anthropology Papers of the Museum of Anthropology*.23. University of Michigan, Ann Arbor.

Correll, D. S., and M. C. Johnston
1970 *Manual of the Vascular Plants of Texas.* Texas Research Foundation, Renner, Texas.

Densmore, Francis
1928 Uses of Plants by the Chippewa Indians. *Bureau of American Ethnology Annual Report*.44:275-397.

Driver, H. E.
1975 *Indians of North America* (fifth ed.). University Chicago Press, Chicago.

Flannery, K. V., Anne Kirkley, Michael Kirkley, and A. W. Williams
1970 *Farming Systems and Political Growth in Ancient Oaxaca.* Plant identification by C. Earl Smith, U. S. Department of Agriculture.

Gayton, A. H.
1948 Yokuts and Western Mono Ethnography II: Northern Foothill Yokuts and Western Mono. *University of California Anthropology Records* 10(2):143-302.

Gifford, E. W.
1936 California Balanophagy. In : *Essays in Anthropology Presented to A. L. Kroeber.* University of California Press. pp. 87-98.

Gunn, Joel, and Royce Mahula
1977 An Experiment in Stone Boiling by W. Max Witkind. In: *Hop Hill: Culture and Climatic Change in Central Texas.* The Center for Archaeological Research, The University of Texas at San Antonio.

Guthe, A. K.
1958 The Late Prehistoric Occupation in Southwestern New York: An Interpretive Analysis. *New York State Archaeological Association, Research and Transactions* 141.

Hecklewelder, John
1882 History, Manners and Customs of the Indian Nations Who Once Inhabited Pennsylvania and the Neighboring States. New and revised edition, *Members Historical Society* 12, Pennsylvania.

Hester, T. R.
1971 Archaeological Investigations at the La Jita Site, Uvalde County, Texas. *Bulletin of the Texas Archeological Society* 42, Dallas.
1973 The Formation of a 'Burned Rock Midden': A California Example. *The Record* (Dallas Archaeological Society) 29(3).
1980 *Digging Into South Texas Prehistory.* Corona Publishing Co., San Antonio, Texas.

Hester, T. R. and T. C. Hill, Jr.
1975 Some Aspects of Late Prehistoric and Protohistoric Archaeology in Southern Texas. *Center for Archaeological Research, The University of Texas at San Antonio. Special Report* No. 1.

Jarvis, R. W., and D. D. Crawford
1974 Archaeological Excavations on Interstate Highway 10, Sutton County, Texas. *Texas Highway Department Publications in Archaeology* 4, Austin.

Jones, C. J.
1980 A Further Experiment in Stone Boiling: A Calcining Process for Acorns. *La Tierra* 8(2):31-38.

Jury, Wilfred
1941 The Clearville Prehistoric Village Site in Oxford Township, Kent County. *Bulletin of the Museum, University of Western Ontario* 2. London, Ontario, Canada.

Kelley, J. C., and T. N. Campbell
1942 What are the Burned Rock Mounds of Texas? *American Antiquity* 7(3):319-322.

Kroeber, A. L., R. L. Olson, R. H. Lowie, and E. W. Gifford
1937-1939 Culture Element Distribution. *University of California Publications in Anthropological Records* 1. University of California Press, Berkley.

Merriam, C. H.
1918 The Acorn, A Possibly Neglected Source of Food. *National Geographic Magazine*, 34:129-137. Washington, D. C.

Montet-White, Anta
1968 The Lithic Industries of the Illinois Valley in the Early and Middle Woodland Period. *Anthropology Papers of the Museum of Anthropology, University of Michigan* 35.

Newcomb, W. W., Jr.
1973 *The Indians of Texas*. The University of Texas Press. Austin.

Parker, A. C.
1910 Iroquois Uses of Maize and Other Food Plants. *New York State Museum Bulletin* 144.

1918 A Prehistoric Iroquoian Site on the Reed Farm, Richmond Mills, Ontario County, New York. *Research Transactions of the New York State Archaeological Association* 1:1-41.

Ritchie, W. A.
1945 An Early Site in Cayuga County, New York: Type Component of the Frontenac Focus Archaic Pattern. *Rochester Museum of Arts and Sciences Research Records* 7.

1959 Excavation of an Owasco Village Site in New York: Report on 1958 Settlement Pattern Studies in the Northeast. *Eastern States Archaeological Federation* 18:11-12.

Sanders, W. T., and B. J. Price
1968 *Mesoamerica: The Evolution of a Civilization.* Random House, Inc.

Scheutz, M. K.
1957 A Report on Williamson County Mound Material. *Bulletin of the Texas Archeological Society* 28:135-168.

Smith, H. H.

1923 Ethnobotany of the Menomini Indians. *Bulletin of the Museum of the City of Milwaukee* 4(1):1-174.

1928 Ethnobotany of the Meskwaki Indians. *Bulletin of the Museum of the City of Milwaukee* 4(2):175-326.

1932 Ethnobotany of the Ojibwa Indians. *Bulletin of the Museum of the City of Milwaukee* 4(3):327-525.

1933 Ethnobotany of the Forest Potawatomi Indians. *Bulletin of the Museum of the City of Milwaukee* 7(1):1-230.

Snow, Dean

1976 *The Archaeology of North America.* Viking Press, New York.

Sorrow, W. H.

1969 Archaeological Investigations at the John Ischy Site: A Burned Rock Midden in Williamson County, Texas. *Texas Archeological Salvage Project Paper* 18.

Spencer, R. F., J. D. Jennings, C. E. Dibble, Elden Johnson, A. R. King, Theodore Stern, K. M. Stewart, O. C. Stewart, and W. J. Wallace.

1965 *The Native Americans.* Harper and Row, New York.

Struever, Stuart

1962 Implications of Vegetal Remains From an Illinois Hopewell Site. *American Antiquity* 27(4):584-587.

Suhm, D. A., A. D. Kreiger, and E. B. Jelks

1954 An Introductory Handbook of Texas Archeology. *Bulletin of the Texas Archeological Society* 25.

Swezey, Sean

1975 The Energetics of Subsistence-Assurance Ritual in Native California. *Contributions of the University of California Archaeological Research Facility.* University of California, Berkley.

Voeglin, E. W.

1942 Culture Element Distribution: XX, Northeastern California. *University of California Anthropology Records* 7(2):47-251.

Waugh, F. W.

1916 Iroquois Foods and Food Preparation. *Canada Department of Mines, Geological Survey, Anthropology Series,* No. 12.

Weir, F. A.

1976 The Central Texas Archaic. Doctoral Dissertation. Department of Anthropology, Washington State University.

Wilson, E. W.

1930 Burned Rock Mounds of Southwest Texas. *Bulletin of the Texas Archaeological and Paleontological Society* 2.

Wintemberg, W. J.
1939 Lawson Prehistoric Village Site, Middlesex County, Ontario. *National Museum of Canada Bulletin* 94:1-104.
1946 The Sidney–Mackay Village Site. *American Antiquity* 11(3):154-182.

Wolf, C. B.
1945 *California Wild Tree Crops.* Rancho Santa Ana Botanical Gardens.

Yarnell, R. A.
1970 Aboriginal Relationships Between Culture and Plant Life in the Upper Great Lakes Region (reprint of 1964 ed.). *Museum of Anthropology, University of Michigan* 23.

Notes on Obsidian from the Fort Hood Area of Central Texas

Richard E. Hughes

ABSTRACT

Nondestructive energy dispersive x-ray fluorescence analyses were performed on two obsidian artifacts from the Fort Hood area of Bell and Coryell counties in Central Texas. These studies showed that the obsidian came from two different sources in southwestern and north central New Mexico.

INTRODUCTION

The presence of obsidian in Texas archeological sites has evoked comment for more than half a century (e.g. Studer 1931; Ray 1935). Although obsidian has not been found in great abundance at any archeological site in the state, speculation on the parent geological sources has had a long history (see Krieger 1947, Newell and Krieger 1949:160). Today, however, it is no longer necessary to speculate, because sophisticated measurement techniques developed in the physical sciences (i.e. x-ray fluorescence and neutron activation) can be used to detect the geochemical composition of obsidian artifacts. First, the minor, trace, and rare earth element compositions of obsidian sources are measured to construct an elemental "profile" for each source. The corresponding elemental profiles, or "fingerprints," of particular artifacts are then generated and compared with profiles of obsidian samples from known geologic sources to determine the most likely origin for each artifact. This procedure, sometimes known as fingerprinting or obsidian-sourcing research, has been pursued steadily in Texas for more than a decade (e.g. Hester and Mitchell 1974, Hester et al. 1975, 1980, 1986; Hester, Asaro, and Stross 1980; 1982, Mitchell et al. 1980). Consequently, despite the relative rarity of obsidian in the state, comparatively more is known about its prehistoric distribution in Texas than currently is known about distributions in adjacent areas that are richly endowed with natural deposits of volcanic glass. This paper reports the results of the analysis of two obsidian artifacts from the Fort Hood area and offers some brief comparisons with previous sourcing research in Central Texas.

THE SAMPLES

The two obsidian artifacts studied here were recovered from two archeological sites—one (site 560) in Coryell County, within the boundaries of the U.S. Army's Fort Hood Military Installation, the other (41BL59) in Bell County near Morgan's Point (Figure 1).

A small, concave-base projectile point (Figure, 2, a) (Cat. no. 86-1005) was recovered in Coryell County at site 560 in Fort Hood on the surface of a terrace that overlooks Owl Creek. The site also contained Baird, Bulverde, and Wells type dart points (Briuer, personal communication), but the shape and size of this specimen suggest that it is either a Fresno or Maud type arrowpoint. This particular specimen is slightly smaller than illustrated Fresno and Maud points (cf. Suhm and Jelks 1962:Plates 137, 141): its shallow basal concavity is somewhat greater than those of illustrated Fresno points, yet less extreme than on the Maud examples. Despite this classification ambiguity, the overall morphological attributes of the point suggest that it probably was manufactured no earlier than A.D. 1000 and no later than A.D. 1800 (Suhm and Jelks 1962:273, 281).

The other specimen (Figure, 2, b) is an obsidian biface fragment (Cat. no. 86-1006) recovered by avocationalists from excavations at site 41BL59 along Cedar Creek at Morgan's Point in Bell County. Briuer (personal communication) indicated that the obsidian flake was associated with Perdiz and Cliffton points and Leon Plain pottery, below historic material, but above late Archaic deposits (including Ensor and Montell projectile points). Although the morphological attributes of this artifact provide no clues as to its age, if the specimen was associated with these points and pottery, it would date from about A.D. 1200 to 1500 (cf. Suhm and Jelks 1962:95, 269, 283).

ANALYTICAL METHOD

Laboratory analyses on these artifacts were performed on a Spectrace™ 5000 (Tracor X-ray) energy dispersive x-ray fluorescence spectrometer equipped

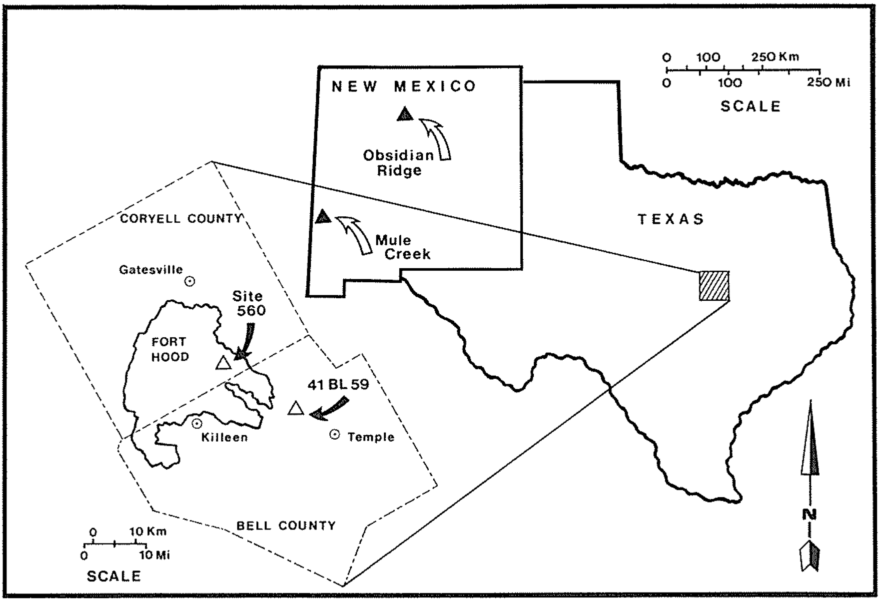

Figure 1. Map of the study area, showing archeological sites (open triangles) and obsidian sources (solid triangles) discussed in the text.

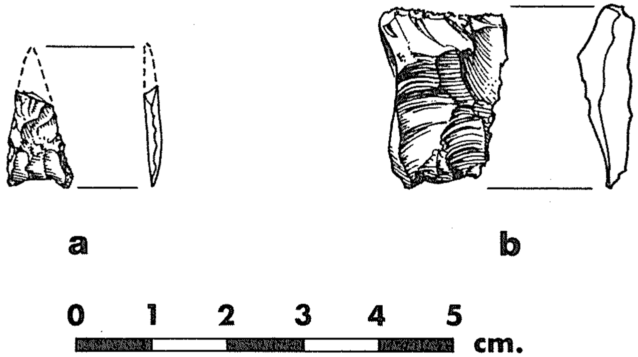

Figure 2. Obsidian artifacts from the Fort Hood area, Texas: a) projectile point (Cat. no. 86-1005) from Fort Hood site 560; b) biface fragment (Cat. no. 86-1006) from site 41BL59.

with a rhodium (Rh) x-ray tube, a 50 kV x-ray generator, and a lithium-drifted silicon solid state detector with 150 eV resolution (FWHM) at 5.9 keV in a 30 mm^2 area. The analysis technique is completely nondestructive; no part of the specimen was powdered or otherwise altered. The only sample preparation undertaken before analysis was a simple rinsing in distilled water to remove possible surface contaminants. Technical details of the analyses (e.g. primary beam filter selection, calibration) appear in Hughes (n.d.), but operating conditions for the x-ray tube were similar to those reported elsewhere (Hughes 1986a, b).

RESULTS

Trace element concentration values for these two artifacts (Table 1) show that whereas titanium (Ti), iron (Fe), rubidium (Rb), strontium (Sr), and yttrium (Y) are similar in both specimens, their manganese (Mn), zirconium (Zr), niobium (Nb) and barium (Ba) values are quite different, indicating that two distinct geochemical varieties of obsidian are represented. Comparison of these trace element values with those generated from parent obsidian sources to the west (Baugh and Nelson 1987, Hughes 1988, Nelson 1984, Newman and Nielsen 1985), the north, (i.e., Malad, Idaho; Hughes 1984:Table 3, Hester et al. 1986), and south (Hester et al. 1985:Table 1) indicates that both specimens were fashioned from obsidian originating in New Mexico.

Specifically, the projectile point from Fort Hood site 560 in Coryell County matches the trace element profile of Mule Creek obsidian from southwestern New Mexico (see Hughes 1988), indicating that obsidian from this source was more widely distributed than previously believed (see Findlow and Bolognese 1982a, 1982b). To the author's knowledge, this is only the second report of Mule Creek obsidian in Texas; the first reported specimen was from a site in

Table 1. Trace Element Concentration Determinations for Obsidian Artifacts from the Fort Hood Area, Texas

Specimen	Trace Element Concentrations											Obsidian Source
No.	Ti*	Mn*	$Fe_2O_3{}^T$*	Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	Ba**	(Chemical Type)
86-1005	444.5	429.4	0.99	59.1	14.0	239.1	12.4	41.9	113.4	32.0	68.4	Mule Creek
	±34.6	±25.9	±.09	±11.5	±9.1	±6.6	±3.2	±2.9	±4.7	±3.8	±16.3	
86-1006	480.9	583.0	1.13	96.4	26.3	208.5	3.8	56.7	175.9	91.7	0.0	Obsidian Ridge
	±32.6	±25.7	±.09	±7.7	±4.0	±5.5	±2.6	±2.4	±4.5	±3.6	±14.4	

* Values in parts per million (ppm), except for iron, expressed as total iron ($Fe_2O_3{}^T$) in weight percent.

± Counting and fitting error uncertainty at 200(*) and 300(**) seconds livetime.

Note: Specimen numbers are those assigned by the Obsidian Dating Laboratory, New Mexico State University.

McMullen County south of San Antonio (Hester and Mitchell 1974), even farther from the source than the Fort Hood specimen.

The obsidian biface fragment from site 41BL59 conforms to the fingerprint of Obsidian Ridge glass from the Jemez Mountains volcanic field in northern New Mexico. In reporting on obsidian sourcing analyses from Hutchinson and Roberts counties, Texas, Mitchell and his co-workers (Mitchell et al. 1980:304, 305) identified an obsidian type they termed (following R. N. Jack's suggestion) "High Nb" obsidian, and tentatively suggested that the geographic source counterpart for this group was somewhere in the Valles Caldera, west of Santa Fe, New Mexico. Specimen 86-1006 from Fort Hood contains a high amount of Nb (about 92 ppm), and its Rb, Sr, and Zr composition also agrees with the High Nb profile (Mitchell et al. 1980:Table 1). Recent geochemical analyses conducted on obsidians from northern New Mexico (e.g. Newman and Nielsen 1985, Baugh and Nelson 1987) support Mitchell's hypothesis that Obsidian Ridge, in the Bandelier Tuff within the Jemez Mountains volcanic field, which circumscribes the Valles Caldera (see Smith and Bailey 1966), is probably the source for the High Nb group.

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REFERENCES CITED

Baugh, Timothy, and F. W. Nelson, Jr.
1987 New Mexico Obsidian Sources and Exchange on the Southern Plains. *Journal of Field Archaeology* 14:313-329.

Findlow, F. J., and Marisa Bolognese
1982a Regional Modeling of Obsidian Procurement in the American Southwest. In: *Contexts for Prehistoric Exchange,* edited by Jonathon E. Ericson and Timothy K. Earle, pp. 53-81. Academic Press, New York.

1982b A Preliminary Analysis of Prehistoric Obsidian Use Within the Mogollon Area. In: *Mogollon Archaeology: Proceedings of the 1980 Mogollon Conference,* edited by Patrick H. Beckett, pp. 297-316. Acoma Books, Ramona, California.

Hester, T. R., Frank Asaro, and Fred Stross

1980 Source Analysis of Obsidian Artifacts in Texas: new results. *Houston Archaeological Society Newsletter* 68: 12-16.

1982 Results of Some Recent Studies by the Texas Obsidian Project. *Journal of the Houston Archaeological Society* 73: 8-10.

Hester, T. R., Frank Asaro, Helen Michel, Fred Stross, & F.W. Nelson

1986 Trace Element and Geologic Sources Studies of an Obsidian Artifact from Site 41LK51, Live Oak County, Texas. Appendix V in The Prehistoric Sites at Choke Canyon Reservior, Southern Texas: Results of Phase II Archaeological Investigations, by Grant D. Hall, Thomas R. Hester, and Stephen L. Black. *Center for Archaeological Research, University of Texas at San Antonio, Choke Canyon Series,* Volume 10: 510-522

Hester, T. R., G. L. Evans, Frank Asaro, Fred Stross, T.N. Campbell, and Helen Michel

1985 Trace Element Analysis of an Obsidian Paleo-Indian Projectile Point from Kincaid Rockshelter, Texas. *Bulletin of the Texas Archeological Society* 56: 143-153.

Hester, T. R., J. W. House, R. N. Jack, and F. H. Stross

1975 X-ray Fluorescence of Obsidian Artifacts from the Rio Grande Plain, Southern Texas. *Texas Journal of Science* 26 (1-2): 286-289.

Hester, T. R., and J. L. Mitchell

1974 Source Analysis of Obsidian Artifacts from McMullen County, Southern Texas. *Lower Plains Archeological Society Bulletin* 4:25-32.

Hester, T. R., J. L. Mitchell, Frank Asaro, and Fred Stross

1980 Further Notes on Obsidian Artifacts From Dimmit County, Southern Texas. *La Tierra* 7 (3): 30-33.

Hughes, R. E.

1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes. *Contributions of the University of California Archaeological Research Facility* 45: 1-19.

1986a Trace Element Composition of Obsidian Butte, Imperial County, California. *Bulletin of the Southern California Academy of Sciences* 85: 35-45.

1986b Energy Dispersive X-ray Fluorescence Analysis of Obsidian from Dog Hill and Burns Butte, Oregon. *Northwest Science* 60: 73-80.

1988 Archaeological Significance of Geochemical Contrasts Among Southwestern New Mexico Obsidians. *Texas Journal of Science,* 40(3).

n.d. The Coso Volcanic Field Re-examined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geomorphology*. In press.

Krieger, A. D.

1947 Culture Complexes and Chronology in Northern Texas. *University of Texas Publication* No. 4640.

Mitchell, J.L., T. R. Hester, Frank Asaro, and Fred Stross

1980 Notes on Trace Element Analysis of Obsidian from Hutchinson and Roberts Counties in the Texas Panhandle. *Bulletin of the Texas Archeological Society* 51: 301-308.

Nelson, F. W., Jr.

1984 X-ray Fluorescence Analysis of Some Western North American Obsidians. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes. *Contributions of the University of California Archaeological Research Facility* 45: 27-62.

Newell, H. P., and A. D. Krieger

1949 The George C. Davis site, Cherokee County, Texas. *Society for American Archaeology Memoir* 5.

Newman, J. R., and R. L. Nielsen

1985 Initial Notes on the X-ray Fluorescence Sourcing of Northern New Mexico Obsidians. *Journal of Field Archaeology* 12: 377-383.

Ray, C. N.

1935 The Pottery Complex Artifacts of the Abilene Region. *Bulletin of the Texas Archaeological and Paleontological Society* 7:70-88.

Smith, R.L., and R.A. Bailey

1966 The Bandelier Tuff: A Study of Ash-flow Eruption Cycles from Zoned Magma Chambers. *Bulletin Volcanologique* 29: 83-103.

Studer, F. V.

1931 Archaeological Survey of the North Panhandle of Texas. *Bulletin of the Texas Archaeological and Paleontological Society* 3: 70-75.

Suhm, D. A., and Edward B. Jelks

1962 Handbook of Texas Archeology: Type Descriptions. *Texas Archeological Society Special Publication* 1 and *Texas Memorial Museum Bulletin* 4, Austin.

Prehistoric Subsistence Strategies in Northeastern Central Texas

David O. Brown

ABSTRACT

This paper examines the hypothesized paleoenvironment of the Aquilla Lake area at the margin of the Cross Timbers and Blackland Prairie biotic regions in northeastern Central Texas. Quantitative approximations are offered for both the faunal and floral resources of the area during the prehistoric period. Prehistoric resource procurement is discussed in light of faunal data excavated from the McDonald site at Aquilla Lake. The data are then utilized to offer suggestions concerning possible adaptive strategies in the northeastern Central Texas area. Prehistoric subsistence and the exploitation of various food resources along the northeastern edge of the Central Texas culture area are discussed. At the core of the discussion is a model proposed by Skinner, Shaw, Huckaby, and Bartsch for the Aquilla Lake area in Hill County. The plant resources of the Aquilla Lake area are discussed, and some preliminary figures are presented. The previously developed quantitative model of faunal exploitation is tested against actual excavation data from the McDonald site at Aquilla Lake. The revised model is examined in the context of proposed adaptive strategies for the northeastern Central Texas area.

INTRODUCTION

Aquilla Lake is a reservoir project of the U. S. Army Corps of Engineers in central Hill County about 16 km (10 miles) west of Lake Whitney (Figure 1). Geologically, the area is underlain by sandstone as well as shales and clays of Cretaceous age. The western part of the lake area, along Aquilla Creek, is underlain by sands of the Woodbine Formation and forms the west boundary of the eastern Cross Timbers vegetation zone. The eastern arm of the lake, which follows Hackberry Creek, cuts into Eagle Ford clays and shales that underlie the Blackland Prairie.

The region has been the scene of much archeological activity, most notably that associated with Lake Whitney (Jelks 1962, Stephenson 1970, Lynott 1978). Archeological projects have been undertaken in Aquilla Lake by both Southern Methodist University (SMU) (Lynott and Peter 1977, Skinner and Henderson 1972, Skinner et al. 1978, 1979) and the Texas Archeological Survey (Watson 1982, Brown 1987a). Surveys of the lake area recorded more than a hundred prehistoric archeological sites ranging in age from Late Paleo-Indian to Late Prehistoric.

As with many archeological projects in Central Texas, lithic artifacts comprise most of the materials recovered from the Aquilla Lake. Analysis of the stylistic and functional variability of lithic materials provides an essential base for the understanding of prehistoric lifeways, but there are noticeable limitations

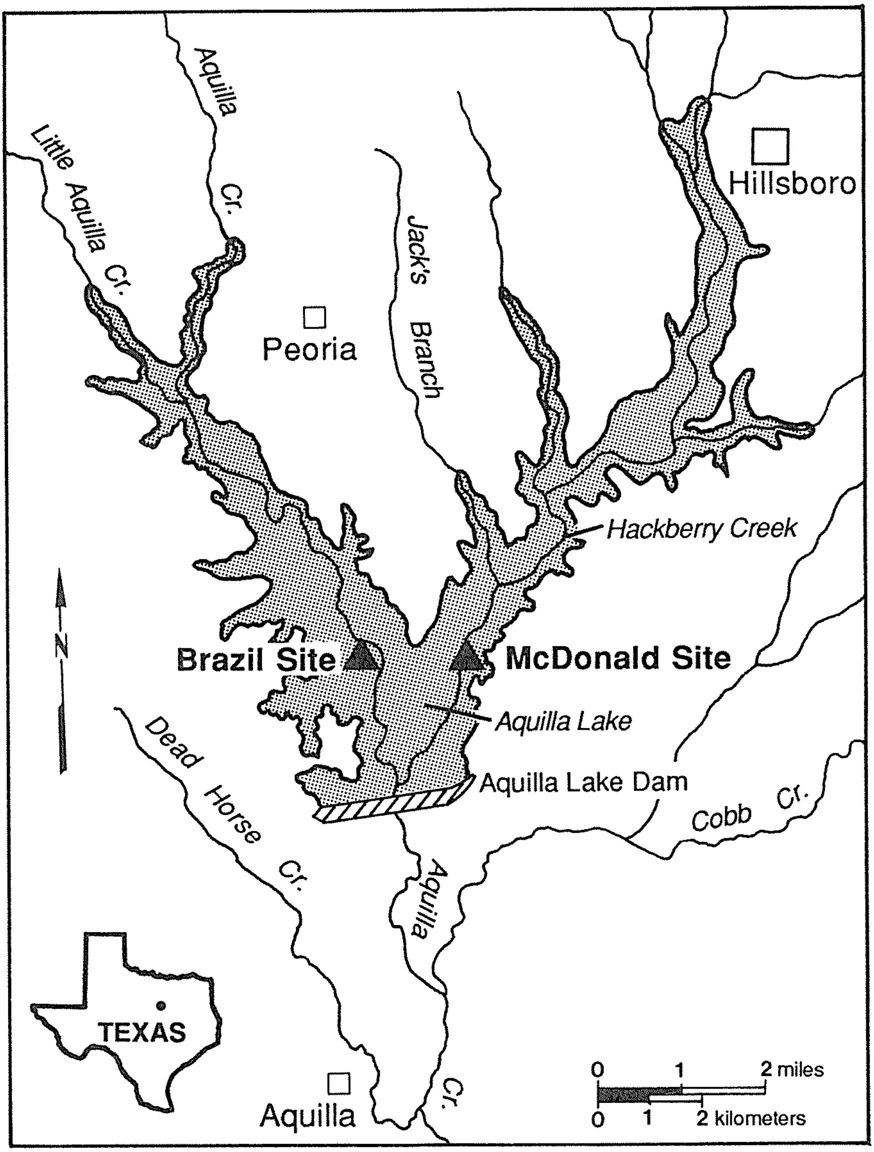

Figure 1. Map of the Aquilla Lake area, Northeastern Central Texas.

in attempting to extrapolate from lithic material culture to other cultural subsystems. One area in which these limitations leave unfortunately large lacunae is the interpretation of the exploitation by the prehistoric group of the biotic resources of their environment. Although it is possible to make limited ecological inferences from tool forms (e.g., hunting activities based on the presence of projectile points), for the most part such interpretations cannot substitute for the actual faunal or floral remains that make up the primary data.

One approach to the study of utilization of environmental resources that is not necessarily limited by the fortuitous preservation of faunal or floral materials is catchment analysis. This technique, originally devised by Higgs, Vita-Finzi, Harris, and Fagg (1967) for Paleolithic sites in Epirus, Greece, and later expanded upon by Vita-Finzi and Higgs (1970) in a study of Upper Paleolithic and Neolithic sites in Palestine, involves determination of the resources available within a stated distance from a site. Site catchment analysis has been widely used in many parts of the world in the study of both hunter-gatherers and village agriculturalists (Davidson 1976, Findlow and Erickson 1980, Flannery 1976, Peebles 1978, Webley 1972, Zarky 1976, Zvelebil 1983). Roper (1979) and Dennell (1980) have discussed some of the better applications of catchment analysis as well as some of the limitations of the technique.

In the report on the 1976 testing at Aquilla Lake (Skinner et al. 1978), SMU conducted preliminary catchment analysis of the area. This analysis, centered on the Brazil site (41HI76), described the faunal and floral resource potential for the Cross Timbers and Blackland Prairie biotic zones. A detailed list was compiled of potentially exploited faunal and floral species, and some quantitative approaches were suggested for the derivation of yield values. Faunal resource potential was explored in greater detail, taking into account animal population densities, maximum harvest rates, kilograms of usable meat, and calories per individual. This potential was compared with the estimated caloric requirements necessary for the survival of human groups of various sizes.

The complexities of catchment analysis are beyond the scope of this paper, but a brief discussion of some of the more troublesome problems is in order. One of the major difficulties in any such analysis is the identification and characterization of aboriginal resource zones. The identification of microareal resources zones is all but impossible, and even the use of generalized resource zones can be problematical in areas where agriculture and grazing have radically altered the landscape. At Aquilla Lake, where the major biotic zones are controlled by readily identifiable geologic features (sandstones versus shales and clays), this problem is somewhat alleviated. There are still many questions, however, about the character of the aboriginal vegetation of the two major biotic zones and about the nature and extent of a possible ecotonal region between the two.

Other major problems include the choice of a catchment area of appropriate size. Following Lee's (1968) observation of foraging distances among the !Kung Bushmen, 10 km (6 miles)—the figure used by the analysts at SMU—has become common. However, the use of a single value without question brings on difficulties. In addition to the problems with distance, there remains the critical problem of aboriginal selection of resources. No known group exploits the full potential of its environment, and many groups exploit resources such as roots and insects, which are rarely quantified in modern environmental studies.

Due to the lack of preservation at the Brazil site and at many such sites in the area, the question of which resources were used cannot be answered completely, but, fortunately, a faunal collection is available from the McDonald site (41HI105). Although the resources in the McDonald site might differ somewhat from those at the Brazil site, the 10-km catchment rings for both are nearly identical. There are slightly more Blackland Prairie and slightly less Cross Timbers in the McDonald site 10-km catchment ring than in the Brazil site catchment ring, but the differences are certainly within the margin for error for estimating aboriginal resource zones from modern topographic maps. For this reason, the figures derived from the 1978 catchment analysis will be used here as a first approximation.

FLORAL RESOURCES

Modeling the Aquilla Lake Paleoenvironment

The catchment analysis developed at Southern Methodist Univesity describes in some detail the floral resources that were available to the aboriginal populations, but stops short of providing quantitative estimates.

In this analysis, Skinner, Shaw, Huckaby, and Bartsch (1978:150-151) divide the Blackland Prairie into three zones. The principal climax dominant of their upland zone is little bluestem grass *(Schizachyrium scoparium),* with subdominants including Indian grass *(Sorghastrum nutans),* big bluestem *(Andropogon gerardii),* Texas wintergrass *(Stipa leucotricha),* and dropseed *(Sporobolus* sp). Areas along drainages are divided into a drier grassy lowland zone with big bluestem grass as the dominant and Indian grass and switchgrass *(Panicum virgatum)* as subdominants. The wetter bottomland zone includes an overstory of red ash *(Fraxinus pennsylvanica),* cedar elm *(Ulmus crassifolia),* and hackberry *(Celtis* sp.), with an understory of weedy vines such as grapes *(Vitis* sp.), poison ivy *(Toxicodenron radicans),* and greenbriar *(Smilax bona-nox)* and frutescents such as rough-leaf dogwood *(Cornus drummondii),* downy and green haws *(Crataegus mollis* and *C. viridis),* big-tree and hog plums *(Prunus mexicana* and *P. rivularis),* Eve's necklace *(Sophora affinis),* black haw *(Viburnum rufidulum),* and coralberry *(Symphoricarpos orbiculatus).* Occasional overstory species include red oak *(Quercus shumardii),* pecan *(Carya illinoiensis),* post oak *(Quercus stellata),* red mulberry *(Morus rubra),* and live oak *(Quercus virginiana).*

Although there is not complete agreement regarding the original vegetation of the Cross Timbers region, it seems likely that various species of oak wood were more important in the upland areas of the Cross Timbers than in the Blackland Prairie. Skinner, Shaw, Huckaby, and Bartsch (1978) apparently favor an upland savannah with stands of post oak and blackjack oak *(Quercus marilandica),* with some white oak *(Quercus* sp.), red oak, and black hickory *(Carya texana).* The understory, in addition to greenbriar, probably consisted primarily of little bluestem, big bluestem, Indian grass, tall dropseed *(Sporobolus asper),* sideoats grama *(Bouteloua curtipendula),* and hairy grama *(B. hirsuta).* They also suggest that the Cross Timbers bottomland was very much like the Blackland Prairie bottomland.

As Skinner, Shaw, Huckaby, and Bartsch (1978) point out, grasses were the predominant vegetation over much of the upland area of the Aquilla Lake region. Some of the Quaternary terrace surfaces and some of the bottomland areas may have been predominantly grassy. They also suggest that the small size of the seeds of these grasses would not have made them very desirable as aboriginal food resources. In any case, many grass species are widely spread throughout the are in several biotic zones or subzones. Ubiquitous in the lake area are little and big bluestem grasses, which account for as much as 70 percent of the cover in some areas (Skinner et al. 1978). Except for Texas wintergrass, which produces seed in the spring, all of the grasses produce seed in the (generally late) summer and in the fall (Figure 2).

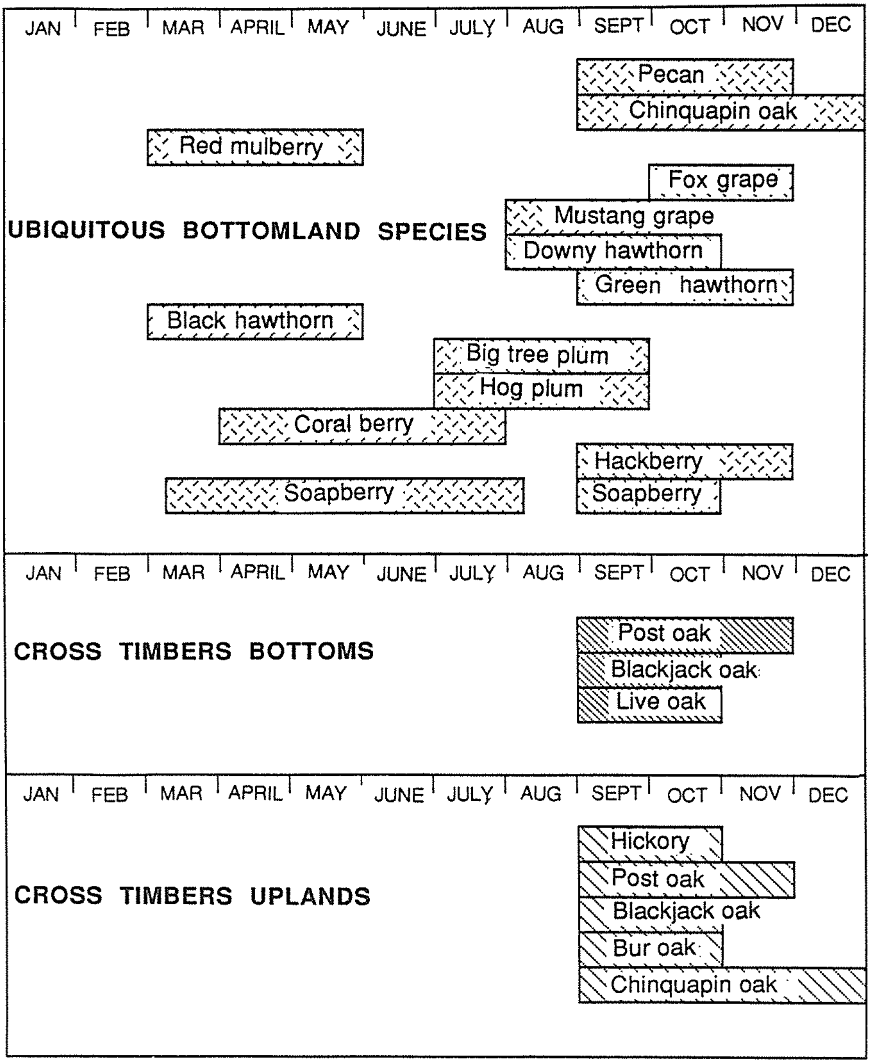

Figure 2. Chart showing seasonality of grass seeding in the Cross Timbers and Blackland Prairie of Texas. Adapted from Skinner, Shaw, Huckaby, and Bartsch (1978:Table 14).

Aboriginal vegetal resources would have been found in the bottomland areas as well as in stands of oaks in the upland areas of the Cross Timbers. In the chart showing the seasonality of the major nongrass vegetal species (Figure 3), it should be noted that there are no major species listed for the Blackland Prairie uplands, which are thought to be almost exclusively grasslands. This figure shows the productivity of the bottomlands of both biotic zones and their similarity; the Cross Timbers biotic zone differs from the Blackland Prairie only in the addition of various oak species. The greatest potential resource production period for both areas is fall, although both bottomland zones have secondary fruiting seasons in the spring and available plant foods in summer, as well. Limited largely to oak, the upland Cross Timbers is a major food resource production area probably used almost exclusively during the fall.

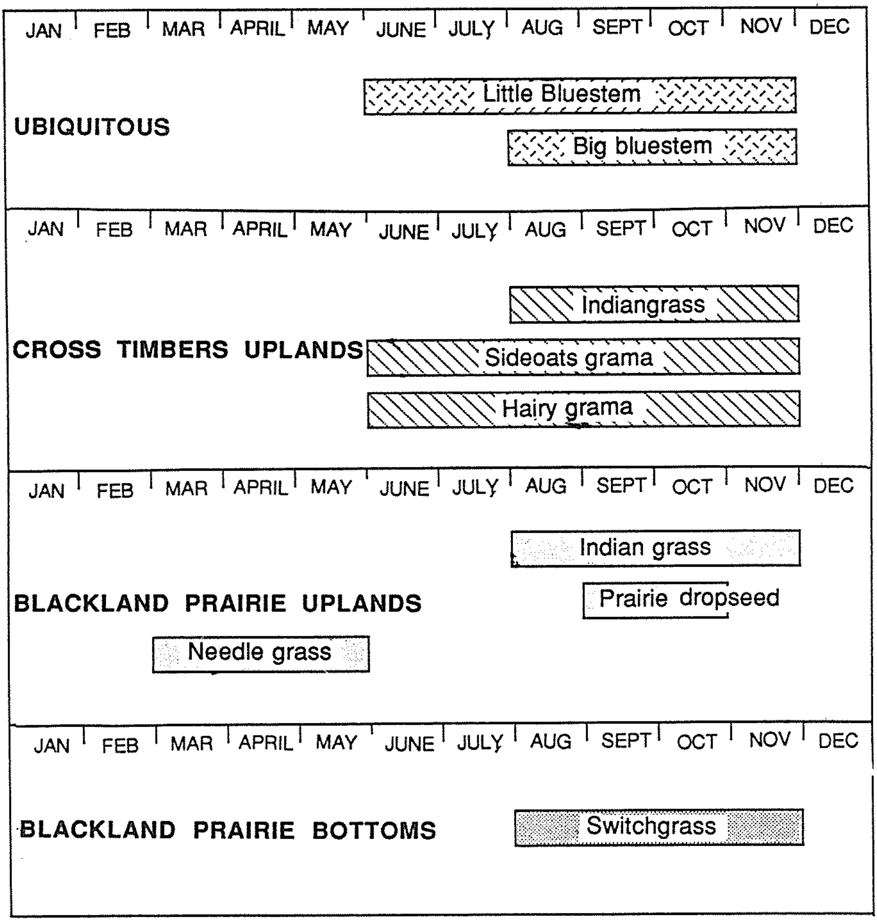

Figure 3. Chart showing plant seasonality in the Cross Timbers and Blackland Prairie of Texas. Adapted from Skinner, Shaw, Huckaby, and Bartsch (1978:Table 14).

The list of edible plants (Table 1) by no means exhausts the edible plants available, many of which have been documented as used by historic Indian groups and by early settlers. Nonetheless, the lack of both preserved botanical remains and detailed ethnohistoric and ethnographic information from the area hinders further investigation.

Elaboration of the Paleoenvironmental Model

The original SMU catchment model attempted quantification of the available faunal resources of the Aquilla Lake area, but no such model was created for the floral resources of the area. Any attempt to recreate the paleoflora of a disturbed ecosystem such as that in the study area is obviously fraught with difficulties, but quantitative estimates of the modern vegetal communities were unavailable for the area at the time of the original model (Skinner et al. 1978:152), so the task was almost impossible. A more recent study by Texas A&M University (Slack and Marcy 1983), which provides valuable data on the density of modern floral resources in the Aquilla Lake area, has been used here to estimate the amounts of available floral resources.

Areal figures used for this reanalysis are ones provided by Southern Methodist University for the 20-km-diameter catchment circle around the Brazil site, which was considered by them to be an example of a Late Archaic base camp (Skinner et al. 1978:150). These figures include 15,450 ha of upland and 390 ha of bottomland in the Blackland Prairie, 13,560 ha of upland and 1,640 ha of bottomland in the Cross Timbers biotic province, and 360 ha of remnant terraces that do not fall into either biotic zone. Although the potential food value of grasses to the aboriginal inhabitants might have been great, the following estimates are confined primarily to hardwood nuts and fruits, which are thought to have contributed a significant portion of the vegetal resources in the Aquilla Lake area. The differential preservation of floral remains introduces considerable bias into quantitative analyses, but hardwood nuts are the primary vegetal remains at many East Texas Caddo sites (Keller 1974:142; Jackson 1981; Perttula and Bruseth 1983:18-19).

For this study, only two major biomes are considered in estimating resource potential. These are the riparian forests lining the creeks and major lateral tributaries of both biotic zones and the oak savannah of the Cross Timbers uplands. The bottomland area of both the Blackland Prairie and Cross Timbers is assumed to be part grassland and part riparian forest. Although the percentages of forest would have fluctuated through time, with perhaps much greater areas of grassland occurring during both very wet and very dry climates, a figure of 50 percent riparian forest is assumed here for bottomland areas. In not precisely comparable figures, the Slack and Marcy (1983) study recorded 278 ha of riparian forest in the 4,133-ha project study area, which corresponds closely to the actual lake area; this yields 6.7 percent riparian forest. In their broad study area of 17,465 ha, which corresponds more closely to the range of habitats found in the catchment circle, only 394 ha of riparian forest was recorded, yielding 2.3

Table 1. Potential Edible Plant Species at Aquilla Lake

Scientific Name	Common Name	Scientific Name	Common Name
Allium drummondii	Wild onion	*Prunus mexicana*	Big-tree plum
Bumelia lanuginosa	Gum bumelia	*Prunus rivularis*	Hog plum
Carya illinoiensis	Pecan	*Psoralea esculenta*	Prairie potato
Carya texana	Black hickory	*Quercus macrocarpa*	Bur oak
Cassia fasciculata	Partridge pea	*Quercus marilandica*	Blackjack oak
Celtis laevigata	Sugarberry	*Quercus stellata*	Post oak
Celtis reticulata	Net-leaf hackberry	*Quercus shumardii*	Shumard oak
Cirsium vulgare	Bull thistle	*Quercus virginiana*	Live oak
Crataegus mollis	Downy hawthorn	*Rhus glabra*	Smooth sumac
Crataegus spathulata	Pasture haw	*Rubus trivialis*	Dewberry
Crataegus viridus	Green hawthorn	*Sambucus canadensis*	Elderberry
Diospyros virginiana	Common persimmon	*Sapinus drummondii*	Western soapberry
Gleditsia triacanthos	Honey locust	*Salix nigra*	Black willow
Helianthus annus	Common sunflower	*Smilax bona-nox*	Greenbriar
Ilex decidua	Possumhaw	*Symphoricarpos orbiculatos*	Coralberry
Juniperus virginiana	Eastern red cedar	*Taraxacum officinale*	Dandelion
Lepidum densiflorum	Peppergrass	*Toxicodendron radicans*	Poison ivy
Lepidum virginicum	Virginia peppergrass	*Triodanus prefoliata*	Venus's looking glass
Latuca canadensis	Wild lettuce	*Typha latifolia*	Common cattail
Malva neglecta	Mallow	*Ulmus crassifolia*	Cedar elm
Monarda citriodora	Lemon horsemint	*Ulmus rubra*	Slippery elm
Morus rubra	Red mulberry	*Viburnum rufidulum*	Southern black-haw
Opuntia leptocaulis	Tasajillo	*Verbena halei*	Texas vervain
Opuntia phaeacantha	Prickly pear	*Vitis mustangensis*	Mustang grape
Populus deltoides	Eastern cottonwood	*Vitis volpina*	Fox grape
Prosopis glandulosa	Honey mesquite	*Zanthoxylum clava-herculis*	Hercules club

SOURCE: Occurrence, Flook (1972), Slack and Marcy (1983)
Edibility, Skinner et al (1978), Winkler (1982), McCormick (1973), Keller (1974)

percent riparian forest. Adding to this figure the 149 ha of developed riparian land yields an overall figure of 3.1 percent potential riparian forest, which is almost identical to the 3.2 percent figure from an estimation of 50 percent of the catchment area bottomland as forested.

Reconstructing the vegetation of the upland Cross Timbers area is more difficult. Slack and Marcy describe 1,029 ha (24.9 percent of the smaller study area) as forest during the original 1979 survey (by the 1982 vegetation survey). Additional forested acreage had been cleared, so the later figures are not used here. This 1,029-ha figure includes some parkland and savannah, however, only 644 ha (15.6 percent) are described as woodland forest.

Despite recent lossses to cropland, the invasion of brushy species following historic grazing and agriculture and the introduction of modern fire control measures may have contributed to increased woodland area in the Cross Timbers. An examination of Slack and Marcy's less disturbed primary habitat types—cedar elm woodland, oak woodland, pecan woodland, mesquite/cedar elm parkland, mesquite woodland, mesquite savannah, and riparian woodland—shows that only one—oak woodland—approximates the original habitat. For the sake of simplicity, the oak woodland habitat has been chosen to represent the original forest, estimated as comprising only 10 percent of the total upland Cross Timbers area. Admittedly, this figure may a gross underestimation of the extent of the upland forest during moist climatic periods, but it provides a starting point for further analysis. The remaining 90 percent of the upland and terrace areas is assumed to be grasslands and is not considered further here.

Production figures used here (Tables 2, 3) are, with some adjustments, extrapolated into the Aquilla Lake area from those reported by Keller (1974) for similar species in East Texas. The climate at Aquilla Lake is drier than in East Texas, so these figures may overestimate the available resources, but the overestimation of resources should be offset by the underestimation of upland forest. Keller (1974:146-147) gives the average annual weight and the caloric value per pound of fruit produced annually by many common species (Tables 2, 3).

The total estimated production from these two areas is 10,909,800,000 kilocalories, which is enormously greater than the 137,051,207 kilocalories estimated for animal resource potential for the catchment area. However, the bulk of the vegetal production is acorn production from the Cross Timbers upland area, where the estimated percentage of forested area was set quite low. The implications of this figure will be discussed in the concluding section of this paper.

FAUNAL RESOURCES

The Paleoenvironmental Model

Skinner, Shaw, Huckaby, and Bartsch (1978) have discussed the Aquilla Lake fauna in some detail, estimating animal population densities, potential harvest rates, meat yields, and caloric values for several important game species.

Table 2. Productivity of Bottomland Forest

Species	Density (N/Ha)	Total Trees[a]	Annual Yield (Kg)	Kcal/[b] Kg	Total Kcal
OVERSTORY					
Quercus macrocarpa (Bur oak)	4.5	4568	4.54	3726	77.2x10^6
Carya illinoiensis (Pecan)	13.1	13297	22.68	3825	1153.5x10^6
Morus rubra (Red mulberry)	22.4	22736	2.72	661	40.9x10^6
Celtis laevigata (Texas sugarberry)	11.6	11774	2.72	441	14.1x10^6
Gleditsia *triacanthos* (Honey locust)	7.4	7511	4.54	772	26.3x10^6
Crataegus spathulata (Pasture haw)	4.5	4568	2.49	551	6.3x10^6
TOTAL					1318.3x10^6
UNDERSTORY[c]					
Carya texana (Black hickory))	70.7	71761	9.07	2789	907.7X10^6
Morus rubra (Red mulberry)	10.6	10759	2.72	661	9.7x10^6
Celtis laevigata (Texas sugarberry)	196.4	199346	2.72	441	119.6x10^6
Gleditsia triacanthos (Honey locust)	35.3	35830	4.54	772	61.5x10^6
Crataegus spathulata (Pasture haw)	50.7	51461	2.49	551	35.3x10^6
TOTAL					1133.8x10^6
BOTTOMLAND PRODUCTION					2452.1x10^6

[a] Kilocalories

[b] Based on half of the estimated bottomland, or 1015 ha.

[c] Understory kilocalorie figures halved to account for smaller yields and immature trees.

These species include deer, racoon, opossum, turkey, cottontail, fox squirrel, and blacktailed jackrabbit. Several other potential animal food resources are listed, but no yield calculations are offered for individual species. The minor

Table 3. Productivity of Cross Timbers Forest

Species	Density (N/Ha)	Total Trees[a]	Annual Yield (Kg)	Kcal[b]/Kg	Total Kilocalories
OVERSTORY					
Quercus stellata (Post oak)	607.2	823363	1.68	3726	5148.8x10^6
UNDERSTORY[c]					
Quercus stellata (Post oak)	593.4	804650	1.68	3726	2518.4x10^6
Quercus marilandica (Blackjack oak)	86 7	117565	3.45	3726	755.0x10^6
Crataegus spathulata (Pasture haw)	38.2	51799	2.49	551	35.3x10^6
TOTAL					3308.9X10^6
CROSS TIMBERS PRODUCTION					8457.7x10^6

[a] Based on 10% of upland Cross Timbers area or 1356 hectares.
[b] Kilocalories
[c] Understory kilocalorie figures halved to account for smaller yields and immature trees.

game resources consist of gray fox, coyote, bobcat, weasel, mink, striped skunk, shrew, swamp rabbit, pocket mouse, gray squirrel, ground squirrel, muskrat, gopher, rat, vole, woodchuck, otter, frog, toad, salamander, lizard, box turtle, snakes, waterfowl, other birds, fish, and shellfish. Nutria, a historically introduced species (Burt and Grossenheider 1964:210), is incorrectly listed. Together, these minor species are estimated to comprise about one-fourth of the total meat calories consumed by the aboriginal populace.

Deer are a major source of animal protein as projected for the aboriginal population, providing almost 90 percent of meat consumed by weight (Table 4). Since there are no data on the prehistoric capacity of the Cross Timbers and Blackland Prairie to support deer, and the prehistoric population has become all but extinct, these figures for deer, which are extrapolated from the ecologically quite different Edwards Plateau area, may be too high. On the other hand, it is probably realistic to expect deer to form the greatest single component of the faunal assemblage.

After deer, whose available meat weight per individual is more than ten times that of any other animal on the list, the fox squirrel, with the smallest available meat weight, is listed as providing the greatest caloric addition to the diet. Racoon and opossum each provide more than half of the caloric total of the fox squirrel, while both lagomorph species each provide only about half of this total. Wild turkey, with a meat weight equal to or larger than any of the smaller mammals, provides only a minor fraction of the total calories. The minor species

Table 4. Estimated Meat Yields and Caloric Values, Southern Methodist University Catchment Model

Species	Meat Yield (Kg)	Kcal/Kg	Total Kcal[a]	Protein/Kg	Total Protein
PRIMARY RESOURCES					
White-tailed deer	71,974	1,260	90,687,240	210	15,114,540
Raccoon	986	2,800	2,760,240		
Opossum	927	2,800	2,585,600		
Turkey	156	2,180	340,080	201	31,356
Cottontail	1,080	1,350	1,458,000	210	226,800
Fox squirrel	4,029	1,000	4,029,000		
Black-tailed jackrabbit	878	1350	1,185,300		
TOTAL			103,046,020		
SECONDARY RESOURCES					
Pocket mouse	Vole				
Snake	Swamp rabbit				
Box turtle	Striped skunk				
Muskrat	Gopher				
Rat	Lizard				
Salamander	Toad				
Frog	Otter				
Bobcat	Woodchuck				
Shellfish	Fish				
Waterfowl	Birds				
Shrew	Ground squirrel				
Weasel	Mink				
Gray fox	Coyote				
TOTAL			34,005,187		
GRAND TOTAL			137,051,207		

[a] Kilocalories

listed in the paragraph above are not individually quantified by SMU but are estimated to provide collectively an additional 34,005,187 kilocalories, or one-third of the 103,046,020 kilocalories estimated for the major game species. Dividing 34,005,187 by the 28 potential minor game resources (excluding nutria) yields 1,214,471 kilocalories per resource; each minor game resource provided a contribution to the faunal diet equal to that of the jackrabbit. Of course, all of these minor species were not likely to have been exploited with equal diligence, and many animals not included on the list may have comprised a significant minor portion of the diet. Fish and shellfish, for example, may have played an important dietary role at some riverine sites.

The construction of a model describing the food resources potentially exploited by the aboriginal inhabitants in the Aquilla Lake area could be approached from the point of view of the biotic potential of the study area, as Smith (1975) has done for Late Prehistoric populations in the upper part of the Lower Mississippi Valley, or from the point of view of human subsistence requirements, as done by Reidhead (1979) for Late Woodland populations in Illinois. Although the parameters of a subsistence model, considering the current knowledge of human nutritional needs, are much more likely to be recovered than prehistoric faunal densities are, the complexities of such a model might outweigh its utility. As Jochim (1983) has pointed out with respect to Reidhead's study, the actual data show a stronger correlation with biomass estimates than with the Reidhead model.

SMU's biotic potential model (Skinner et al. 1979) is similar in many respects to Smith's (1975), substituting locally available animal population figures. Unfortunately, the study suffers from the lack of figures for the Cross Timbers and Blackland Prairie biotic zones. Even if such figures were available, the extent of historic land modification in these areas would make them automatically suspect when extrapolated backwards to the prehistoric condition. The difficulties in accurate paleofauna reconstruction render any model questionable.

But even without such data, the SMU model can serve as a first approximation of the aboriginal resource exploitation of the area, i.e, a hypothesis to be tested by the data.

McDonald Site Fauna: Quantifying the Paleoenvironmental Model

The McDonald site is a deeply buried prehistoric occupation site on the floodplain adjacent to the modern channel of Hackberry Creek (Figure 1). Cultural remains recovered from the site range between the Middle Archaic and the Late Prehistoric periods. Most occupational debris accumulated during the Late Prehistoric period and, in addition to lithics and ceramics collected from the site, an excellent sample of faunal remains was recovered. The site is divided into two areas by a gully that apparently follows an old creek channel. Area A is closest to the modern channel, and Area B is across the paleochannel to the east. Both areas have extensive and possibly contemporaneous deposits of Late Prehistoric occupational debris. Cultural strata sloping toward the creek, observed in a backhoe trench cut laterally into the creek bank, indicate that the modern channel was active at least during the Late Prehistoric occupation; i.e, during the occupation the site was on the river bank and probably was surrounded by riparian forest. The riparian woodland—possibly a virgin stand—that surrounded the site at the time of excavation in 1982, had a remarkable diversity of species, and was relatively clear of undergrowth. Although no stumps were evident, it is possible that some hardwoods were logged out of the bottoms during the nineteenth or early twentieth century.

A few hundred meters to the east of the site, an oak forest covers the valley slopes and the deeply incised drainages that cut back into them. Because of the unsuitability of these slopes for agriculture, it is unlikely that this area has been cleared in the past. Between the riparian woodland and the oak forest is a strip of grassland that extends to the creek south of the site. Much or all of this grassland may be land that was cleared for agriculture, but, if partly natural (i.e., if it is part of SMU's grassy lowland zone described above), it would have been part of a relatively large edge forest that would have made the area attractive to deer and other species that exploit diverse resources.

Above the oak-lined hillsides are rolling hills that are now almost completely cleared and cultivated. Although patches of the hillside forest would have extended over the top and spilled out onto the rolling hills, as they do now, these fields are at the west edge of the Blackland Prairie, which begins only about half a kilometer east of the site. (For a more detailed discussion of the environment, see the site descriptions in Peter, Brown and Jackson (1987) and Brown, Watson, Peter, and Rawn-Schatzinger (1987)).

The Brazil site, a few kilometers west of the McDonald site (Figure 1), also represents occupation over a long period of time, with artifacts ranging between the Early Archaic and the Late Prehistoric periods. The environmental setting of the Brazil site is similar in many respects to that of the McDonald site. Situated on a low alluvial terrace, it abuts the modern floodplain of Aquilla Creek, but it is some distance from the modern channel; an apparent filled channel, which marks the east edge of the site, may have been the course of the creek at the time of occupation. The Brazil site is somewhat closer to upland slope and upland forested areas than the McDonald site, but, because the slope and forest follow a narrow projecting finger ridge, the Brazil site is nevertheless much farther from the main upland landform. Although oak forest still grows on the projecting upland remnant, only a very thin strip of riparian woodland remains along the edge of the stream in this area.

A major distinction between the two sites is that the Brazil site is near the east edge of the Cross Timbers, whereas the McDonald site is at the extreme west edge of the Blackland Prairie. The immediate environments of both are, however, similarly riparian. The major differences between the two are the closeness of the Brazil site to oak forest, which it abuts and actually extends on to, and the possible distance of the Brazil site from major upland prairie areas.

Faunal materials (Table 5) were collected during the three seasons of excavation at the McDonald site (see Brown et al. 1987). All of the material described here was recovered from quarter-inch-mesh screen, so the smaller species are underrepresented. Dry screening was carried out at the first two seasons of excavation; water screening was used during the third season, a change that may have affected the sample recovery.

The faunal data are grouped by broad cultural strata. The shallower excavations in Area A included some Late Archaic material, but, because of the difficulty in matching stratigraphy between widely separated test excavations, the small sample of Late Archaic materials cannot be separated out. It is estimated that the total faunal sample from Area A probably includes less than 10 percent Late Archaic material. In Area B, the divisions between the cultural strata were more easily identified, but, since the diagnostic markers were limited in number, the divisions may not always have been equally precise. The larger amounts of material in the upper strata of Area A primarily reflect larger excavation unit sizes, but there was also some decrease in the quality of bone preservation with depth.

Faunal figures (Table 5) are for number of identified specimens (NISP) rather than for minimum numbers of individuals (MNI). MNI figures are generally preferable, since they make it possible to calculate meat yield per individual animal more accurately, but such calculations present several problems. Binford (1978) has criticized the standard calculation of meat yield from MNI based on differential utilization of animal parts. Yates (1982) has pointed out the difficulties in calculating MNI from small samples where many species are represented by only one or two bones. Additionally, the McDonald site faunal analysis was conducted by two different analysts over three seasons of investigation. A combination of the MNI figures, based on different elements for each season, has been attempted in the Aquilla Lake excavation report (Brown et al. 1987) but these are probably underestimates of the actual figures. Even while recognizing the potential for errors that can result from the comparison of SMU's kilocalorie figures with NISP faunal material figures, an approximation still can be generated. In such a comparison, differential recovery becomes important.

White-tailed Deer (Odocoileus virginianus)

As predicted by the SMU catchment analysis model, the white-tailed deer is apparently the most commonly exploited faunal resource at the McDonald site. Based solely on the frequency of bones identified to the the species level alone, white-tailed deer comprise 10.4 percent of the McDonald site faunal remains. The intentional fragmentation of deer bone for marrow complicates the interpretation of this percentage, since many bones probably attributable to this species have been fragmented beyond identification. In fact, all of the bone fragments identified simply as large mammal remains probably represent large artiodactyls other than bison (which is included in the extra large mammal category or in the bison category, based on bone wall thickness). In the Aquilla Lake area, such artiodactyls are limited to white-tailed deer and pronghorn *(Antilocapra americana)*. Pronghorn remains have been identified from the McDonald site and from other Central Texas sites, but the density of this grassland-loving species was apparently low in aboriginal Central Texas, and they may represent only a tiny fraction of the total large mammal remains. The modern distribution of pronghorns is restricted to the western half of Texas from the panhandle to the lower Rio Grande area (Davis 1974:248). On the other hand, pronghorn remains are difficult to identify without relatively complete articular surfaces on bone elements, so some misidentification of material is possible. A third possibility is the occurrence of an occasional mule deer *(Odocoileus hemionis)*, but the usual range of this species is much farther to the west and it is not expected in the

Table 5. Fauna from the McDonald Site

Species	Area A		Area B								Overall	
	Prehistoric/ Late Archaic		Late Prehistoric II		Prehistoric I		Late Archaic		Middle Archaic			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
MAMMALIA												
Small	101	0.9	29	0.7	2	0.1	18	1/0	11	1.7	173	0.8
Medium	101	0.9	1	0.0	6	0.3	0	0.0	8	1.2	117	1.6
Large	9,417	81,3	2,588	58.8	1,373	71.8	651	66.2	482	73.8	14,549	70.5
TOTAL INDETER- MINATE MAMMALIA	9,624	83.1	2,618	59.5	1,381	72.2	669	68.0	501	76.7	14,846	72.0
Artiodactlya												
Bison bison	23	0.2	6	0.1							156	0.8
Odocolleus virginianus	1,268	11.0	138	3.1	85	4.4	64	6.5	42	6.4	2,131	10.3
Antilocapra americana	2	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.0
TOTAL ARTIODACTYLIA	1,293	11.2	144	3.3	85	4.4	64	6.5	42	6.4	2,289	11.1
Lagomorpha												
Sylvilagus sp.	33	0.3	6	0.,1	1	0.1	6	0.6	2	0.3	58	0.3
Lepus californicus	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
TOTAL LAGOMORPHA	34	0.3	6	0.1	1	0.1	6	0.6	2	0.3	59	0.3
Procyanid												
Procyon lotor	1	0.0	2	0.0	0	0.0	0	0.0	0	0.0	4	0.0
Marsupalla												
Didelphis virginiana	4	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	0.0
Carnivora												
Canis sp.	124	1.1	2	0.0	4	0.2	5	0.5	10	1.5	145	0.7

Rodentia												
Sciurus niger	5	0.0	2	0.0	7	0.4	0	0.0	0	0.0	14	0.1
Castor canadensis	2	0.0	0	0.0	4	0.2	0	0.0	0	0.0	8	0.0
Spermophilus	3	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
Geomys sp.	2	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
Cynomys sp.	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Marmota sp.	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Sigmodon hispidus	5	0.0	14	0.3	1	0.0	0	0.0	0	0.0	22	0.1
Peromyscus sp.	2	0.0	1	0.0	0	0.0	0	0.0	0	0.0	3	0.0
Reithrodontomys sp.	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Neotoma Sp.	1	0.0	1	0.0	0	0.0	0	0.0	0	0.0	4	0.0
Perognathus sp.	0	0.0	1	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Microtus sp.	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Rodent, Indeterminate	3	0.0	4	0.1	4	0.2	3	0.3	1	0.2	20	0.1
TOTAL RODENTIA	25	0.2	23	0.5	16	0.8	3	0.3	1	0.2	82	0.4
TOTAL MAMMALIA	11,105	95.9	2,795	63.5	1,487	77.7	747	75.9	556	85.1	17,480	84.5
OSTEICTHES												
Lepisosteus sp.	39	0.3	4	0.1	6	0.3	1	0.1	0	0.0	54	0.3
Centrarchidae	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Ictalurus sp.	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	010
Fish, Indeterminate	20	0.2	16	0.4	13	0.7	3	0.3	0	0.0	62	0.3
TOTAL OSTEICTHES	61	0.5	20	0.5	19	1.0	4	0.4	0	0.0	118	0.6

Continued

Table 5, *Continued*

Species	Area A		Area B								Overall	
	Prehistoric/ Late Archaic		Late Prehistoric II		Prehistoric I		Late Archaic		Middle Archaic			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
AVES												
Meleagris galopavo	9	0.1	0	0.0	0	0.0	0	0.0	0	0.0	10	0.0
Corvus sp.	3	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
Fringillidae	1	0..0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Colinus virginianus	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Anas sp.	0	0.0	1	0.0	0	0.0	0	0.0	0	0.0	1	0.0
Buteo sp.	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0	1	0.0
Bird, Indeterminate	21	0.2	4	0.1	1	0.1	0	0.0	0	0.0	26	0.1
TOTAL AVES	34	0.3	5	0.1	1	0.1	1	0.1	0	0.0	43	0.2
REPTILIA												
Chrysemys spp.	27	0.2	708	16.1	94	4.9	46	4.7	49	7.5	936	4.5
Graptemys sp.	5	0.0	0	0.0	0	0.0	0	010	0	0.0	5	0.0
Terrapene sp.	7	0.1	17	0.4	89	4.7	24	2.4	1	0.2	192	0.9
Chelydra sp.	0	0.0	14	0.3	0	0.0	0	0.0	0	0.0	14	0.1
Trionyx sp.	8	0.1	0	0.0	2	0.1	0	0.0	0	0.0	12	0.1
Turtle, Indeterminate	310	2.7	813	18.5	213	11.1	158	16.1	45	6.9	1,811	8.8
Crotalinae	4	0.0	2	0.0	1	0.1	0	0.0	0	0.0	7	0.0
Colubridae	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.0
Snake, Indeterminate	13	0.1	23	0.5	7	0.4	2	0.2	2	0.3	47	0.0
Phrynosoma sp.	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
TOTAL REPTILIA	375	3.2	1,577	35.8	406	21.2	232	23.6	97	14.9	3,029	14.7
AMPHIBIA												
Indeterminate	1	0.0	2	0.0	0	0.0	0	0.0	0	0.0	4	0.0
SITE TOTAL (% OF SAMPLE)	11,576	56.1	4,399	21.3	1,913	9.3	984	4.8	653	3.2	20,624	100

Aquilla Lake fauna. At present, their range is restricted to the Trans-Pecos area and parts of the High Plains (Davis 1974:254).

A total of 71.1 percent of all the identifiable faunal remains from the McDonald site is attributed to large mammals. If these are assumed to be white-tailed deer, the total percentage of deer remains would be 81.5, a figure even greater than the 66.2 percent meat yield predicted by SMU. Comparing such figures is, of course, unrealistic. Bone for bone, white-tailed deer yield a much larger quantity of meat, on the order of ten times as much as other commonly exploited small mammals (Skinner et al. 1978) Contrasted with this is the extreme fragmentation of deer bone at the McDonald site, suggesting that marrow extraction was an important activity. The true percentage of exploitation may be somewhat closer to a figure suggested by a comparison of the MNI figures for all species.

Whatever the method of accounting, it is clear that white-tailed deer was the single most important faunal resource at the McDonald site, both in terms of individuals and caloric yield, a not uncommon finding in Texas prehistoric sites. At Bear Creek shelter on nearby Lake Whitney (Murry 1978), white-tailed deer comprise the single most numerous identified species throughout most of the cultural strata, ranging between a low of 1.4 percent in the Middle Archaic levels and 6.9 percent in the Austin phase materials. Deer are underrepresented in the Late Archaic (where specimens of *Sigmodon hispidus* are more numerous) and particularly in the Middle Archaic (where at least 10 species are more numerous), but the addition of fragmentary material identified only as large artiodactyls increases these totals dramatically. Combined deer and large artiodactyl percentages (which presumably do not include bison, generally rare at the site) range between a low of 13.1 percent for the Middle Archaic and a high of 37.3 percent for the Austin phase. It is not clear whether the low frequencies of deer in Late and Middle Archaic levels are a function of the low sample size in these two strata or actually represent lower utilization during these periods.

White-tailed deer are also the most numerous single identified species throughout the various strata at the Kyle site (Lundelius 1962). Other Lake Whitney sites show similar figures (Stephenson 1970). Farther to the south, white-tailed deer are the most numerous species represented at both the Baylor and Britton sites at Lake Waco, although the total sample is relatively small in both cases (Story and Shafer 1965). The pronghorn is also represented by a few bones at both the Baylor and Britton sites and at the Kyle site.

For sites with a sample size of more than 100 bones at the North Fork and Granger reservoirs on the San Gabriel River (Yates 1982), white-tailed deer ranged from a low of 4 percent in the Clear Fork horizon at 41WM73 up to 46 percent in the San Marcos component at 41WM124. White-tailed deer are the most numerous single species present at nine of the 15 sites with larger sample sizes.

The importance of white-tailed deer at the McDonald site cannot be overstated. As noted above, deer comprised both the greatest number of individuals captured and the probable largest animal caloric addition to the diet. However it is indeed possible that animal resources that are not represented by large numbers of bones were exploited at the site. Such unrecorded contributions could have come from the use of dried meats or from butchering larger animals where they were killed, with only the meat being brought to camp. Although almost any animal might have been butchered away from the camp, the most important single resource, in addition to deer, that presents a transportation problem is bison. Bison bones are present in small quantity at the McDonald site, but, for a number of reasons, bison are thought to have made only a minimal contribution to the overall subsistence at the site.

Although it is not possible to quantify readily the actual caloric intake from deer meat, the 66.2 percent figure estimated by SMU may be nearly correct. This brings up two important points. One, the prehistoric population at the McDonald site, and perhaps throughout the Aquilla Lake area, appears to have been highly dependent upon deer as a food source. Too, an aboriginal population of any size might well have placed some stress upon the reproductive potential of the deer population, an important point because, although the enormous reproductive potential of deer populations is well known (see Smith 1975:24-26 and McCullough 1979:44-46), deer populations tend to be controlled, by exogenous factors, primarily available subsistence base and predators. Fluctuating deer populations, caused either by excess predation from increased human population density or reduced subsistence resources from drought or extreme cold, may have, in turn, placed some stress upon the aboriginal population.

The dangers of specialization in a single resource are clear, particularly if that resource has any hint of instability. The percentage of deer in the diet suggests such extreme specialization, but it must be remembered that only the caloric intake from animals is considered here, since no botanical information has been preserved that might give an indication of the contribution made by plant foods to the diet. In fact, many ethnographically documented groups find a significant portion of their subsistence in plant foods.

Turtles

Since it is almost impossible to calculate accurately the number of individuals represented from a sample of turtle carapace and plastron fragments, it is difficult to estimate the proportion of the McDonald site inhabitants' diet that was made up of turtle meat. The issue is further complicated by the fact that turtle shell has a unique structure and may deteriorate somewhat differently from other bone. Nonetheless, it is clear that turtles, not considered a major food source in the SMU catchment analysis, were an important source of food throughout most of the occupation of the McDonald site.

The figures of 4.6 percent for pond sliders and 13.7 percent for all turtles are of little value except perhaps for comparison to percentages of turtle shell fragments from other sites. The 2,799 shell fragments from the McDonald site could represent as few as 20 or 25 individuals or perhaps many more. Estimating meat yield is also difficult when the age, size, and species of most of the specimens is not known (most of the shell fragments could not be identified as to species).

Seven turtle species have been identified in the McDonald site fauna, including include two species of the genus *Chrysemys*—*Chrysemys scripta*, the pond slider, and *C. concinna*, the cooter—which comprise the largest portion of the sample. Shell fragments from *Terrapene ornata*, the western box turtle, are a little more than a fifth as numerous as the *Chrysemys* specimens. Three species, *Chelydra serpentina* (snapping turtle), *Trionyx* cf. *spiniferous* (spiny softshell turtle), and *Graptemys* sp., (map turtle), are represented by only a few specimens each.

At Bear Creek shelter (Murry 1978), turtles are also an important resource, ranging between 9.9 percent in the Middle Archaic zone and 28.0 percent in the Austin phase stratum. *T. spiniferous* comprises nearly all of the identified sample (Murry 1978:56). At the nearby Kyle shelter (Lundelius 1962), turtles, listed as softshell and miscellaneous, comprised only a small portion of the total sample.

Turtle shell is found throughout most of the units at the Baylor site in McClennan County, comprising nearly 30 percent of the identified bone elements (Story and Shafer 1965:132-133). It is somewhat less common at the nearby Britton site, where it comprises less than 10 percent of the elements identified. Only one individual genus was identified, *Trionyx* sp., from a single element in each of the two sites.

Still further to the south in the North Fork and Granger reservoirs, turtle elements ranged between barely half a percent of the total in the Late Prehistoric cultural strata at 41WM230 and more than 20 percent at the Clear Fork component at 41WM56 and the mixed Clear Fork and Round Rock component in Area B of 41WM73. The pond slider appears to be the most frequently exploited species by a slight margin, but softshell *(Trionyx* sp.), yellow mud *(Kinosternon flavescens),* and other kinosterninae (musk and mud turtles) are strongly represented among water turtles, and box turtles *(Terrapene ornata)* are also quite common.

The recovery of various turtle elements from a riverine site that has also yielded fish and pelycypod remains is not surprising. However, land turtles were also used, and, after the pond slider, the box turtle is the most common identified genus. Various species of turtles are found in all cultural levels at the site, but they are generally most common in the Late Prehistoric levels, where they account for nearly a third of all elements recorded (31.0 percent in levels 8-13). They are also most common in the Late Prehistoric levels at Bear Creek shelter (Murry 1978), but this trend does not extend to the Late Prehistoric sites in the North Fork and Granger Lake areas (Yates 1982).

Little has been written about the aboriginal exploitation of freshwater turtles, but Smith (1975:10-14,100-102) specifically lists snapping turtles (Chelydrinae) as a secondary food resource of the Middle Mississippi groups, ranking ninth overall in total projected meat yield at the sites in his study. He speculates that

> it is entirely possible, of course, that snapping turtles, and other species of aquatic turtles, were never deliberately hunted, but rather were collected along with fish during the continual summer harvest from ever-diminishing shallow backwater lake areas [Smith 1975:102].

Such a possibility seems remote at many Central Texas sites where turtle carapace fragments greatly outnumber fish bones and scales, but this difference may be a function of the poor preservation of fish bone and the relatively excellent preservation of carapace and plastron. In any case, turtles may never have been actively hunted, but only gathered when observed basking on shoals or foraging on banks.

Ubelaker and Hall (1972:248-249) report eleven different species of turtles in the modern Aquilla Lake project area, but Slack and Marcy (1983) were able to document only five species in their more recent study. The aboriginal remains include at least six species (note: *Chrysemys* includes two species, *scripta*, the pond slider, and *concinna*, the river cooter, both of which were recorded in the sample but were combined in Table 5). The aboriginal specimens represent all of the groups that have been reported in the area, except for the family Kinosternidae and one genus in the family Emydidae, suggesting that the aboriginal population was not highly selective in its choices.

Small Mammals

No other single resource approaches deer or turtle in the total number of elements identified in the sample, with the exception of shellfish, which, though numerous, may not have been as important as small mammals to the McDonald site diet. Skinner, Shaw, Huckaby, and Bartsch (1978), in their catchment analysis of the Aquilla Lake area, projected five small mammals—racoon, opossum, cottontail, fox squirrel, and blacktailed jackrabbit—as significant secondary resources (after white-tailed deer) for the aboriginal population. In their projections, the greatest total caloric contribution was made by the fox squirrel; racoon and then opossum, both with fewer individuals captured but greater body weights, each contributed a little less than three-fourths of the squirrel total. Next in order of importance were the cottontail, which contributed less than a third of the squirrel total, and the blacktailed jackrabbit, which contributed slightly more than a fourth of the squirrel total.

All of the projected species are found at the McDonald site, though clearly none of them contribute the estimated amounts. Bones of the cottontail, *Sylvilagus* sp., the most numerous, are more than twice as common as the other four purportedly major small mammals combined. The ratio of identified deer bone to cottontail bone is about 37:1. Based on the meat yield estimates of 45 kg (100 pounds) for deer and 79 kg (1.75 pounds) for rabbit, the meat yield ratio is 2,100:1. This calculation assumes, albeit somewhat tenuously, that the number of individuals consumed is directly proportional to the number of identifiable bone elements at the site. Although there are certain problems with this assumption, notably potentially different preservation and differential breakage for marrow consumption (i.e., the larger deer bones probably would have been broken more frequently for marrow), the ratio is still vastly greater than the 67:1 ratio predicted by the SMU catchment model. This suggests that rabbit and the other small mammals were less heavily exploited than was predicted. Using the same calculating procedure, a total deer-to-small-mammal meat yield ratio (using weight estimates from Skinner et al. 1978) at the McDonald site is 1,072:1, which compares quite unfavorably to the meat yield ratio of 9:1 predicted from the SMU model.

Except for rodents, which form a comparatively small portion of the McDonald site fauna, some of which may be recent, only two other small mammals are recorded—beaver and wolf (as well as other unidentified canid remains). At the McDonald site a wolf, found in the upper levels of Area A, is a nearly complete skeleton and apparently postdates the aboriginal occupation at the site. The other canid remains, all from Area B, are probably from at least three individuals and may be dog or coyote. Beaver is represented by eight elements, including several teeth and a mandible fragment, from both areas at the site.

Small mammals are a somewhat more prominent part of the faunal assemblage at the nearby Bear Creek shelter at Lake Whitney (Lynott 1978). Cottontail is by far the most common, with an elemental ratio of identified deer bone to rabbit bone of less than 3:1. Using the SMU meat weight figures, this would yield a meat weight ratio of 458:1, showing a much greater proportion of rabbit than at the McDonald site. The range of small mammals represented at the Bear Creek shelter site is about the same as at the McDonald site, without any specimens of opossum, but with skunk *(Mephitis mephitis)* and bobcat *(Lynx rufus)* represented by a few elements each.

At the North Fork and Granger Lake areas, cottontail percentages (in sites with larger samples) are from less than 1 percent to nearly 15 percent of all bones, with the lowest percentages apparently occurring in Late Archaic (Twin Sisters phase) and Late Prehistoric sites (Yates 1982). Blacktailed jackrabbit is the second most important small mammal in most of the larger sites, with beaver a distant third. Fox squirrels are found at many sites in very low percentages, and opossum and racoon are found sporadically in variable percentages. Badger *(Taxidea taxa),* not noted in any of the Hill County sites (except for a few elements recorded at the Kyle site (Lundelius 1962)), is found in several North Fork and Granger sites.

Although the five small mammals predicted to be secondary food resources after deer in the Aquilla Lake aboriginal diet are present in the faunal remains from the McDonald site, it is clear that they do not comprise the proportion anticipated in the catchment analysis. How much of this reduced proportion is due to differential preservation or treatment of the bone and how much is due to actual underutilization of these resources is uncertain, but it is suggested that the figures represent an overall emphasis of larger mammals, particularly deer.

Despite its small size, the cottontail appears to be the most important small mammal, both numerically and in total meat yield, at the McDonald site, just as in many other Central Texas sites. Fox squirrel, predicted to be the second greatest contributor to the animal portion of the diet, is barely present, as are the other larger members of this group (racoon and opossum, and the other leporid, the blacktailed jackrabbit). The samples of each of these other small mammals are so small that it is difficult to determine whether any one made a larger contribution than the others. It is interesting to note that all of the projected secondary small mammals besides cottontails were recovered from Late Prehistoric parts of the site. Although it is tempting to suggest a dependence on a wider variety of resources during the Late Prehistoric, the large Late Prehistoric sample and the low overall sample size suggest that such differences might well be attributed to sampling methods.

The reason for the predominance of the cottontail in this sample may lie in their overall density or in the relative ease with which rabbits can be caught. Fox squirrels, since they are arboreal and perhaps slightly more difficult to snare, and provide only a small meat yield, might be expected to be exploited only minimally. Racoon and opossum, although larger than the rabbit and providing more meat, are nocturnal animals and may occur at lower density levels than the rabbit. Further, although the Hill County area appears to be within the range of the blacktailed jackrabbit (Hulbert 1984), the cottontail is much more common.

Mussels

Shellfish are clearly one of the most important supplementary resources at the McDonald site, possibly far surpassing the minor role assigned to them in the SMU catchment analysis model (Brown et al. 1987, Neck 1987). Although the evidence is difficult to assess, mussel might well be the most important dietary element after white-tailed deer at the site (Table 6).

A calculation of the approximate meat weight (using approximations from Brown 1987b:Table 39.3) of the minimum number of individuals from identified specimens (about half of the total sample) at the site gives a total meat weight of 27.5 kg, equal to the weight of about 22 cottontails or more than half a single deer. Mussels, however, have only slightly more than half the calories and protein per gram that deer or rabbit meat have, so the numbers must be adjusted accordingly to account for the nutritional properties of mussel.

Obviously, like other secondary resources at the site, mussels are only a fraction of the white-tailed deer totals. They do, however, compare quite favorably with other minor resources at the site, such as rabbit and turtle. Although turtle cannot be quantified accurately, the comparison between mussel and rabbit suggests that mussel may have been a more important contributor to the diet, since the total MNI for rabbits (although not formally calculated) probably lies at about 10 individuals. If the unsampled mussel is estimated and the caloric

Table 6. Mussel at the McDonald Site*

Species	Area B								Overall	
	Prehistoric II		Prehistoric I		Late Archaic		Middle Archaic		Site Totals	
	No.	%	No.	%	No.	%	No.	%	No.	%
Amblema plicata	81	57.9	77	48.7	136	78.6	86	64.7	380	62.9
Arcidens confragosus	0	0.0	1	0.6	0	0.0	0	0.0	1	0.2
Cyrtonaias tampicoensis	2	1.4	7	4.4	1	0.6	1	0.8	11	1.8
Lampsilis hydiana	27	19.3	15	9.5	15	8.7	45	33.8	102	16.9
Lampsilis teres	14	10.0	19	12.0	11	6.4	0	0.0	44	7.3
Leptodea fragilia	1	0.7	0	0.0	0	0.0	0	0.0	1	0.2
Megalonaias gigantes	2	1.4	1	0.6	1	0.6	0	0.0	4	0.2
Potamilus purpuratus	7	5.0	5	3.2	0	0.0	0	0.0	12	2.0
Quadrula apiculata	3	2.1	5	3.2	1	0.6	0	0.0	9	1.5
Quadrula aurea	2	1.4	21	13.3	8	4.6	0	0.0	31	5.1
Quadrula houstonensis	0	0.0	2	1.3	0	0.0	0	0.0	2	0.3
Quadrula petrina	0	0.0	4	2.5	0	0.0	1	0.8	5	0.8
Toxolasma texasensis	1	0.7	1	0.6	0	0.0	0	0.0	2	0.3
SITE TOTAL (PERCENT OF SAMPLE)	140	23.2	158	26.2	173	28.6	133	22.0	604	100.0

* Valves identified in one square meter of the 4-meter-deep excavation unit N520/W543. Totals do not include those recovered in the 1978 or 1980 excavations because their collections were not complete.

calculations are made, it would leave the mussel at just under twice the caloric potential of the 10 rabbits. Preservation factors must be taken into account, however, as well as the differences in methods of counting minimum number of individuals. With the small sample size, it is difficult to evaluate accurately the dietary contribution of any one species, but, at the McDonald site,.mussel may equal the contribution of all small mammals, in bulk weight if not in caloric importance.

It is not easy to compare molluscan fauna between sites because of widely differing collection techniques. At the McKenzie site, the other major mussel consumption site at Aquilla Lake, the order of prominence of the species collected is nearly identical to that at the McDonald site. At both sites, *Amblema plicata* is the most important species, with *Lampsilis hydiana* the most important secondary species. *Quadrula apiculata* comprises a substantial percentage of the assemblage from both sites; *L. teres* makes up a large portion of the McDonald site pelycypod fauna. At Bear Creek shelter (Lynott 1978:71), *A. plicata* is a relatively minor species, falling fourth after *Obovaria olivaria, Cyrtonaias tampicoensis*, and *Potamilus purpuratus. O. olivaria* was not recorded from the Aquilla Lake sites (nor, as Lynott [1978:72] notes, had it been previously recorded anywhere in Texas), and the latter two were very minor components. Both *L. hydiana* and *L. teres* are only minor species at Bear Creek shelter. The similarity among the Aquilla Creek mussel assemblages and the differences between these and the Bear Creek shelter faunas probably parallels the differences that different flow regimes and different sedimentary contexts produce in the indigenous assemblages that existed between these two streams

Bison (Bison bison)

The contribution of bison to the diet of the inhabitants of the McDonald site is not entirely clear. Numerically, skeletal elements of bison comprise the second largest identified mammal species at the site, accounting for almost three times the cottontail total Since a full-grown bison may yield as many as 500 times as much meat as a rabbit; (see Roe 1970:57-61 for bison size ranges), the potential contribution of bison at the site is significant.

Despite the enormous potential significance of bison as a food resource, its overall contribution to the inhabitants of the McDonald site may have been negligible through time. In the first place, bison has a restricted distribution at the site, generally occurring only in the uppermost (Late Prehistoric) cultural levels. No bison bone was recovered below level 8 in Area B or below the top cultural level in Area A (Table 5). Secondly, perhaps only two individuals are represented by the large number of bones—one in Area A and one in Area B. The specimen in Area B, a juvenile only tentatively identified as a bison, was found stratigraphically above the Late Prehistoric cultural layers in a stratum that yielded a few other bones and very few tiny flakes. Cut marks on the specimen suggest that it was butchered, but the absence of tools or significant quantities of debitage in the layer with the bones suggests that the bones represent a single individual that was killed and butchered on the spot after the last major campsite occupation in Area B. Finally, because of its size, bison is identifiable (in prehistoric contexts) from only small fragments of bone, thus skewing upward its potential contribution.

Other Faunal Resources

One other animal, the turkey *(Meleagris galopavo)*, was listed separately by SMU in its secondary faunal resources from the Aquilla Lake area (Skinner et al. 1978); 29 other species or animal groups are included in the additional potential game resources category. Of these other species, turtles and shellfish have been described above as important secondary resources, and beaver has been included with the small mammal group. Many of the remaining additional potential game resources are absent, or they are found in such small numbers that they would have been of questionable value as food resources.

In addition to turtles and shellfish, fish were probably of some importance at the site, adding to the inhabitants' full exploitation of the available resources of the site's riverine setting. However, fish remains are not found in great quantity, and it is not clear whether this is due to only minimal use of fish, the poor preservation of fish bones, or perhaps a special method of disposal. The most common single item is gar scales *(Lepisosteus sp.)*, which survive well and are found in some quantity in Area A and throughout the Late Prehistoric levels in Area B (Table 5). However, the total number of scales found is small, much less than the total on a single fish. Bones from the bass family (Centrarchidae) and catfish *(Ictalurus* sp.) were also identified No fish remains were recovered from the Archaic levels at the site.

In the faunal sample from the site are several different species of birds, not all of which may have been consumed by the inhabitants. Turkey bones are the most common, primarily from Area A, but five other species are present as well. Crow *(Corvus brachyus)* was represented by three bones in Area A. The remaining specimens, all represented by single elements, include an unidentified duck or teal *(Anas* sp.), a hawk *(Buteo* sp.), a member of the finch or sparrow family (Fringillidae), and a bobwhite quail *(Colinus virginianus)*. The hawk bone is the only identified bird bone from the Archaic levels at the site.

Rodents are fairly common at the site, but much less common than at Bear Creek shelter on Lake Whitney (Lynott 1978). Beaver, which may have contributed a small amount to the subsistence of the site's inhabitants, has been mentioned above. Most of the remaining rodents are smaller, and, although their bones outnumber those of many other species, it is not at all clear that they contributed much, if anything, to the diet at the site. Some of the rodent bones appear to be more recent; some individuals may have died in burrows after the occupation of the site. Only a few, if any, of the bones can be convincingly noted as burned or broken by human agency.

The relatively small size of the faunal sample from the site and the predominance of deer make any comparative study of these minor food resources statistically meaningless. Many of the species included here, the bones of some of which were burned or spirally fractured, were obviously utilized by the inhabitants, but some of the species may have been incidental to the site. In a study of the burned and spirally fractured bones from the 1980 excavation season at the McDonald site, in addition to many specimens from turtle, deer, and various other mammals, only one blackened turkey bone, and slightly charred single specimens from an indeterminate fish and a crotalid snake were found (Brown et al. 1987). In contrast, more than 6 percent of all identifiable deer bones were burned (and a much greater percentage of indeterminate large mammal bone fragments). With the exception of a single turkey bone, spiral or green bone fractures occurred only on mammal bones.

Interpretations

As noted above, white-tailed deer remains comprise the largest sample from the site. Adding to their number the indeterminate large mammal remains, which, as previously noted, should consist primarily of white-tailed deer, yields a proportion that is close to the SMU estimate of deer as providing about two-thirds of the available animal calories. This comes as no surprise, since deer, which are large and not difficult to catch, are certainly an attractive resource. Deer are the predominant species in almost all faunal samples from Central or East Texas sites. Their bones are found in the largest numbers at both open sites and rockshelters along the Balcones Escarpment, as seen at the North Fork and Granger Lake areas and at Lake Whitney, further to the north. They are also the most important faunal resource by meat yield at many East Texas sites such as the George C. Davis site (41CE19) in Cherokee County (Keller 1974:158) and the Tadlock site (x41WD39) on Lake Fork Creek in Wood County (Perttula and Bruseth 1983).

For these reasons, the high percentage of deer has very little significance for specialized adaptations at the site, since most sites (except for short-term special activity sites such as the McKenzie site at Aquilla Lake reported by Brown 1987b) will have such assemblages. On the other hand, the high percentage of deer suggests a clear, but not exclusive, dependence on this resource.

Some attempts to model prehistoric resource utilization in other parts of the country have indicated that deer might not be the primary resource (at least not throughout the entire year) in a least-cost-resource-procurement solution. Reidhead (1980) predicted that deer would rank fourth in Late Woodland animal utilization at the Leonard Haag site in Illinois, with fish, mussel, and turtle ranking higher in a four seasonal aggregate model. However, examination of faunal remains from the sites showed that deer ranked first, with fish, mussel, and turtle falling way behind, ranked tenth, eleventh and ninth respectively.

In attempting to explain the differences between the model and the actual recovered animal remains, Reidhead notes that mussels and turtles were included in the model because they are rich sources of calcium. If the calcium needs of the population were satisfied in some other way, for instance, from the calcium-rich water in the limestone bedrock area, then mussels and turtles would drop out of the optimal solution altogether, moving the hypothetical ranking of deer second only to fish. Jochim (1983), however, argues that the nutritional model offered by Reidhead is needlessly complex and that a simple model based on animal size and abundance more closely approximates the actual ranking found at the site.

The SMU catchment analysis is essentially a size-abundance model like the one Jochim feels might be more suited to the Leonard Haag data than to Reidhead's model, which uses not only size and abundance but nutritional data and a measure of procurement costs as well. Yet the lack of fit for the SMU model, except for deer and, perhaps, cottontail, is striking. Two factors may account for this lack of fit. One, incorrect data on species abundance for the Aquilla Lake area may have altered the model. Two, other factors such as nonfood resource values, nutritional deficiencies, unusually high procurement costs, and socio-cultural factors such as prestige and taboos may alter the equation. In fact, all of these factors are possible contributors to the inaccuracies in the solution.

In the first place, although there is little hard data, the exclusion of turtles and mussels from the primary resources may be a mistake based on underestimation of abundance. Unfortunately, no quantitative data are available for the occurrence of either resource in the Aquilla Lake or southern Cross Timbers area. Both reproduce themselves rather slowly, however, and, in view of the relatively small area of aquatic habitat in the catchment area, it is unlikely that they would rival the cottontail in total annual harvestable yield. On the other hand, they may be numerically more important than many of the other small mammals or bird species.

The lack of adequate quantification makes further speculation difficult, but one point is important. It was noted above that a possible reason for the apparent underrepresentation of the fox squirrel in faunal collections is the presumed high procurement cost relative to the size of meat yield. Procurement costs may be a factor in the exploitation of turtles and mussel. Mussels, whose search-time costs vary with the level of knowledge of the area and the preferred habitat types, have essentially no pursuit costs and may require only minimal preparation. Turtles, which can be caught easily as they bask in the sun, are perhaps easier to cook than many small mammals.

It could, of course, be speculated, as maintained by Reidhead, that turtles and mussels were important to the aboriginal Aquilla Lake population for their calcium content. The absence of extensive limestone deposits in the Aquilla Lake area might have made the acquisition of calcium a resource procurement behavior selected for through time. If aquatic resources were important as providers of calcium, it might also indicate that the local groups did not spend much time in the west along the limestone bluffs and calcium-rich waters of the Brazos River.

As predicted by the SMU catchment analysis model, data from the McDonald site indicate that deer were a primary food resource. This was the case at the

Leonard Haag site (Reidhead 1980), the Tadlock site (Perttula and Bruseth 1983), and in the two faunal exploitation models that served as primary inspirations for the SMU model—the Middle Mississippi study of Smith (1975) and the Davis site Caddo study of Keller (1974). At the McDonald site, however, deer appear to make an even more important contribution to the animal diet than predicted by the model. The underrepresentation of lesser-ranked species in the diet may be an indication that there was no stress on the total resources of the area, so that only the most highly prized resources needed be taken. Such a condition could come about if plant foods contributed heavily to the diet and meat was only a supplement, perhaps as important to prestige as to nutrition. The other major possible causal factor might be a human population density well below the predicted carrying capacity .

It would be no surprise to find that plant foods did not contribute greatly to the Aquilla Lake diet, nor would it be surprising to find that the population was maintained well below the theoretical carrying capacity. Such conditions are not unknown in ethnographically documented hunter and gatherer populations. However, it would be difficult, if not impossible, to evaluate these possibilities in the light of the available data. Even data from pollen or plant macrofossils would not provide estimates of the true dietary mix. Although unlikely, it is possible that the dietary mix could be detected from coprolites that might be recovered from cave sites in the region, since some remarkably preserved coprolites were recovered from the Kyle site at Lake Whitney (Jelks 1962)

RETHINKING THE MODEL

Aquilla Lake Subsistence Economy

Even without evidence for the actual diet of the aboriginal inhabitants of Aquilla Lake, it is reasonable to speculate on the overall exploitation of resources in the study area. Two important conclusions are clear. First, white-tailed deer, almost to the exclusion of all other species, were a source of animal protein. If the number of bones can be taken as an indication, then as much as 90 percent of all faunal kilocalories were provided by deer. In fact, the 90 percent figure may be an underestimation of the importance of deer. Second, the enormous amount of plant food resources that were available provided a relatively stable, if somewhat cyclic, diet with a potential caloric yield as much as a hundred times greater than the yield from faunal resources in the Aquilla Lake area.

The emphasis on deer among faunal resources may be an indication, as noted above, of the absence of resource scarcity in the local population and the concentration on the primary resource. It should be remembered, however, that the extreme emphasis on deer at the McDonald site is not necessarily the rule at other Central Texas sites. Deer are frequently the single most important species, but they are not always as dominant as they are at the McDonald site, and the data from a single campsite at Aquilla Lake are not an adequate basis for making an unqualified extrapolation to the rest of Aquilla Lake or to the central Brazos region.

The estimated amount of available floral resources at Aquilla Lake totals 10,909,800,000 kilocalories, in contrast to the 137,051,207 kilocalories projected by SMU for the faunal resources. Obviously, such a figure would provide food for a relatively large population, but several adjustments must be made. First, the apparent importance of deer is corrected for, and the importance of animals such as fox squirrels, not clearly represented in the faunal remains, is heavily modified or they are dropped from the original SMU model. The modified estimates for deer, mollusca, turtle, rabbit, other small mammals, and other resources (including fish, birds, and, at times, bison) total less than the SMU total (Table 7). This is intended to reflect the complete dominance of deer and the apparent absence of stresses that might have forced partial dependence on lesser resources. It might also have been useful to drop the total figure for deer exploitation in order to reflect further the absence of resource stress, but such a reduction could be little more than arbitrary. Therefore, as a comparative baseline to the SMU study, the deer exploitation figure has remained unchanged.

If the total estimated food resources available to the aboriginal inhabitants of Aquilla Lake were used, the faunal total from Table 7 would be less than 1 percent of the total subsistence, well below the 20 percent minimum found in nearly all ethnographic sources (Lee 1968:42). It is therefore reasonable to suggest that the Aquilla Lake peoples, like many ethnographically documented groups, were probably somewhat selective in their use of plant resources, harvesting far less than the maximum available. Lee (1968:33) also points out that after the harvest of tens of thousands of pounds of mongongo nuts, the primary Bushman subsistence item, thousands more rot on the ground each year.

Obviously, all of the available plant foods cannot be harvested for one reason or another. Animal competition is a major factor; birds, arboreal mammals, and small ground-dwelling animals consume a portion, and the major

Table 7. Modified Estimates of Faunal Resource Yields

Animal	SMU[a] Estimate (Kcal[b])	New Estimate (Kcal)
White-tailed deer	90,687,240	90,687,240
Turtle	c	729,000
Mollusca	c	729,000
Cottontail	1,458,000	364,500
Other small mammals[d]	10,560,700	182,250
Other resources[e]	34,345,267	2,308,010
TOTAL	137,051,207	95,000,000

[a] Southern Methodist University.

[b] Kilocalories

[c] Originally included in the Other Resources total.

[d] Includes racoon, opossum, fox squirrel, and blact-tailed jackrabbit.

[e] ncludes additional resources listed in Skinner, Shaw, Huckaby, and Bartsh (1978) in addition to turkey. See Table 4.

competitor for the resources, particularly for hardwood nuts, may be the principal faunal resource, the white-tailed deer. In addition, some fruits or nuts never ripen properly or rot on the trees, and finally, perfect harvest scheduling is probably impossible, particularly for some fruits that may mature and rot quickly if the trees are not visited at precisely the right time.

In his study of the ecology of the Caddo, Keller (1974:144) accepts a figure of 30 percent for all such losses, but this figure may be too low for the maintenance of an animal population and to account for potential losses as well. Keller himself lists a potential 34 percent in losses from arboreal mammals and defective nuts alone. A figure of 50 percent is used here to account for the total of such losses, leaving the resources of the 10-km-radius area at 5,454,900,000 kilocalories.

In order to calculate the extent of utilization possible for this resource potential, a few diets can be hypothesized with meat percentages within typical ranges for hunter-gatherers. Lee (1968:43) notes that, except in the highest latitudes, hunted foods generally constitute from 20 to 45 percent of the diet. If the percentage of meat at Aquilla Lake were near the minimum, at 20 percent, then only 380 million calories of plant foods would be consumed in the remaining 80 percent, or only about 7 percent of the adjusted total of available floral resources. With meat consumption at 35 percent, a figure Lee cites as the apparent median (the Bushman meat intake is 37 percent), about 176.4 million calories of plant food would supplement the diet, and, for a maximum meat consumption figure of 50 percent, only 95 million calories of plant food would be consumed.

If it were assumed that gatherers foraged over smaller areas than hunters, foraging areas could be calculated for each of these percentages. If the 20 percent of meat in the diet were recovered from the entire 10-km catchment area, the plant food foragers would have to cover an area with a radius of only about 2.6 km in order to gather the estimated 380 million kilocalories available after a 50 percent reduction from losses. Correspondingly, at the 35 percent level, foragers would need a plant food catchment area with a radius of only 1.8 km, and, at the 50 percent level, an area with a radius of only 1.3 km.

Another approach to the use of these potential yield figures is to calculate various potential population sizes. The following calculations use a rounded figure of 2000 calories per day per person, essentially the same as that computed for the Aquilla Lake population (Skinner et al. 1978) and those found by Lee (1968) for the Bushman population. Using the 50 percent plant food figure and the full animal resource figure, a total of 5,549.9 million calories, supports 7,602 persons, an obviously high figure for a prehistoric hunter-gatherer population. Another approach is to use Zubrow's (1971:132) 5 percent human resource exploitation figure as Keller (1974:156) did in the Caddo region. Five percent of the total available resources (eliminating the 50 percent plant food reduction in this case, since it is redundant) of 11,059.8 million calories would support a population of 758 persons, a much more reasonable figure. Yet another approach is to use the 35 percent meat utilization figure calculated above; the 271.4 million calories available would support 372 people in the area.

None of the figures can be verified, but some population density parameters can be calculated. For 758 persons, the population density would be .024 persons per ha (2.41 persons per km^2), and, for a population of 372 persons, the density would be .012 persons per ha (1.18 persons per km^2).

To put it differently, a band of 25 persons in the Aquilla Lake catchment area with an annual requirement of 18.25 million calories, would be utilizing the area only to less than two-tenths of 1 percent efficiency, an extremely low figure. Operating at a 5 percent efficiency ratio, the same band would need to exploit a territory of only 10.4 km^2, an area with a radius of only 1.8 km.

With a subsistence territory of this size, the establishment of permanent settlements might be expected. The archeological evidence does not clearly support any trend toward a sedentary lifeway. Rather, figures such as these suggest either a gross overestimation of the available resources or populations that may have existed well below the carrying capacity of the land. Some overestimation of resources is probable. The amount of forested area in the Cross Timbers biotic zone is hardly clear, and the estimation of the original resource potential using the modern oak forest, with its generally small post oak specimens, may be a serious error. Modern yield figures may also be highly inaccurate. Nonetheless, it seems that there is at least some evidence to suggest that the Aquilla Lake and, perhaps, the central Brazos populations also may have functioned at well below the carrying capacity of the land. More precise quantification might be helpful in ascertaining the degree to which such underutilization of the resources occurred, but appropriate figures for the reconstruction of the paleofauna and paleoflora never may be available.

Broader Adaptive Strategies

Considering the model developed above, what is the evidence for particular adaptive strategies in the Aquilla Lake area? Was there a specialized adaptation localized along the Aquilla Creek drainage? Or was there a broader, less specialized adaptation throughout the central Brazos or even all of northern Central Texas? Or, if such adaptations cannot be clearly isolated, what are some of the environmental parameters that might have defined such an adaptation.

Shafer and Bryant (1976) have proposed two adaptive strategies for the North Fork and Granger reservoirs on the San Gabriel River in Williamson County. WIlliamson County and the San Gabriel River are many miles to the south, but they share with Aquilla Lake and Hill County the role of transitional area between the Edwards Plateau and the Blackland Prairie. In other words, both archeological project areas are on the extreme eastern edge of the Central Texas culture area.

The first of these adaptive strategies is termed the Prairie Centered Adaptation. This model proposes an adaptation centered upon the gallery forests along the major streams of the Blackland Prairie in which prehistoric groups ranged east and west to exploit the resources of the Post Oak Savannah and the Edwards Plateau. Moore, Shafer, and Weed (1978:72-77) point out that the model implies that none of these zones could support populations throughout the annual subsistence cycle, but Peter and Hays (1982:19-5) suggest that this assumption may not be valid and that the resources of the prairie alone could have supported a group throughout the year.

The second model, considered the least likely of the two alternatives (Moore, Shafer, and Weed 1978:75), is termed the Prairie Ecotone Adaptation. In this model, the Blackland Prairie is seen as the boundary or ecotone between adaptations centered in the Edwards Plateau and the Post Oak Savannah. Although they find some evidence for contact with culture areas to the south and east on the East Texas Coastal Plain (as indicated by the presence of coastal shells and sandy paste ceramics after 1750 B.P.), Peter and Hays (1982:19-8) suggest that what little is known about specific Post Oak Savannah adaptations (e.g., Mallouf 1979) does not strongly support this model.

The different nature of the biotic zones of the Aquilla Lake area precludes the exact correspondence of Aquilla Lake to these models, they can be translated into parallel forms that may serve to explain locally successful adaptations. Such a translation generates two basic forms: (1) an adaptation centered on the Cross Timbers region, dividing resource procurement time between the bottomland hardwood forests and the upland oak savannah areas, and (2) adaptations to the east and west that jointly exploit the resources of the Cross Timbers area. This latter model implies that the resources of the Cross Timbers region might become a zone of contention between groups, as those of the Blackland Prairie would in the Granger region (Peter and Hays 1982:19-4). There is no clear evidence for such contention, and there is little to suggest that the available resources of the Cross Timbers region would have been worth fighting over.

Although Lynott's (1977) characterization of the Blackland Prairie uplands as a "sea of inedible grasses" may be an overstatement, it does seem quite unlikely that the resources of the prairie uplands were sufficient by themselves to support a prehistoric group of any size throughout its annual cycle. A group determined to remain in the prairie ecozone would have had to have been "tethered" to one of the larger floodplain-riparian forests that cross the prairie. Streams of sufficient size to maintain even small groups are widely spread to the east of the Aquilla Lake area, and, although the Blackland Prairie area adjacent to Aquilla Lake may be somewhat wider than that found in the Granger Lake area, it seems less likely that a true Prairie-Centered Adaptation would be a successful alternative in the Aquilla region.

On the other hand, a localized adaptation between the Edwards Plateau and the Post Oak Savannah may well have centered upon the Cross Timbers and the southward-flowing Aquilla Creek with its substantial gallery forest and floodplain. Aside from the presence of the Cross Timbers biotic zone (which also runs north-south), one of the major differences between the Granger-North Fork area and the Aquilla Lake area is the east to southeasterly flow of the major streams in the Granger-North Fork area and the southward flow in the Aquilla Lake area.

Therefore the model replacing the Prairie-Centered Adaptation in the Aquilla Lake area is one centered on the Cross Timbers and Aquilla Creek. There are two possible versions of this adaptive model. In the first, the adaptation is centered on Aquilla Creek, ranging westward to the Brazos River and eastward through the Blackland Prairie to the Post Oak Savannah region. This model, adapted to a basically east-west seasonal subsistence territory, is termed the Stream Centered Model. A second model is proposed that ranges the length of Aquilla Creek, foraging in the immediately adjacent upland areas but only rarely venturing to the Brazos or very far east into the Blackland Prairie area. This model is tentatively termed the Stream-Oriented Model.

.It is possible to envision a Prairie Ecotone Adaptation occurring within the Aquilla Lake region. Certainly, if the prairie were not the center of a particular adaptation, it would hardly have been left unexploited. The model defined above as Stream Centered is in reality a version of this ecotonal model. Another possibility considered here is the Cross Timbers and Aquilla Creek as a cultural ecotone between prehistoric groups adapted to the Brazos River on the west and to either the Blackland Prairie or Post Oak Savannah on the east. As already mentioned, a specific Blackland Prairie adaptation seems unlikely except along major east-west prairie tributaries such as Richland-Chambers Creek to the northeast of the project area. Additionally, it is not altogether clear whether the resources would have been sufficiently different or plentiful to draw groups from the Post Oak Savannah across the Blackland Prairie.

A similar argument could be made for the Brazos River adapted groups. There is little if any evidence that any single resource was plentiful enough or scheduled differently enough in the Cross Timbers area or the Aquilla Creek drainage to be attractive to people who lived in a zone of plentiful resources. Skinner and Henderson (1972) had originally proposed that the prehistoric inhabitants of Aquilla Lake were based along the Brazos River and foraged seasonally into the Aquilla drainage area. However, upon examination of the data regarding base camps versus seasonal foraging stations, Lynott and Peter (1977) suggested that the converse could be possible, since the largest sites along Aquilla and Hackberry creeks were larger than the sites nearer the Brazos. In any case, the argument for a localized Aquilla Creek or Cross Timbers adaptation has been opened.

It has been determined above that the resources available in the Aquilla Lake catchment area could support a fairly large population, with estimates ranging between 372 and 7,602 persons. The estimated resource potential of the Cross Timbers, which includes 1,640 ha. of bottomland, is 10,438.7 million kilocalories; the resource potential of the Blackland Prairie zone, tallied exclusively from bottomland riparian forest, is estimated at only 471.1 million kilocalories. The differences in productivity are immediately obvious; the 15,200 ha of Cross Timbers land in the Aquilla Lake catchment area have an average production potential of .69 kilocalories per ha, whereas the 15,840 ha of Blackland Prairie are projected to yield only .03 kilocalories per ha. So the ratio of Cross Timbers to Blackland Prairie production is 23:1, making it clear that the Blackland Prairie is less attractive in terms of resource potential.

Another way of looking at the differences above is to examine them in terms of the adaptation models. The Aquilla Lake catchment area, with a total area of 314.16 km^2, produces 10,909.8 million kilocalories annually. An equivalent area contained totally within the Cross Timbers biotic province would produce about twice that, or 21,576.5 million kilocalories. A corresponding area of Blackland Prairie would produce only 933.1 million kilocalories. Obviously, the survival of a population in the pure Blackland Prairie would require a larger subsistence range, i.e., to support a population equal to carrying capacity in the Aquilla Lake catchment area would require in the Blackland Prairie an area 23 times greater, or 7,225.68 km^2, a catchment circle with a radius of 48.0 km. However, this calculation is somewhat misleading, for whereas the Cross Timbers resources are spread across the landscape, the Blackland Prairie resources are confined primarily to riparian forests along stream drainages. To equal the Aquilla Lake catchment area's potential annual resources, some 974.1 km of stream drainage would be needed. This strongly suggests that a true Prairie-Centered Adaptation, relying totally on riparian resources within the prairie zone, is not possible in the Aquilla-Central Brazos area, but the data analyzed have yet to provide a clear choice between the two versions of the model that center on the Aquilla Creek drainage.

Considering the apparent surplus available in the Cross Timbers area, the potential differential may be of less importance than is apparent. It seems unlikely that the population of the Aquilla Lake catchment area ever exceeded a thousand, much less seven thousand, at any one time. Even the lower estimate of 372 persons given above may be high for a permanent population confined to this area. It is possible that the area may have been inhabited at well below its carrying capacity by only a few small bands. Further quantitative analysis of food remains from sites in the area will be necessary to reduce the speculative nature of the population estimates given here.

The adaptive models discussed here, however valid they may be, are primarily static models. Peter and Hays (1982), in their discussion of the adaptations through time in the North Fork and Granger Lake areas, suggest that it is unrealistic to expect a single model to remain valid throughout the entire prehistoric period, for with at least minor climatic changes throughout the prehistoric period, some changes should be expected. There is at least some evidence in the Aquilla Lake area for shifting spheres of cultural influence through time (Brown 1987c), for the most part apparently indicating very early and very late participation in the broad cultural traditions of Central and East Texas, with some degree of independence throughout the Middle and during parts of the Late Archaic. It may well be that home ranges of prehistoric groups narrowed considerably during these latter periods. Although no major adaptive changes are documented during the prehistoric period of Central Texas, such range shifts may indicate subtle changes in adaptive strategies.

It is all but impossible for archeologists to track the remains of single bands. As Weissner (1983) has pointed out, study of material culture alone may not be sufficient to provide distinctions among separate bands. Only broader adaptations can be distinguished to any degree, but even these may provide clues to the maximum limits of band territories within regions.

Gunn and Prewitt (n.d.), in their broad ecotone model, have discussed the possible changing patterns of Central Texas cultures This model views the Central Texas culture area as having a changing environment that tends to promote alterations to adaptive strategies, and it views the broad ecotone of Central Texas as a climatically unstable area that, unlike the narrow ecotone that promotes the development of complex cultures, tends to inhibit long-term cultural development.

Gunn and Prewitt's model is tied to both the Primary Forest Efficiency model of Caldwell (1958) and the Focal-Diffuse adaptive model of Cleland (1976), as well as to the model of tethered nomadism proposed by Taylor (1964). They propose a series of maximum ranges for each of the phases of Prewitt's (1981) cultural chronology of Central Texas and the correlation between each of these and interpreted climatic changes is examined.

Gunn and Prewitt (n.d.) describe the climate of the Late Prehistoric as primarily cool and dry, with a warm, moist spike during the late Austin phase. The estimated mean northern hemisphere temperatures during the mid-Toyah phase are at their coolest since the Pleistocene. Ranges during the Late Prehistoric are at their maximum to the north, east, and south. The early Late Archaic (San Marcos and early Uvalde) is warm and moist, with a cool, dry interval peaking at the beginning of the Twin Sisters phase and becoming hot and dry during the Driftwood phase. Cultural ranges of the Late Archaic phases are average during the middle phases and constricted during the Driftwood and San Marcos phases. The Middle Archaic begins with a cool, dry interval that peaks in the late Clear Fork; a major hot and dry interval peaks at the transitional between the Marshall Ford and Round Rock phases. Ranges of the later phases are moderate, but the early Clear Fork phase is constricted. Climates during the Early Archaic vary from warm and moist to hot and dry, with the warmest average temperature of the entire Archaic period falling at the beginning of the Jarrell phase. Another warm peak, at the end of a long late Pleistocene warming trend, occurs at the beginning of the Circleville phase. Ranges are narrowly constricted during the later part of the Early Archaic, but the Circleville phase range expands to nearly the extreme width of the Late Prehistoric.

These Central Texas ranges can be examined from the perspective of the presence of Central Texas materials in the Aquilla Lake area. Gunn and Prewitt's (n.d.:Figure 9) summary of the ranges of Central Texas groups during the Archaic and post-Archaic suggests the following predictions. The Central Texas phases least likely to be heavily represented in the Aquilla area are, in the approximate order of distance, Oakalla, Jarrell, San Marcos, Driftwood, and Clear Fork. After the Late Prehistoric phases and the San Geronimo and Circleville phases, those predicted as most likely to be represented are Round Rock, Marshall Ford, and Uvalde.

Examination of the sample of projectile points from the Aquilla Lake area (see Brown 1987c for discussion) shows that there is no evidence of the diagnostic artifacts of the Oakalla or Clear Fork phases and only minimal evidence of any from the San Marcos phase. Projectile points linked to the Driftwood and Jarrell phases are present, though not in great numbers. Round Rock and Marshall Ford and, to a lesser degree, Uvalde phase projectile points apparently are more prominent in the Aquilla Lake area, but the overall numbers are still small. The presence of Central Texas projectile points from both the early part of the Early Archaic (San Geronimo and Circleville) and the Late Prehistoric (both Austin and Toyah phases) is well documented in and around the project area (Brown 1987c).

The projectile point sample seems to indicate that, except for the Late Prehistoric, extension of Central Texas cultures into the Aquilla Lake area was at its maximum during hot and dry intervals such as the Early Archaic and mid-Middle Archaic. The smallest amount of northward extension from Central Texas came during both warm-moist and cool-dry intervals, so it is possible that the resources of the Cross Timbers may have drawn groups from other areas in hot, dry times when, away from the major drainages, much of Central Texas may have consisted of relatively unproductive grasslands .

It is easy to envision different adaptive strategies, strongly linked to varying population densities and resource depletion pressures, emerging during different climates. During cool or moist periods, population densities may have been lowered, resulting in less pressure on the resources from marginal groups. A true Cross Timbers-Centered Adaptation may have arisen during these periods. It may have been during the cool, dry interval of the mid-Late Archaic that the apparently locally centered Godley projectile points and the people who used them first appeared. During warmer and drier periods, adaptations may have ranged farther along the peripheral drainages of the Blackland Prairie, not only to maximize the exploitation of resources in hard times, but to increase spacing between band territory centers in the face of increased population density. The resources of the uplands of the Cross Timbers would be shared, but from home range territories that extended out across the prairie.

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REFERENCES CITED

Binford, L. R.
1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

Brown, D. O. (editor)
1987a Archeology at Aquilla Lake: 1978-1982 Investigations. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

Brown, D. O.
1987b The McKenzie Site - 41HI115. In: Archeology at Aquilla Lake: 1978-1982 Investigations, Volume II, edited by David O. Brown. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

1987c Aquilla Lake: A Culture History Perspective. In: Archeology at Aquilla Lake: 1978-1982 Investigations, edited by David O. Brown. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

Brown, D. O., R. P. Watson, D. E. Peter, and V. Rawn-Schatzinger
1987 The McDonald Site - 41HI105. In: Archeology at Aquilla Lake: 1978-1982 Investigations, Volume II, edited by David O. Brown. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

Burt, W. H., and R. P. Grossenheider
1964 *A Field Guide to the Mammals*. Houghton Mifflin Co., Boston.

Caldwell, J. R.
1958 Trend and Tradition in the Prehistory of the Eastern United States. *American Anthropological Association Memoir* 88.

Cleland, C. E.
1976 The Focal-Diffuse Model: An Evolutionary Perspective on the Prehistoric Cultural Adaptations of the Eastern United States. *Mid-Contintent Journal of Archaeology* 1(1):59-76.

Davidson, I.
1976 Les Mallaetes and Mondúver: The Economy of a Human Group in Prehistoric Spain. In: *Problems in Economic and Social Archaeology*, edited by G. de G. Sieveking, I. H. Longworth and K. E. Wilson, pp. 483-499. Westview Press, Boulder, Colorado.

Davis, W. B.
1974 The Mammals of Texas. *Texas Parks and Wildlife Bulletin* 41. Austin.

Dennell, Robin
1980 The Use, Abuse and Potential of Site Catchment Analysis. In: Catchment Analysis: Essays on Prehistoric Resource Space, edited by Frank J. Findlow and Jonathon E. Ericson, pp. 1-20. *Anthropology UCLA*. 10(1-2). Department of Anthropology, University of California, Los Angeles.

Findlow, F. J., and J. E. Ericson.
1980 Catchment Analysis: Essays on Prehistoric Resource Space. *Anthropology UCLA*. 10(1-2). Department of Anthropology, University of California, Los Angeles.

Flannery, K. V.
1976 Empirical Determination of Site Catchments in Oaxaca and Tehuacan. In: *The Early Mesoamerican Village*, edited by K. V. Flannery, pp. 91-95. Academic Press, New York.

Flook, J. M.
1972 Aquilla Lake Botanical Survey. In: The Natural and Cultural Environmental Resources of the Aquilla Creek Watershed, Hill County, Texas. S. Alan Skinner, compiler. *Southern Methodist University. Archaeology Research Program Research Report* 17.

Gunn, J., and E. R. Prewitt
n.d. Theory of Culture Change on Broad Ecotones. Unpublished MS.

Higgs, E. S., C. Vita-Finzi, D. R. Harris, and A. E. Fagg
1967 The Climate, Environment, and Industries of Stone Age Greece: Part III. *Proceedings of the Prehistoric Society* 33:1-29.

Hulbert, R. C., Jr.
1984 Latest Pleistocene and Holocene Leporid Fauna from Texas: Their Composition, Distribution and Climatic Implication. *The Southwestern Naturalist* 29(2):197-210.

Jackson, J. M.
1981 Floral and Faunal Remains. In Archeological Investigations at the George C. Davis Site, Cherokee County, Texas: Summers of 1979 and 1980. *Texas Archeological Research Laboratory. The University of Texas at Austin. Occasional Papers* 1.

Jelks, E. B.
1962 The Kyle Site: A Stratified Central Texas Aspect Site in Hill County, Texas. *The University of Texas at Austin. Department of Anthropology. Archeology Series* 5.

Jochim, M.A.
1983 Optimal Models in Context. In: *Archaeological Hammers and Theories,* edited by J. A. Moore and A. S. Keene, pp. 157-172. Academic Press, New York.

Keller, J. E.
1974 The Subsistence Paleoecology of the Middle Neches Region of Eastern Texas. Unpublished Ph.D. Dissertation, Anthropology Department, University of Texas at Austin.

Lee, R. B.

1968 What Hunters Do for a Living, or, How to Make Out on Scarce Resources. In: *Man the Hunter,* edited by R. B. Lee and I. DeVore, pp. 30-48. Aldine, Chicago.

1979 *The !Kung San.* Cambridge University Press, London.

Lundelius, E.L., Jr.

1962 Nonhuman Skeletal Material from the Kyle Site. Appendix to The Kyle Site: A Stratified Central Texas Aspect Site in Hill County, Texas. by E. B. Jelks. *The University of Texas at Austin. Department of Anthropology. Archeology Series* 5.

Lynott, M. J.

1977 A Regional Model for Archaeological Research in North Central Texas. Unpublished PhD. Dissertation, Department of Anthropology, Southern Methodist University. Dallas.

1978 An Archaeological Assessment of the Bear Creek Shelter, Lake Whitney, Texas. *Southern Methodist University Research Report* 115. Dallas.

Lynott, M. J., and D. E. Peter

1977 1975 Archaeological Investigations at Aquilla Lake, Texas. *Southern Methodist University. Archaeology Research Program. Research Report* 100. Dallas.

McCormick, O. F., III

1973 The Archaeological Resources in the Lake Monticello Area of Titus County, Texas. *Southern Methodist University. Contributions in Anthropology* 8. Dallas.

McCullough, D. R.

1979 *The George Reserve Deer Herd.* University of Michigan Press, Ann Arbor.

Mallouf, M. G.

1979 Archeological Investigations at Lake Limestone. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 71.

Moore, G. L., H. J. Shafer, and C. S. Weed

1978 Archeological Surveys of Granger and North Fork Reservoirs. Volume 1, The Granger Report. *Texas A&M University. Anthropology Research Laboratory Report* 38a. College Station.

Murry, P. A.

1978 Vertebrate Faunal Remains. An Archaeological Assessment of the Bear Creek Shelter, Lake Whitney, Texas. *Southern Methodist University, Research Report* 115. Dallas.

Neck, Raymond

1987 Analysis of 1982 Molluscan Fauna. In: Archeology at Aquilla Lake: 1978-1982 Investigations, Volume III, edited by David O. Brown. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

Peebles, C. S.
1978 Determinants of Settlement Size and Location in the Moundville Phase. In: *Mississippian Settlement Patterns,* edited by Bruce D. Smith, pp. 369-416. Academic Press, New York.

Perttula, T. K., and J. E. Bruseth
1983 Early Caddoan Subsistence Strategies, Sabine River Basin, East Texas. *Plains Anthropologist.* 28(99):9-19.

Peter, D. E., D. O. Brown, and J. M. Jackson
1987 The Brazil Site - 41HI75. In: Archeology at Aquilla Lake: 1978-1982 Investigations, Volume II, edited by David O. Brown. *Texas Archeological Survey. The University of Texas at Austin. Research Report* 81.

Peter, D. E., and S. Hays
1982 Models of Prehistoric Adaptation in the San Gabriel River Valley. In: Archeological Investigations at the San Gabriel Reservoir Districts, Central Texas. Institute of Applied Sciences. North Texas State University. Denton.

Prewitt, E. R.
1981 Cultural Chronology in Central Texas. *Bulletin of the Texas Archeological Society* 56:65-89.

Reidhead, V. A.
1979 Linear Programming Models in Archaeology. *Annual Review of Anthropology* 8:543-578.

1980 The Economics of Subsistence Change: a Test of the Optimization Model. In: *Modeling Change in Prehistoric Economies,* edited by T. K. Earle and A. L. Christenson, pp. 141-186. Academic Press, New York.

Roe, F. G.
1970 *The North American Buffalo: A Critical Study of the Species.* University of Toronto Press, Toronto.

Roper, D. C.
1979 The method and theory of site catchment analysis: a review. In *Advances in Archaeological Method and Theory.* Volume 2, edited by Michael B. Schiffer. Academic Press, New York.

Shafer, H. J,. and V. M. Bryant, Jr.
1976 A Prelminary Assessment of the Cultural Resources in the North Fork and Granger Reservoir, Williamson County, Texas. A Supplemental Report to An Archaeological Survey of Granger and North Fork Reservoir, Preliminary Report. Texas A&M University. Anthropology Research Laboratory. College Station.

Skinner, S. A. (editor)
1972 The Natural and Cultural Environmental Resources of the Aquilla Creek Watershed, Hill County, Texas. *Southern Methodist University, Archaeology Research Program, Research Report* 17.

Skinner, S. A., and M. L. Henderson

1972 Archaeological Resources of the Aquilla Watershed. In: The Natural and Cultural Environmental Resources of the Aquilla Creek Watershed, Hill County, Texas, edited by S. Alan Skinner. *Southern Methodist University. Archaeology Research Program. Research Report* 17.

Skinner, S. A., C. Shaw, K. Huckabay, and M. L. Bartsch.

1978 An Evaluation of Archaeological Resources at Aquilla Lake. *Southern Methodist University. Archaeology Research Program. Research Report.* Dallas.

Skinner, S. A., T. S. Turner, D. E. McGregor, and J. H. Richards.

1979 Prehistoric Settlement at Aquilla Lake, Texas. Unpublished MS. Southern Methodist University, Archaeology Research Program.

Slack, R. D., and L. E. Marcy

1983 Pre-Impoundment Environmental Study of Aquilla Lake. U.S. Army Corps of Engineers. Supplement to Design Memorandum 9. Fort Worth.

Smith, B. D.

1975 Middle Mississippi Exploitation of Animal Populations. *University of Michigan, Museum of Anthropology, Anthropological Papers* 57. Ann Arbor.

Stephenson, R. L.

1970 Archeological Investigations in the Whitney Reservoir area, Central Texas. *Bulletin of the Texas Archeological Society* 40:32-257.

Story, D. A., and H. J. Shafer

1965 1964 Excavations at Waco Reservoir, McLennan County, Texas: The Baylor and Britton Sites. *Texas Archeological Salvage Project, The University of Texas at Austin, Miscellaneous Papers* 6.

Taylor, W. W.

1964 Tethered Nomadism and Water Territoriality: an Hypothesis. In: *Actas y Memorias del XXV Congreso Internacional de Americanistas 1962,* pp. 197-203.

Ubelaker, J. E., and N. M. Hall

1972 Zoological Resources of the Aquilla Lake Watershed. In: The Natural and Cultural Environmental Resources of the Aquilla Creek Watershed, Hill County, Texas, edited by S. Alan Skinner. *Southern Methodist University, Archaeology Research Program, Research Report* 17.

Vita-Finzi, C., and E. S. Higgs

1970 Prehistoric Economy in the Mount Carmel area of Palestine: Site Catchment Analysis. *Proceedings of the Prehistoric Society* 36:1-37.

Watson, R. P.

1982 The Archeology of Aquilla Creek Reservoir: Implications for a Regional Research Design from the Central Brazos River Basin, Texas. Unpublished PhD. Dissertation, Anthropology Department, The University of Texas at Austin.

Webley, D.

1972 Soils and Site Location in Prehistoric Palestine. In: *Papers in Economic Prehistory,* edited by E. S. Higgs, pp.169-180. Cambridge University Press, London.

Weissner, Polly

1983 Style and Social Information in Kalahari San Projectile Points. *American Antiquity* 48(2):253-276.

Winkler, B. A.

1982 Wild Plant Foods of the Desert Gatherers of West Texas, New Mexico and Northern Mexico: Some Nutritional Values. Unpublished M.A. Thesis, Anthropology Department, The University of Texas at Austin.

Yates, B.

1982 Vertebrate Faunal Remains. In: Archeological Investigations at the San Gabriel Reservoir Districts, Central Texas, Institute of Applied Sciences, North Texas State University, Denton.

Zarky, A.

1976 Statistical Analysis of Catchments at Ocos, Guatemala. In: The *Early Mesoamerican Village,* edited by K.V. Flannery, pp. 117-128. Academic Press, New York.

Zubrow, E. B.

1971 Carrying Capacity and Dynamic Equilibrium in the Prehistoric Southwest. *American Antiquity* 36:127-138.

Zvelebil, Marek

1983 Site Catchment Analysis and Hunter-Gatherer Resource Use. In: Ecological Models in Economic Prehistory, edited by Gordon Bronitsky, pp. 73-114. *Arizona State University, Anthropological Research Papers* No. 29.

A Comparison of the Ceramic Assemblages of Five Nineteenth Century Texas Sites Using Classification by Decoration

Joan Few

ABSTRACT

A revolution took place in the English ceramics industry in the latter part of the eighteenth century. New ceramic technology and mass production brought uniformity in ware manufacturing, making eighteenth centruy ware type classifications of paste and glaze impractical for nineteenth century ceramics. This revolution led to the nineteenth century practice of describing and marketing ceramics by type of decoration. The ceramic assemblages of five nineteenth century historic sites in Texas, selected for the amount of excavation and documented time of nineteenth century occupation, have been divided according to decoration for site comparisons. All but 18 of the 2,769 sherds from these five sites could be classified by decoration. The seven decorative categories proposed herein are a valid taxonomic system for nineteenth century ceramics. Classification of nineteenth century ceramics by decoration makes identification easier than by the ware type method. It encourages site and assemblage comparisons and may prove also to be an indicator of economic status.

INTRODUCTION

George L. Miller (1980) has proposed that ceramics from nineteenth century sites should be compared by the characteristics that were primary for the people who used them—by decoration rather than ware types. The most obvious advantage of this method is that it provides a more consistent system than one based on ware types, where there may be considerable variation in nomenclature. Classification by decoration facilitates the correlation of historical data with archeological data. This paper compares the ceramic assemblages of five nineteenth century Texas home sites by the decoration system. It is hoped that such a system will encourage questions about such traits as behavior, behavioral patterns, cultural process, economic status, ethnic identification, ceramic availability, site dating, and trade patterns in order to give direction to site comparisons and maximum use of ceramics in the study of historic sites.

CLASSIFICATION SYSTEM

The first step in ceramic analysis is classification. The question being addressed here is which taxonomic system to use for classifying nineteenth century ceramics. The system called ware types that has been used by historical archeologists is based on classification by paste and glaze, which, for ceramics made before the nineteenth century were easily identifiable. There was some confusion in nomenclature and classification of ware types, but it was adequate until a revolution took place in the English ceramics industry in the later part of the eighteenth century, making classification of ware types impractical for nineteenth century ceramics.

The technological changes in the ceramics industry in England that brought about ceramic uniformity have been described by George L. Miller (1980:1).

> In the second half of the 18th century, a revolution took place in the English ceramic industry. This period saw the introduction of transfer printing, calcinated flint, liquid glazes, Cornish clays, calcinated bone, canals for transporting raw materials and finished products into and out of the potteries, steam power for working clay and pottery, tariffs against Chinese porcelain, favorable trade treaties with the Continent, and astute marketing of creamware which culminated in English domination of the world ceramic tableware trade by the 1790s.

Creamware displaced the ware types that were distinguishable by their unique pastes and glazes and was the forerunner of the nineteenth century pearlwares, stone chinas, ironstones, and whitewares. Miller contends that the table-, tea-, and toiletware assemblages from the nineteenth century consist almost entirely of these nineteenth century types, which are difficult to distinguish by paste and glaze. This led to the nineteenth century practice of describing and marketing ceramics by their type of decoration, and ware types became less important (Miller 1980:1-3).

Archeologists who attempt to classify nineteenth century ceramics by eighteenth century ware types run into problems of nomenclature, identification, chronological sequence, integration with historical documents, and correlation with social status information. In "An Analysis of Historical Ceramics from the Central Salt River Valley of Northeast Missouri," Teresita Majewski and Michael J. O'Brien discuss the problems faced in trying to use a ware type classification system for nineteenth century ceramics. They urge the adoption of a classification system based on decoration as more reflective of historical reality (Majewski and O'Brien 1984:19-25).

In an effort to solve this nineteenth century classification problem, George Miller (1980) has proposed a system for looking at ceramics by decoration and cost. Miller states that the social status of any commodity is related to how much the object costs, and prices for pottery were determined by how they were decorated. The Staffordshire potters had a series of price-fixing agreements in the eighteenth and nineteenth centuries, and from these documents Miller has culled the classifications and prices set by the potters for their products. Miller has classified nineteenth century ceramics into four groups based on decoration and cost.

Category one consists of the cheapest undecorated white ceramics. Sometimes referred to as CC ware, common wares, white earthen ware, earthen ware, and stone china, these wares mostly chamber pots, plates, bowls, and items related to kitchen use. Category two includes those wares with minimal decoration, such as shell edges, sponge-decorated, banded, mocha, and common cable (finger-trailed slip). These decorations were applied by workers of little skill and were priced only slightly higher than the undecorated wares. Category three is made up of painted wares with motifs such as flowers, leaves, stylized Chinese landscapes, and geometric patterns. A worker needed enough skill to duplicate a pattern well enough to make a set. According to Miller (1980), most of the painted wares found in North American sites bear simple stylized motifs that required minimal artistic skills and were almost always cheaper than transfer-printed vessels. Category four consists of transfer prints, one of the great English innovations in decorated ceramics. Underglazed transfer printing was a common method of decorating ceramics by the 1790s. When first introduced, transfer prints brought as much as five times the price of undecorated wares, but dropped to about double the price of undecorated wares by the middle of the nineteenth century; the willow pattern was the cheapest transfer printed pattern. In the early nineteenth century, a flow-blue pattern of transfer-printed wares was introduced that sold for a higher price than the regular transfer prints. Miller intentionally left porcelain out of this classification because of a lack of pricing information (Miller 1980:2-4).

Miller's four-category system is not adequate for the study of ceramics in nineteenth century sites in Texas. In order to use Miller's system as an indicator of economic status based on price, one must assume that the consumer had access to ceramic wares in all price ranges and selected according to his economic capability. Texans in the nineteenth century were limited in their selection of ceramics by patterns of commercial distribution and availability in the frontier and rural regions. Miller's classification is not directed toward function, behavior, or process, and it does not include all ceramic types found in Texas. It works as a cost indicator only until 1850, for in the 1850s a white granite, or undecorated white ironstone, flooded the market, and this new type of undecorated ware was priced the same as the transfer printed wares (Miller 1980:4). This new undecorated ware seems to have replaced the transfer prints in the markets, weakening the cost-to-decoration relationship. In view of these problems there is reason to question the use of Miller's system. However, he contends that his four categories account for most of the table-, kitchen-, and toiletwares recovered from North American sites during the nineteenth century (Miller 1980:4), and his categories divide ceramics into distinctive groups based on design, decoration, skill, and technology. By adding three more categories—porcelain, colored wares (colored glaze over surface), and stoneware—we have a valid system for classification of most of the nineteenth century ceramic types found in Texas.

Comparisons of Ceramic Assemblages in Texas

The ceramic assemblages of five historic sites in Texas have been subdivided according to decoration for the purpose of site comparisons. The sites (see Figure 1) were selected for this comparison based on the amount of excavation accomplished at each site and the length of time they were occupied during the nineteenth century. At all five sites, enough excavations had been accomplished to assure a representative sampling of the various types of ceramics used at each site.

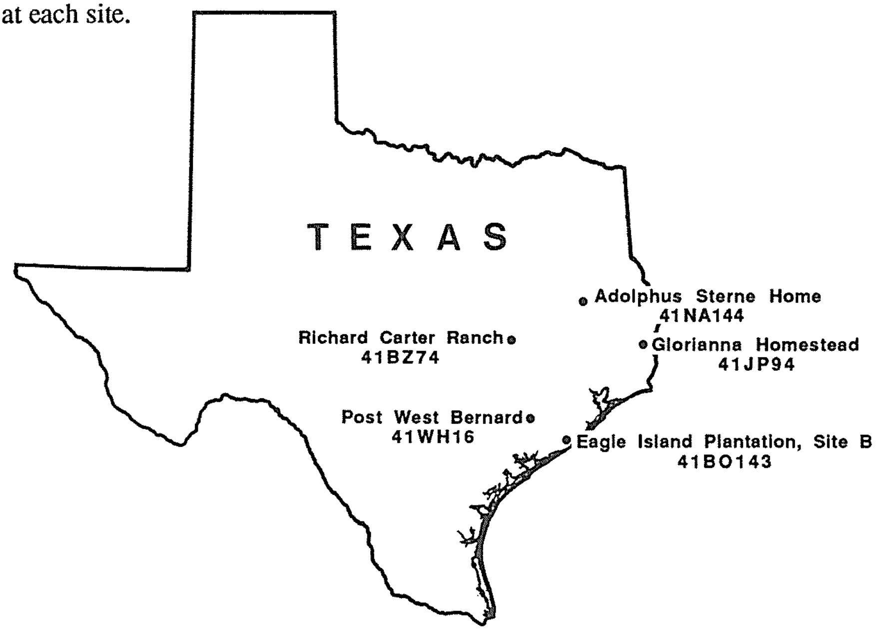

Figure 1. Map of Texas showing locations of the five historic sites used for comparisons in this report.

The Adolphus Sterne home in Nacogdoches (41NA144), was excavated by a crew from Stephen F. Austin State University under the direction of James E. Corbin, with the assistance of Deborah C. Kisling. This ceramic count is from the excavation report published in 1983 and does not include work done at the site during the TAS Field School in the summer of 1985. Sterne built his home in 1828 at the age of 27. He was a prosperous merchant, planter, postmaster, and land agent. "The Sterne home also was a focal point in the social, political, and economic life of Nacogdoches" (Corbin and Kisling 1983:51). Sterne should be ranked in an upper economic bracket with the ability to purchase available material goods.

Post West Bernard (41WH16) was occupied between 1837 and 1839. This site was a storage depot for artillery and heavy camp equipment of The Army of The Republic of Texas. Situated in northeastern Wharton County on the west bank of the West Bernard River, the site was found during a survey for aboriginal sites by Joe D. Hudgins and excavated by the Houston Archeological Society (Hudgins 1987). Analysis by Alton Briggs (1983) showed that the ceramics—remnants of cups, bowls, and plates—appear to be British in origin.

The Eagle Island Plantation Site B in Lake Jackson, Texas was excavated by the Brazosport Archeological Society under the direction of Johnney Pollan

The Eagle Island Plantation Site B in Lake Jackson, Texas was excavated by the Brazosport Archeological Society under the direction of Johnney Pollan and James Smith. The site report has not been published, but Pollan and Smith have graciously allowed the use of their ceramic counts in this paper. The site comprises a structure on a major nineteenth century road that may have been the home of the plantation overseer. The main house of the plantation has been identified and is about half a mile from Site B. The house foundation at Site B is of mortared brick, capable of supporting two stories. This structure, together with artifacts, was destroyed by a storm in 1900. The ceramics were identified by Anne Fox and Johnney Pollan.

The Richard Carter site (41BZ74) was excavated by the Archeological Research Laboratory at Texas A&M University, under the direction of Shawn Carlson. Archeological and historic investigations suggest that Carter, who had a land grant of one league in the Stephen F. Austin colony, was in the upper economic bracket in Brazos County. Carter's wealth appears to have been in land, slaves, and in a cattle herd of 1,000 in 1860. Carter built a one room log cabin in 1841; the lack of architectural artifacts at the site suggests that a more modern structure never was built on the site (Carlson 1983).

The Glorianna plantation (41JP94) in Jasper County was excavated by members of the Houston Archeological Society and The Texas Archeological Society. Historic records indicate that the plantation was established in the 1850s and, after the civil war, was occupied as a homestead until the 1880s. In the 1860 census, William Norsworthy is listed with his wife, seven children, and thirty slaves. He claimed land valued at $17,000. and personal assets of $6,000. The average value of land owned in Jasper County in 1860 was $2,700., and the average personal wealth was $4,555. These figures indicate that the Norsworthys were in an upper economic bracket (Few 1986).

The ceramic assemblages (including surface collections) from these sites should reflect ceramic stylistic changes that took place in the nineteenth century. Sites occupied before 1850 should have higher percentages of transfer-printed wares than those occupied after 1850. Sites settled after 1850 should have high percentages of white undecorated wares. The categories suggested here for use on nineteenth century historic sites in Texas are (1) Uncolored whitewares, (2) Minimally decorated, usually around the edge, (3) Hand painted, (4) Transfer-printed, (5) Porcelain, translucent glaze, (6) Colored ceramics, colored glaze, and (7) Stonewares, highly fired earthenwares that hold water without glazing (Figure 2). (See Appendix for more complete descriptions of these categories.)

DISCUSSION

Since all but 18 of the 2,769 ceramic sherds in this comparative study could be classified by decoration, the seven decorative categories proposed here are a valid system for classification of nineteenth century ceramics (see Figure 2).

Comparisons of these sites (Table 1) show that the difference between sites occupied before and after 1850 reflects the changes in ceramic technology that

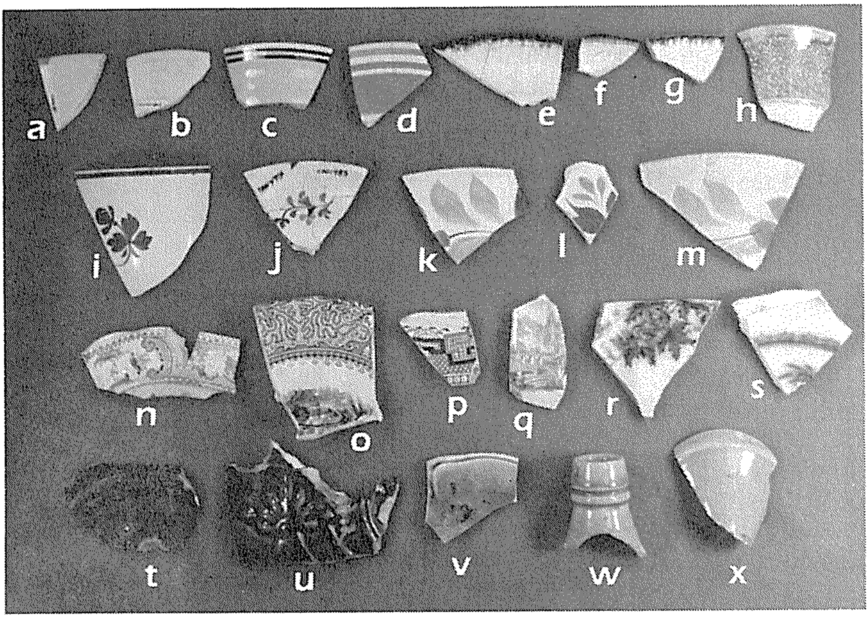

Figure 2. Photograph of sherds illustrating the seven proposed ceramic categories. **Category 1, Uncolored Whitewares**: a, b: **Category 2, Minimal Decoration**; banded, c, d; shell edge, e-g; sponge-decorated, h: **Category 3, Hand Painted Wares,** i-m: **Category 4, Transfer Painted,** n-p: **Category 5, Porcelain,** q-s: **Category 6, Colored Ceramics**; Rockingham slip-glaze, t; English Majolica, u: **Category 7, Stoneware,** v-x.

took place around 1850. There is a definite change in the proportions of decorated wares (with applied color) to undecorated wares (white, devoid of color).

Classification by decoration does make identification easier. It should encourage comparisons among sites and assemblages, and it may prove to be an indicator of economic status and period. High economic status in nineteenth century Texas probably will be reflected in complete sets of dishes and other expensive items such as transfer-printed soup tureens and porcelain tea sets.

Establishment of a ceramic classification system based on decoration is only the first step toward complete ceramic analysis. Total analysis should include both the functional analysis of ceramic sherds (Few 1987) and analysis of spatial relationships between ceramics and other artifacts denoting behavior and process, the inter- and intraregional comparisons of ceramics, the analysis of behavioral processes, and trade throughout the state. Sites must be excavated in such a manner that assemblages accurately reflect all types of ceramics used and in their proper proportions to other artifacts. Ceramic functions correlated with the overall patterns of sites will identify human behavior and cultural process. "Once pattern is abstracted and synthesized with other patterns, these demonstrated regularities are often expressed as empirical laws. The explanation of why these lawlike regularities exist is the goal of archeology" (South 1977:xiii).

Table 1. A Comparison of Ceramics From Five Nineteenth Century Texas Sites Using Seven Decorative Categories

	Decoration Categories								
	1	2	3	4	5	6	7	Un	
SITE	White	Minimal	Hand Painted	Transfer	Porcelain	Color Glaze	Stoneware	classified	TOTAL
GLORIANNA	72%	2 %	2%	5%	15%	1 %	3%	-	
1858-1880	244	8	6	16	49	4	11	-	338
CARTER	81%	10%	2 %	4%	-	-	-	2%	
1831-1876	229	28	7	11	-	-	-	7	282
EAGLE ISL.	81%	1.7%	1%	6%	8%	1.6%	-	-	
1840-1900	1405	30	22	112	142	29	-	-	1740
POST WEST									
BERNARD	23%	12.5%	14%	27%		18%		5.5%	
1837-1839	43	24	27	52	-	34	-	11	191
STERNE	44.5%	5%	8%	33%	8.7%	0.4%	-	-	
1828-1850	97	11	17	73	19	1	-	-	218

APPENDIX

Seven Decorative Classifications for Nineteenth Century Ceramics

1. Uncolored Whitewares (Figure 2, a, b)

Description: Vessels are white, devoid of color; may have raised designs or scalloped edges; were commonly tablewares, chamber pots, and items related to kitchen use.

Common Names: Creamwear, "CC", Common, White Earthenware, Earthenware, Ironstone, Stone China, White Granite, etc. (Miller 1980:3).

2. Minimal decoration (Figure 2, d-h)

Description: White vessels with color usually found on the rim; may have stripes or color along the edge; sponges sometimes used to apply color around the rim or covering the plate; designs required minimal artistic skills.

Common Names: Shell Edge, Sponge-Decorated, Banded (Figure 2, c, d), Mocha, Common Cable, etc. (Miller 1980:4).

Shell Edge (Figure 2, e-g) involved a series of short brush strokes along the rim. In the 1840s and 1850s molding was added to the shell edge design and color was applied parallel to the rim, the molding lending an effect to the edge (Miller 1980:4). Shell edge colors were usually blue or green (Majewski 1984: 33).

Sponge or Spatter decoration (Figure 2, h) was applied to the border, center, or entire vessel. The spatter effect was produced by tapping a brush full of paint against the vessel being decorated. The sponge process was achieved when a color-filled sponge was pressed on the vessel. Cut-sponges resembled stars, flowers, angels, eagles and other forms (Majewski 1984:44).

Dating Information:

1780-1830	Shell Edge Pearlware (blue)
1800-1830	Shell Edge Pearlware (green)
1800-1830	Embossed Edge Pearlware (blue & green)
1830-1860	Shell Edge and Embossed Edge Whiteware (blue) (Majewski 1984:38)
1775-1900	Randall W. Moir has serrated shell-edged wares
1775-1790	Asymmetrically Cockled Edge (Large Shell)
1785-1800	Cockled Edge (Small Shell)
1795-1825	Cockled Edge (Small Shell w/Feather Motif)
1820-1845	Non-Cockled Edge (Fish Scales, Crows' Feet and other Geometric Variants)
1840-1860	Non-Cockled Edge (Lightly Incised Trident)
1850-1865	Non-Cockled Edge Unpainted or Red Painted (Poorly Incised)
1870-1890	Non-Cockled Edge (No Incising, Shell is Brush Stroked) (Moir 1987:3)

3. *Hand Painted Wares* (Figure 2, i-m)

Description: Vessels were hand painted with decorations of flowers, leaves, stylized Chinese landscapes, or geometric patterns; transfer prints sometimes used to outline the colored areas (Miller 1980:4); colors used included blue, brownish green, tan, orange, yellow, black, red, pink, and rust. A typical design included leaves, stylized red and blue flowers, or berries (Majewski 1984:41).

Dating Information:

Popular between 1810 and 1860 (Majewski 1984:41).

4. *Transfer Printing* (Figure 2, n-p)

Description: A method of decorating ceramics where a design is engraved on a copper plate and transferred by way of tissue paper onto the vessel before glazing (Gaston 1983:158); blue was the first color used in this process; flow Blue is a process by which the color of the printing was allowed to flow into the glaze creating a blurred or misty look; deep blue was the most popular, but mulberry, black, yellow, brown, and green were also used (Majewski 1984:33).

The Blue Willow pattern has many variations, but three major components—the willow tree, the orange tree, and the tea house, all of which relate to Oriental culture (Gaston 1983:6).

Dating Information:

Transfer printing developed in 1750 (Majewski 1984:33).
Common by 1790 (Miller 1980).
Blue Willow Pattern: 1780 (Majewski 1984:33 and Gaston 1983:7).
Multicolor transfer prints by 1840 (Majewski 1984:33).
Colors: 1750s- blue; 1828- green, yellow, red, black; 1830- brown, pink, lavender, orange, grey, and light blue.

Color Popularity: 1828-1850 , red, brown, and green; 1830-1850, black; 1830-1860, purple (lavender); 1840-1860, flow transfer prints (Majewski 1984:33-34).

5. *Porcelain* (Figure 2, q-s)

Porcelain paste is a combination of kaolin clay, ball clay, feldspar and flint. The glaze combines kaolin, flint, feldspar, and limestone. Porcelains are fired at temperatures of as much as 2670° F, much higher than other ceramics (Nelson 1960). Porcelains are translucent as opposed to earthenwares, which are opaque (Godden 1964:739). Porcelain rarely occurs undecorated (Miller 1980:4).

Tips for identification: Porcelain, compared to a white stoneware, usually will be whiter, thinner, and lighter, and have a harder glaze that will be less likely to crack. If broken, 1 or 2 mm of the edge will be translucent.

6. *Colored Ceramics* (Figure 2, t-x)

Description: Vessels are completely, or almost completely, covered with a colored glaze; vessels may be tablewares, vases, doorstops, and candlesticks.

Rockingham slip-glaze (Figure 2, t) is achieved by spattering or dripping a rich tan or dark brown color over a white, buff, or yellow paste ware. Rockingham was produced throughout the nineteenth century (Majewski 1984:45). Fiesta-like wares should be included in this category.

English Majolica (an imitation of Italian Majolica, Figure 2, u), developed about 1850 and decorated with a wide range of semitranslucent colored glazes; made in a variety of shapes, it was often decorated with plant or tree motifs (Lewis 1981:135).

7. *Stoneware* (Figure 2, v-x)

Description: "A hard, highly fired variety of earthenware, normally holding water without the need for glazing" (Godden 1964:739). Sometimes referred to as crockery (for a complete description, see Greer 1981); generally used in food preserving and processing; preserve jars, lard jars, churns, milk bowls, butter pots, etc. Colors are grays, tans, and browns.

REFERENCES CITED

Briggs, Alton
1983 Cultural Property Assessment of West Bernard Station. *Houston Archeological Society Journal* 75:5-10.

Carlson, S. B.
1983 Archeological and Historical Investigations at the Richard Carter Site (41BZ74), Brazos County, Texas. *Texas A&M University, Archeological Research Laboratory Reports of Investigations* 2.

Corbin, J. E, and Kisling, D. C.

1983 The Adolphus Sterne Home, Preliminary Archaeological Investigations of a Mid-Nineteenth Century Plantation in Nacogdoches County, Texas. *Stephen F. Austin State University, Papers in Anthropology* No. 4, Nacogdoches, Texas.

Few, Joan

1986 Glorianna Homestead, 41JP94: An Archaeological and Historical Explanation of a Nineteenth Century East Texas Piney Woods Agricultural Adaptation. Unpublished Master's thesis, Anthropology, University of Houston.

1987 Functional Determination and Spatial Analysis of Ceramic Shards From 41JP94, Jasper County, Texas; a Nineteenth Century Plantation Site. *Houston Archeological Society Journal* No. 88, August, 1987.

Gaston, M. F.

1983 *Blue Willow*. Collector Books, Paducah, Kentucky.

Godden, G. A.

1964 *Encyclopaedia of British Pottery and Porcelain Marks*. Schiffer Publishing, Pennsylvania.

Greer, G. H.

1981 *American Stonewares,* Schiffer Publishing, Pennsylvania.

Hudgins, J. D.

1987 Post West Bernard (41WH16)—Republic of Texas Armory, 1837-1839, Wharton County, Texas. *Bulletin of the Texas Archeological Society* 57:143-163 (for 1986).

Lewis, K., and Haskell, Helen

1981 *The Middleton Privy: Discard Behavior in: The Archaeological Record.* Institute of Anthropology and Archaeology, University of South Carolina, Columbia.

Majewski, Teresita and O'Brian, M. J.

1984 An Analysis of Historical Ceramics from the Central Salt River Valley of Northeast Missouri. *Cannon Reservoir Human Ecology Project, American Archaeology Division, Department of Anthropology, University of Missouri-Columbia,* No. 3.

Miller, G. L.

1980 Classification and Economic Scaling of 19th Century Ceramics. *Historical Archaeology* 14: 1-39.

Moir, R. W.

1987 Nineteenth Century Ceramic Traditions in North Central Texas: Examples and Interpretations. Paper presented at the 58th Annual Meeting of the Texas Archeological Society, Waco, October 31,1987.

Nelson, G. C.
1960 *Ceramics*. Holt, Rinehart & Winston, New York.

South, Stanley
1977 *Method and Theory in Historical Archeology*. Academic Press, New York.

A Key to Eleven Common Genera of Carbonized Wood Using Scanning Electron Microscope Photographs

Michael W. Pendleton

ABSTRACT

Eleven genera of carbonized wood commonly found in the southern United States are keyed, using characteristics that can be observed using darkfield light microscopy. Scanning electron photomicrographs (SEM) are used to demonstrate these characteristics, since SEM photos have much greater depth of field than do light photomicrographs.

INTRODUCTION

With increasing interest in prehistoric environment and diet, archeologists have developed techniques (Struever 1968; Pendleton 1979) that efficiently recover great quantities of botanical material from archeological sites. Much of this plant material consists of carbonized wood, since this material does not readily decay in soil contexts in sites (Western 1963). Carbonized wood fragments commonly retain considerable morphological detail (despite occasional heat cracking), which allows identification to genus level in many cases (Maby 1932). However, many of the techniques for examining such wood charcoal characteristics are laborious (Leney and Casteel 1975) because they can involve the production of thin sections embedded in paraffin and synthetic resins. Such techniques may not be available to archeologists in on-site situations where identification of large numbers of charcoal samples may be required (Dimbleby 1967).

Leney and Casteel (1975) have developed a simplified procedure for preparing charcoal specimens for identification. Instead of embedding and thin-sectioning the sample (Carlquist 1975), Leney and Casteel (1975) suggest that the transverse (Figure 1, area A), tangential (Figure 1, area B), and radial (Figure 1, area C) planes of section for each unknown charcoal fragment be produced first by breaking the specimen along the appropriate planes. Leney and Casteel (1975) note that the identification of a charcoal fragment prepared in this way is facilitated by the use of dark field incident light microscopy (Burrells 1961) in conjunction with keys such as those written by Panshin and DeZeeuw (1970). However, a dark field light microscope has a very limited depth of field in a single focus plane, whereas images of charcoal obtained by scanning electron microscopy have much greater depth of field than those obtained by light microscopy. Although scanning electron micrographs of charcoal specimens have great depth of field, a dark field light microscope can be focused through several focus planes and serially show much of the detail obtained using an electron microscope. Scanning electron photomicrographs (Figures 1–35) of 11 common charcoal genera are provided, together with a taxonomic key incorporating characteristics that can be observed using a light microscope.

MATERIALS AND METHODS

All 11 genera of charcoal used in this study were obtained from the Texas A&M Ethnobotany Laboratory. They included hickory, *Carya* sp. (Figures 1, 12, 13, 14), willow, *Salix goodingii* (Figures 2, 3, 4, 5), elm, *Ulmus capestris* (Figures 6, 7, 8), oak, *Quercus marilandica* (Figures 9, 10, 11), ash, *Fraxinus* sp. (Figures 15, 16, 17), walnut, *Juglans cinerea* (Figures 18, 19, 20), cottonwood, *Populus deltoides* (Figures 21, 22, 23), birch, *Betula* sp. (Figures 24, 25, 26), beech, *Fagus sylvalica* (Figures 27, 28, 29), sycamore, *Platanus occidentalis* (Figures 30, 31, 32), and pine, *Pinus stobus* (Figures 33, 34, 35). These specimens were taken from living trees, identified to the lowest taxaonomic level possible, then carbonized in a kiln for 30 minutes at 350°F. Each uncoated charcoal specimen is a 1-cm cube mounted on aluminum scanning electron microscope stubs with liquid colloidal silver manufacted by Ted Pella, Inc., of Tustin, California. A Jeol JSM-25SII scanning electron microscope was used to produce Figures 1 through 35. The operating conditions of the microscope were: condenser setting at 12, tilt from 0 to 50°, 5 KeV, 15 to 700 magnification, contrast from 4.4 to 5.4, aperture 3, and a working distance of 48 mm. For each charcoal taxa, one tangential and two transverse sectional photomicrographs were made with the scanning electron microscope using Kodak Tri-X Pan Professional Film 4164 (ISO 320). Figures 33 through 35 are SEM photos provided by Kathy Cushman.

RESULTS

The following definitions will make the key to carbonized wood genera easier to use. A transverse section is produced by breaking the carbonized specimen across the longitudinal axis of a branch; the tangential section is produced by breaking a section of the specimen parallel to the growth (or cambial) layer and perpendicular to the parenchymous ray cells (Leney and Casteel 1975).

A tree cambium produces xylem cells (as well as fiber cells and thin-walled parenchymous cells) in annual increments that usually form growth rings that are visible in transverse section. Trees growing outside the temperate zone will not always show growth rings because there are no definite periods of growth and dormancy influenced by climatic changes over single seasons (Western 1963). The annual growth increment pattern for many wood species is for *early wood* (tissue produced in the spring) to have xylem cells that are larger in diameter and thinner walled (Figure 2, area D) than the *late wood* (produced in the summer and fall) (Figure 2, area E).

Growth increments in angiosperms (hardwoods like *Salix*) may have ring porous wood with a definite band of large early wood pores and a band of smaller late wood pores in transverse section (Figure 2). These pores are the vessel elements that are present in most of the angiosperms but not in the gymnosperms, except for the order Gnetales. Gymnosperms use tracheids rather than the vessels for water transport through tissues and are termed nonporous woods. If pores in a growth increment of an angiosperm appear to be the same size, the wood is termed diffuse-porous (Barefoot and Hankins 1982). Tyloses are thin walls of tissue that divide larger pores into separate compartments in transverse section.

Although most gymnosperms do not have vessels, their tracheid cells (which serve as the conductive cells in xylem much like vessels in the angiosperms) may change in diameter gradually or abruptly, depending on the tree's growth pattern (Figures 33-35).

The lines of cells that radiate from the center of a tree through both xylem and phloem in a transverse section of wood are the ray cells. Ray width and height are best observed in tangential section. Rays can be one cell wide (uniserate) in tangential section, two cells wide (biserate), or more than two cells wide (multiserate).

DISCUSSION

This key (Table 1) is based on ones developed by Volman (1981) and Panshin and DeZeeuw (1970). The charcoal taxa keyed in this study are all from common tree types that grow in the southern United States so this key should be useful to archeologists working there.

Although Leney and Casteel (1981) advocate the use of three sectional views of a carbonized wood fragment for positive identification, Panshin and DeZeeuw (1970) note that the transverse and tangential sections provide the most important information for identification for most wood taxa. Ray width cannot be determined by observation of a radial section. Therefore this key does not require the examination of the radial section, and radial views are not included in the illustrations. The transverse sectional views shown in the illustrations have important aids to identification, such as the depiction of scalariform perforation plates (Barefoot and Hankins 1982) in the transverse section of *Betula* (Figure 26).

Because scanning electron photomicrographs have great depth of field (Goldstein, et al. 1984), they provide more information for use in conjunction with a charcoal identification key than would either thin section or dark field light photomicrographs alone.

Table 1. Key to Identification of Eleven Genera of Carbonized Wood

OBSERVATION	NEXT STEP OR IDENTIFICATION
1. a-Vessels present (porous wood)	2
b-Vessels absent (nonporous wood)	***Pinus*** (Pine) (Figs. 33-35)
2. a-Early wood pores larger than late wood pores with a distinct transition from early to late wood (ringporous)	3
b-Early wood pores similar in size to late wood pores with an indistinct early to late wood transition (diffuse porous)	6
3. a-Broad rays present (some may be 12 to 30 cells wide)	***Quercus*** (Oak) (Figs. 9-11)
b-All rays less than twelve cells wide	4
4. a-Large early wood pores form contiguous groups of two to five pores	***Ulmus*** (Ellm) (Figs. 6-8)
b.Large early wood pores do not form contiguous groups of up to five pores	5
5. a-Large early wood pores are usually solitary	***Carya*** (Hickory) (Figs. 15-17)
b-Large early wood pores form a band one to two pores in width	***Fraxinus*** (Ash) (Figs. 15-17)

6. a-Pores vary considerably in size, yet the larger ones are readily seen without magnification, large early wood pores solitary, tyloses common.............***Juglans*** (Walnut) (Figs. 18-20)

b-Individual pores small and not visible without magnification, pores solitary and in multiples of two or more (tyloses present), rays fine.......................... 7

7. a-Rays 1 cell thick.. 8

b-Rays more than 1 cell thick.. 9

8. a-Tyloses commonly divide vessel in 2 halves, rarely more..***Salix*** (growth increment shown in area between D and E, Figure 2) (Figs. 2-5)

b-Tyloses frequently divide vessels into 3 or more sections.......................***Populus*** (Cottonwood) (Figs. 21-23)

9. a-Rays narrower than pores...***Betula*** (Birch) (Figs. 24-26)

b-Rays wider than pores... **10**

10. a-Broad and irregularly spaced rays of several widths separated by several narrower rays...***Fagus*** (Beech) (Figs. 27-29)

b-Rays usually all wide, numerous, and uniformly spaced...........................***Platanus*** (Sycamore) (Figs. 30-32)

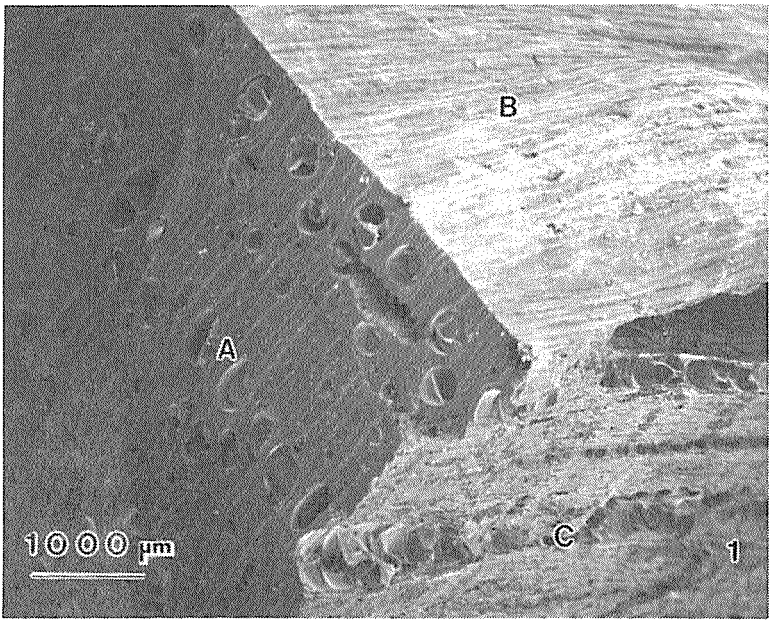

Figure 1. *Carya,* hickory; A, transverse section; B, tangential section; C, radial section; 14 x.

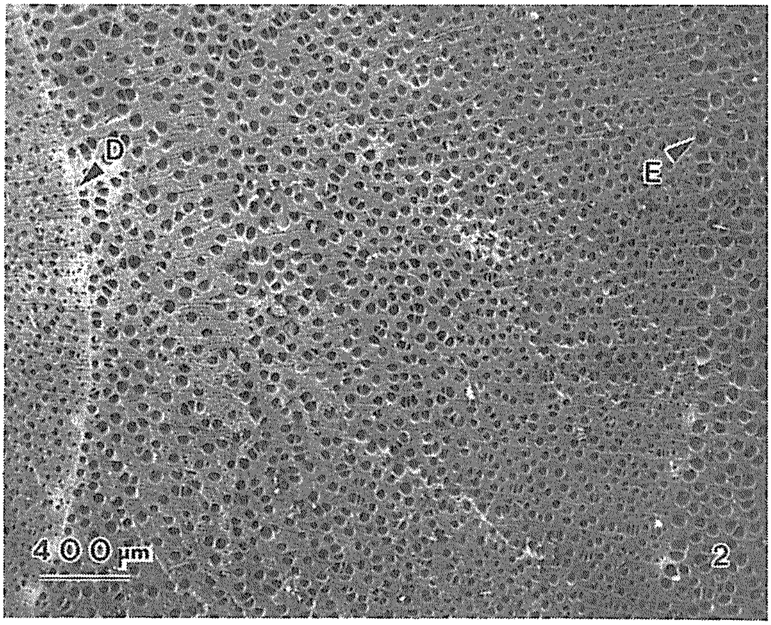

Figure 2. *Salix goodingii,* willow, transverse section. Growth increment between D and E; 28 x.

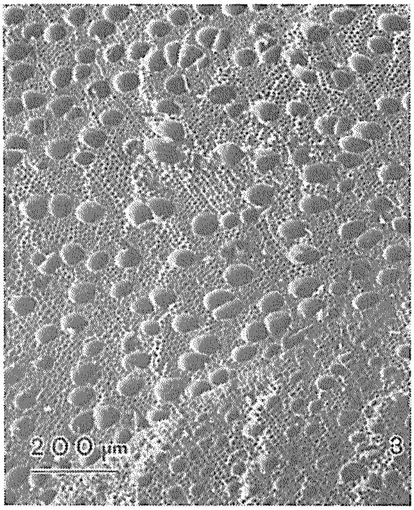

Figure 3. *Salix goodingii,,* willow, transverse section; 70 x.

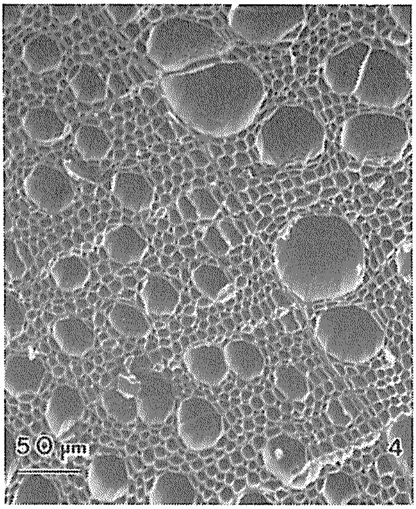

Figure 4. *Salix goodingii,,* willow, transverse section; 150 x.

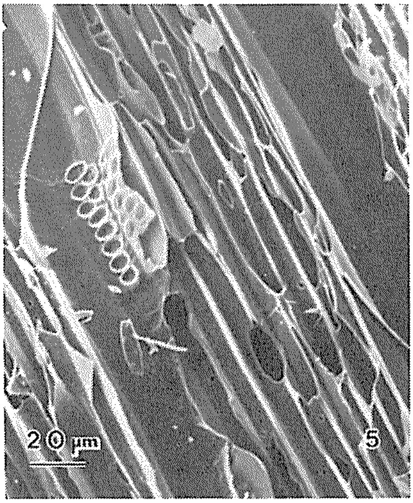

Figure 5. *Salix goodingii,* willow, tangential section; 335 x.

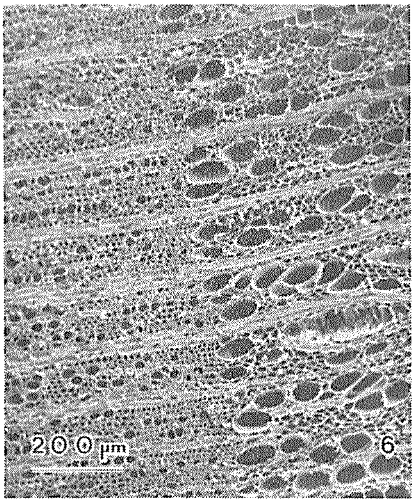

Figure 6. *Ulmus capestris,* elm, transverse section; 50 x.

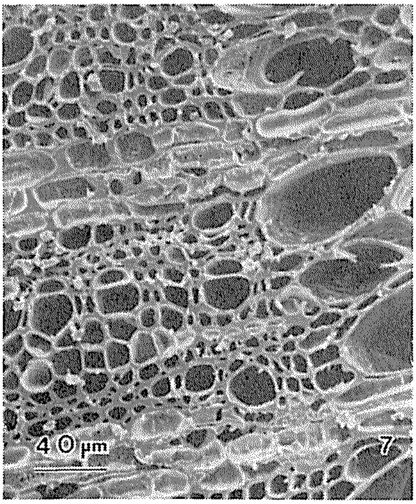

Figure 7. *Ulmus capestris*, elm, transverse section; 225 x.

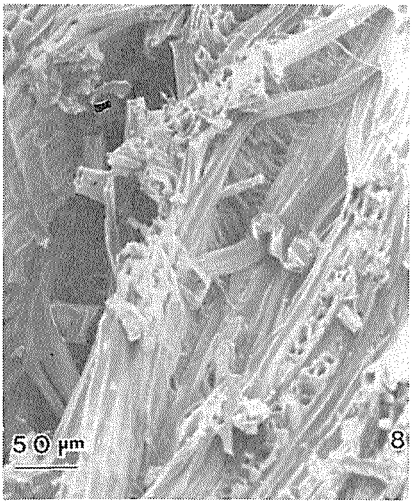

Figure 8. *Ulmus capestris*, elm, tangential section; 150 x.

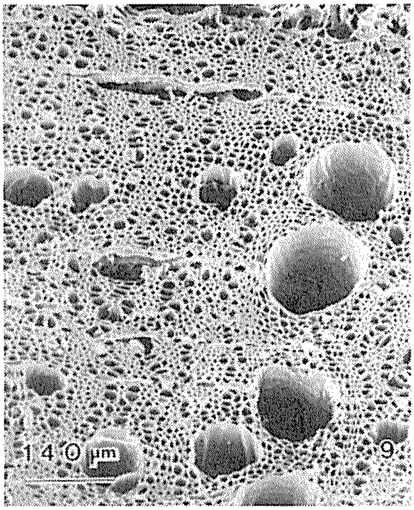

Figure 9. *Quercus marilandica*, oak, transverse section; 75 x.

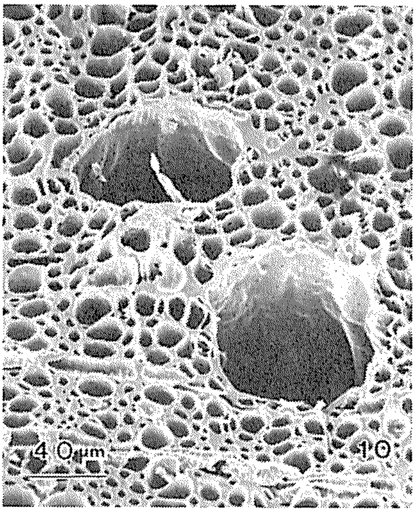

Figure 10. *Quercus marilandica*, oak, transverse section; 225 x.

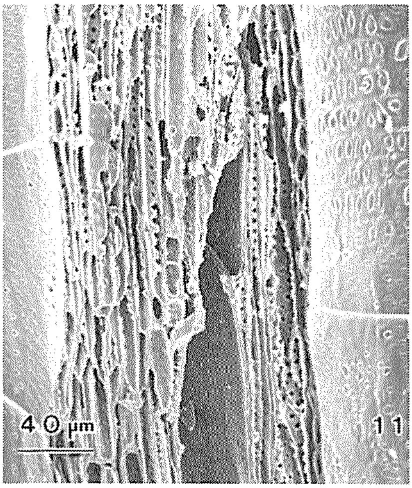

Figure 11. *Quercus marilandica*, oak tangential section; 75 x.

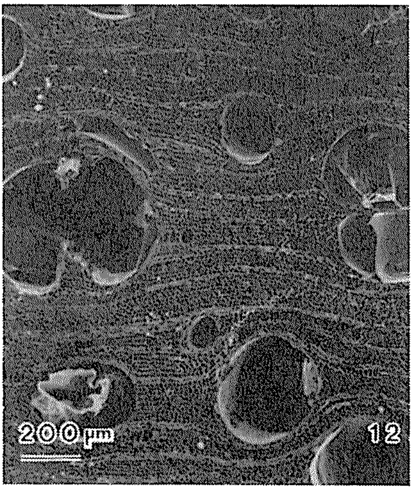

Figure 12. *Carya*, hickory, transverse section; 35 x.

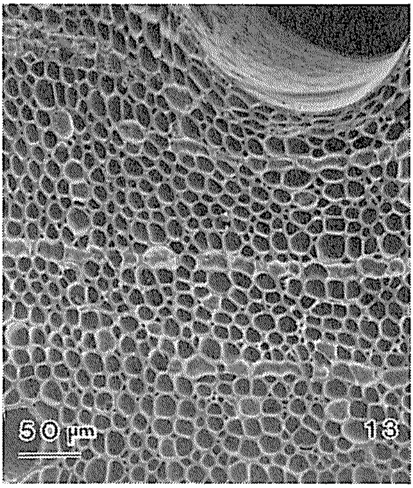

Figure 13. *Carya*, hickory, transverse section; 175 x.

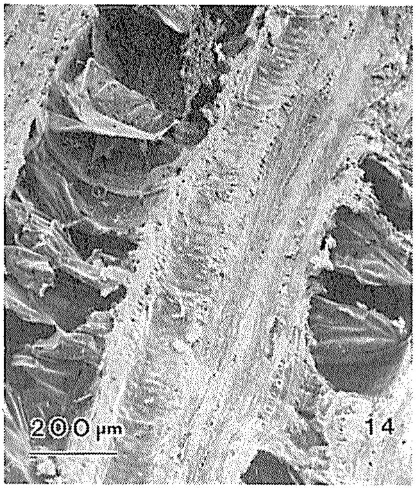

Figure 14. *Carya*, hickory, tangential section; 50 x.

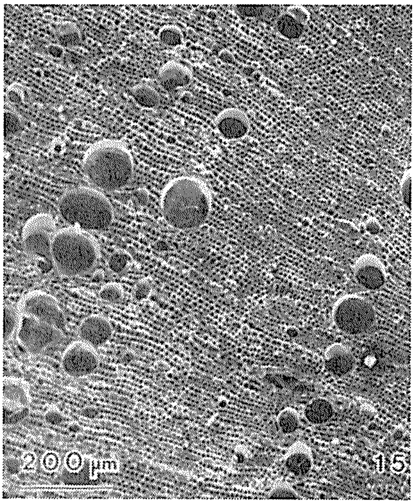

Figure 15. *Fraxinus*, ash, transverse section; 50 x.

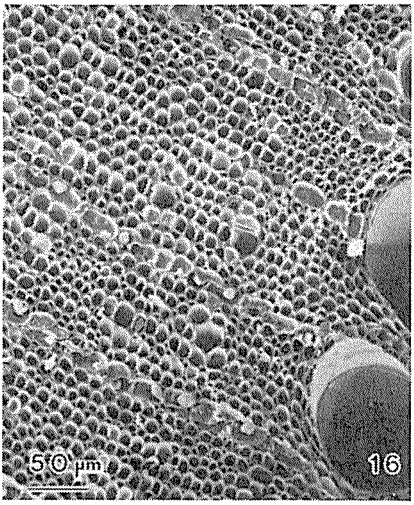

Figure 16. *Fraxinus*, ash, transverse section; 175 x.

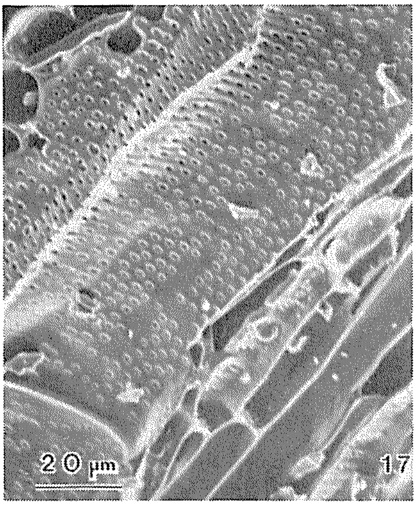

Figure 17. *Fraxinus*, ash, tangential section; 525 x.

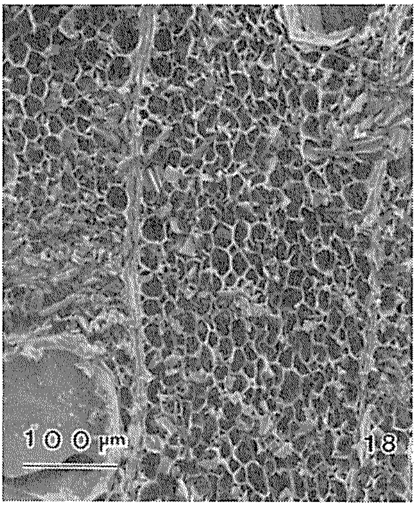

Figure 18. *Juglans cincerea*, walnut, transverse section; 110 x.

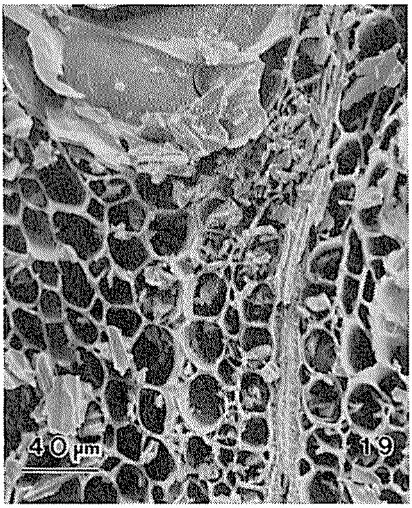

Figure 19. *Juglans cincerea*, walnut, transverse section; 225 x.

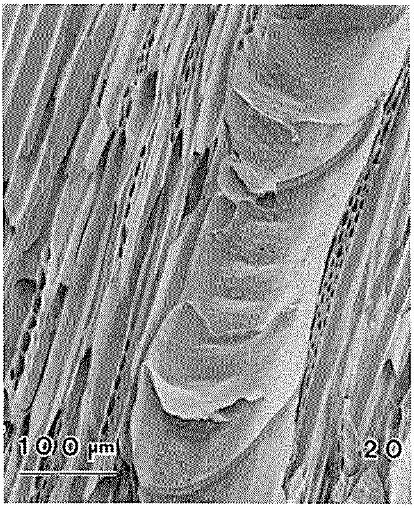

Figure 20. *Juglans cincerea*, walnut, tangential section; 150 x.

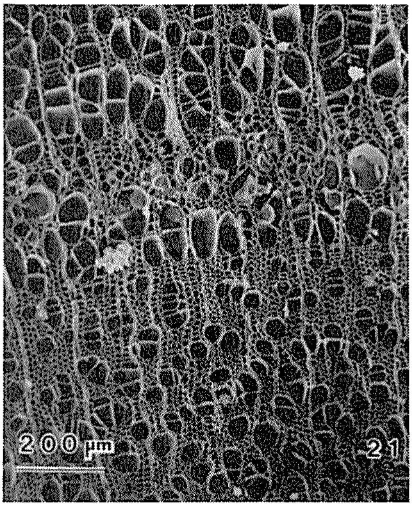

Figure 21. *Populus deltoides*, cottonwood, transverse section; 50 x.

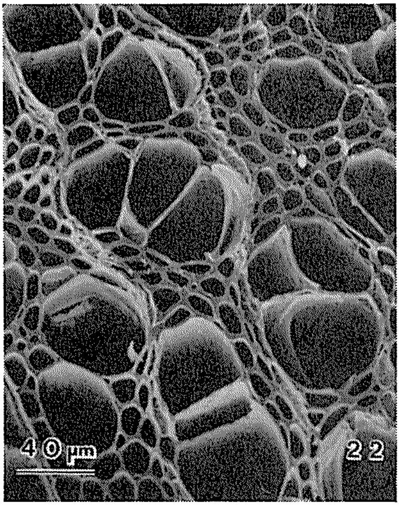

Figure 22. *Populus deltoides*, cottonwood, transverse section; 225 x.

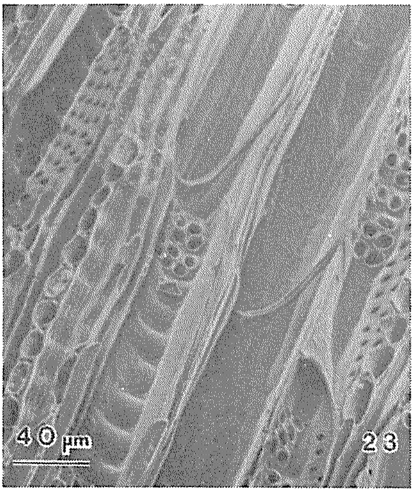

Figure 23. *Populus deltoides*, cottonwood, tangential section; 225 x.

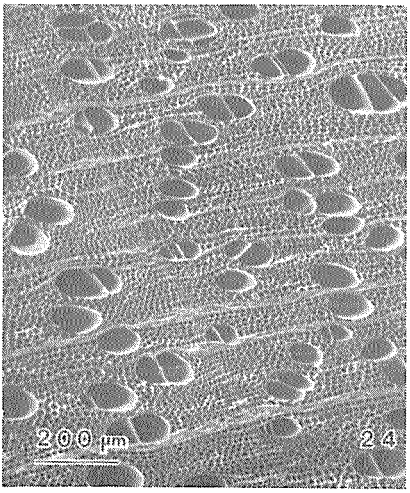

Figure 24. *Betula*, birch, transverse section; 50 x.

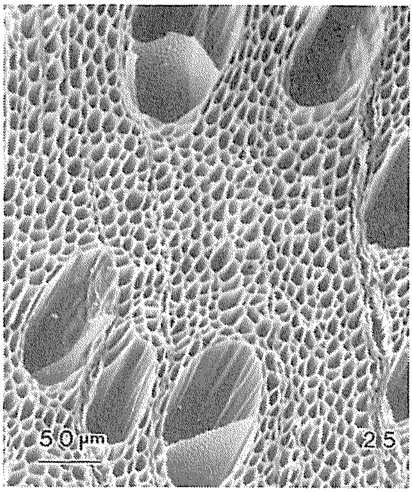

Figure 25. *Betula*, birch, transverse section; 150 x.

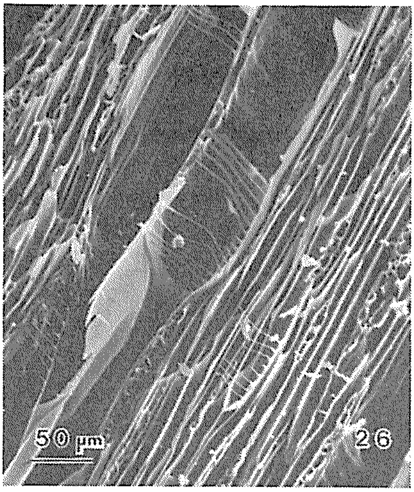

Figure 26. *Betula*, birch, tangential section; 150 x.

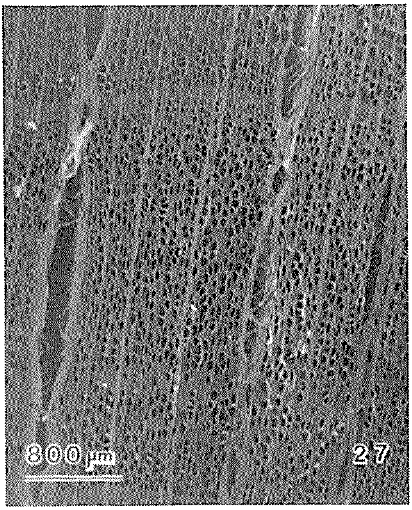

Figure 27. *Fagus sylvalica*, beech, transverse section; 15 x.

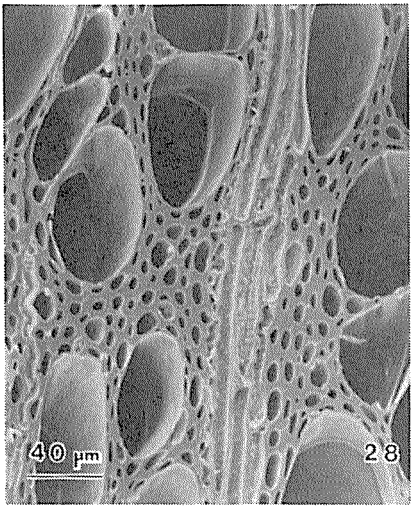

Figure 28. *Fagus sylvalica*, beech, transverse section; 225 x.

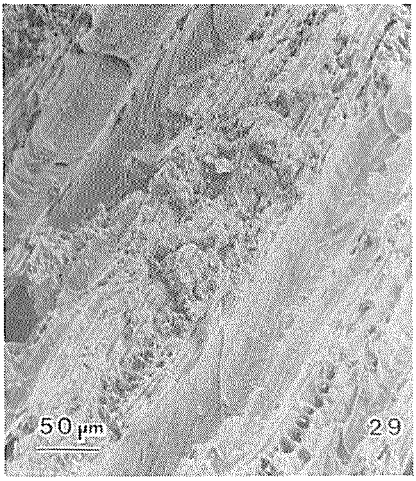

Figure 29. *Fagus sylvalica*, beech, tangential section; 150 x.

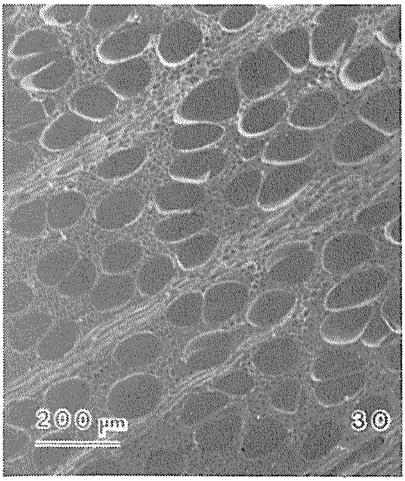

Figure 30. *Platanus occidentalis*, sycamore, transverse section; 58 x.

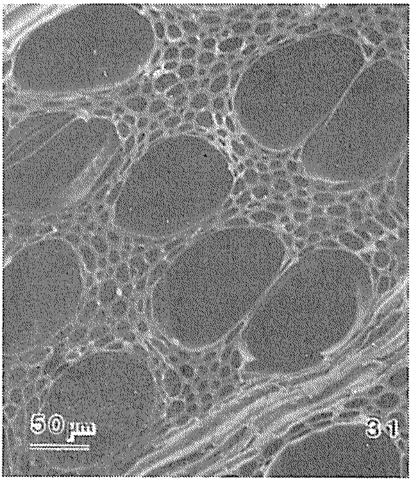

Figure 31. *Platanus occidentalis*, sycamore, transverse section; 170 x.

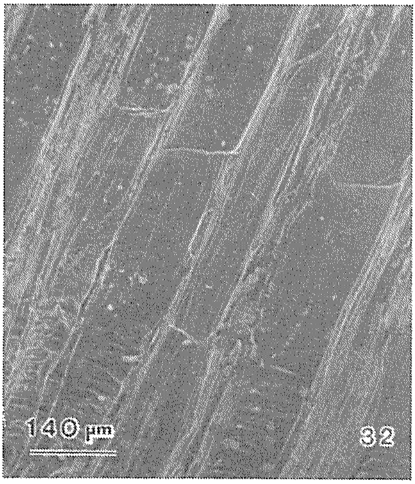

Figure 32. *Platanus occidentalis*, sycamore, tangential section; 85 x.

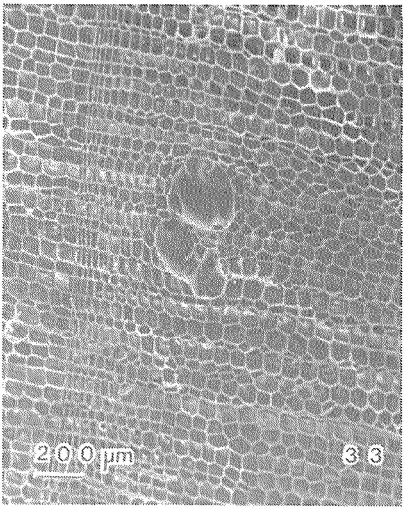

Figure 33. *Pinus strobus*, pine, transverse section; 35 x.

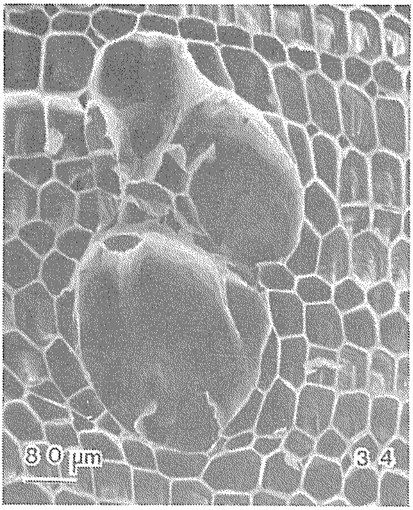

Figure 34. *Pinus strobus*, pine, transverse section; 85 x.

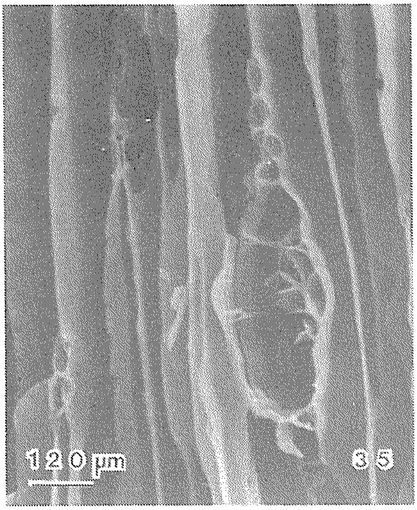

Figure 35. *Pinus strobus*, pine, tangential section; 100 x.

REFERENCES CITED

Barefoot, A. C., and F. W. Hankins
1982 *Identification of Modern and Tertiary Woods*. Clarendon Press, Oxford. pp. 14-15.

Burrells, W.
1961 *Industrial Microscopy in Practice*. Fountain Press, London. pp. 45-52.

Carlquist, S.
1975 Wood Anatomy of Onagraceae With Notes on Alternative Modes of Photosynthetic Movement in Dicotyledon Woods. *Annals of the Missouri Botanical Garden* 62:286-424.

Dimbleby, G. W.
1967 *Plants and Archaeology*. Baker Press, London. pp. 128-143.

Goldstein, J. I., D. E. Newbury, P. Echlin, D. C. Joy, C. Fiori, and E. Lifshin.
1984 *Scanning Electron Microscopy and X-ray Microanalysis: A Text for Biologists, Materials Scientists, and Geologists*. Plenum Press, New York. pp., 29-35.

Leney, L., and R. W. Casteel
1975 Simplified Procedure for Examining Charcoal Specimens for Identification. *Journal of Archaeological Science* 2:153-159.

Maby, J. C.
1932 The Identification of Wood and Wood Charcoal Fragments. *Analyst* 57:2-8.

Panshin, A. J., and C. DeZeeuw
1970 *Textbook of Wood Technology*. McGraw-Hill, New York. pp. 451-567.

Pendleton, M. W.
1979 A Flotation Apparatus for Archaeological Sites. *Kiva* 44:89-93.

Struever, S.
1968 Flotation Techniques for the Recovery of Small Scale Archaeological Remains. *American Antiquity* 33:353-362.

Volman, K. C.
1981 Paleoenvironmental Implications of Botanical Data from Meadowcroft Rockshelter. Thesis, Texas A&M University, Department of Anthropology. College Station, Texas.

Western, C. A.
1963 Wood and Charcoal in Archaeology. In: *Science and Archaeology*. Brothwell and Higgs, eds. Basic Books, Inc., New York. pp. 245-261.

Book Review

COLUMBIAN CONSEQUENCES, Volume I: Archaeological and Historical Perspectives on the Spanish Borderlands West. Edited by David Hurst Thomas. Smithsonian Institution Press, Washington, D.C. 503 pp, 58 maps and illustrations. 1989. $49.95 cloth .

This book is the first of a three-volume series that "addresses the social, demographic, ecological, ideological, and human repercussions of Columbus's arrival in 1492. These volumes are derived from a series of symposia at Society for American Archaeology annual meetings. Deliberately timed to precede the Columbian Quincentenary observances of 1992, this series explores the nature of early European-Native American interactions across the Spanish Borderlands, which run from San Francisco, California to St. Augustine, Florida." This first volume involves the western half of the Spanish Borderlands, including the southwestern United States and northwestern Mexico, Texas, and California.

Of particular interest to Texas archeologists is the middle section of the volume, "Texas and Northeastern Mexico," which includes an overview and a chapter on the material cultures of the mission Indians by Thomas R. Hester, a section on the Indians of Mission Rosario by Kathleen Gilmore, and chapters on the Guerrero missions of northern Mexico by Jack D. Eaton, *Rancho de las Cabras* by Anne A. Fox, the East Texas missions by James E. Corbin, and historic Lower Pecos rock art by Solveig A. Turpin. A tremendous amount of information is packed into the 108 pages of this section, and those interested in Texas archeology will greatly enjoy this synthesis of the most recent information available. We have come a long way from the Spanish Borderlands symposium held in San Antonio in the early 1970s, where Dee Ann Story had to characterize earlier researchers' view of Southern Texas as a "cultural sink," and Thomas N. Campbell encouraged us to get beyond the stereotypes of a general Coahuiltecan culture and research the rich diversity of ethnic groups and languages that existed before and during the initial Spanish contact. Indeed, these chapters are a concise report of the significant progress that has been made in the region during the last 15 years. This volume is a must for anyone who wishes to understand the archeology and ethnohistory of the early Historic Period in Texas and northeastern Mexico.

There are, however, some shortcomings in the book. I, for one, would like to have seen more focus on the early contact period and archeological complexes of northeastern Mexico. The Brownsville focus (phase) of the Rio Grande Delta is largely ignored, although we know, from the finding of glass arrowpoints, that there was substantial early contact. Also ignored are the early trading posts on the lower Texas coast and the expeditions up Padre Island. Certainly, not everything can be included in such a comprehensive volume, but the early contact period in the lower Rio Grande area is one of the greatest gaps in our present understanding of the Spanish Borderlands.

One has to read intensively and digest thoroughly the chapters on northwestern Mexico and California in order to begin to understand the changes in Spanish Law over time, the *encomiendas* grants of Indian labor, the labor drafts or *repartimientos* (which were outlawed in 1670), and the tribute relationship or *corregimiento,* system that replaced it (see McGuire and Villalpando, Chapter 10). This evolution of the Indian-Spanish relationships and royal law in northern Mexico had a great impact on what the crown permitted to happen (and supported by funding from the royal treasury) later on in northeastern Mexico and Texas. Perhaps due to some sensitivity on the part of the crown about Indian rebellions in New Mexico and elsewhere, the Texas missions escaped the more severe economic exploitation suffered in other areas; the Franciscans, Presidio soldiers, and Canary Islanders came to stay, not to conquer, rape, and run.

Some editorial flaws in the volume detract from the immense value of the work of more than a hundred eminent archeologists, historians, ethnohistorians, geographers, and Native Americans. For example, it is not always clear who inserted the endnotes in a chapter or what they mean (see Chapter 10). Some endnotes seem to challenge or quibble with the assertions made by the chapter author(s). Is this the junior author disagreeing with the senior author, or the editor challenging the authors' point? By reading the acknowledgements, it is possible to deduce that some endnotes are the direct result of reviewer comments.

I have not been able to locate the Figure 24-1 referred to in Kathleen Gilmore's initial paragraph (Chapter 14, page 231). If it is Hester's overview map (Figure 12-1, page 192) that should have been referenced, then where are the Cujanes, Coapites, and Cocos, which she was discussing? The maps, at least in the Texas section, are small, half-page illustrations that are difficult to read and comprehend. Corbin discusses seven missions and presidios in East Texas and western Louisiana, and seven are shown on Hester's map of Spanish missions and presidios (Figure 12-2, page 197), yet only six are identified on the map. Las Cabras is shown on the south bank of what must be the Medina River directly south of the San Antonio mission complex rather than on the San Antonio River to the southeast. The short-lived San Xavier missions on the San Gabriel River, barely mentioned in the text, are shown on this map, but the Orcoquizac complex (mission and presidio) on the lower Trinity is not shown. Mission Rosario is shown as just north of Fort. St. Louis in Figure 12-2, but the Rosario excavated and discussed by Kathleen Gilmore was near Goliad, south of the San Antonio River and Mission Espiritu Santo.

The editor of the volume was clearly impressed with Solvieg Turpin's work on the obviously historic rock art in the Lower Pecos region. She was permitted more illustrations than other authors of the section, and one of her illustrations (drawn by David G. Robinson) of rock art from the Hussie Miers site (41VV327) was used as a frontispiece at the beginning of each section and on the book's dust cover (although David is not credited up front in the book for his work). Again, unfortunately, there are problems with the map of Lower Pecos missions and presidios (Figure 18-1, page 280). This map has the headwaters of the San Antonio River at a point due south of the San Saba mission. I recently visited the Blue Hole on the campus of Incarnate Word College in the Olmos Basin in northern San Antonio, which is the official headwaters of the river, and, although it is dry right now, the Blue Hole is still there. A more significant error, however, is a purported "Presidio San Felipe" shown as located in Del Rio, Texas. I know of the San Felipe Springs there but have seen nothing in print that proposes that a Spanish presidio was located there. This must be an editorial error.

Much more could have been done with illustrations in this section on Texas and northeastern Mexico. Most are simply too small, and unecessarily so. Kathy Roemer's beautiful drawing of prehistoric and mission era lithic materials (Figure 13-1, page 216) and the photograph of arrowpoints from Mission Espiritu Santo, 41GD1 (Figure 13-2, page 221), are reduced to half size when, with a little bit of creative reformatting, these illustrations easily could have (and certainly should have) been reproduced at scale without increasing the number of pages.

I may seem overly critical, but I must also admit that there are some subtle gems tucked away in the text that are significant statements of current archeological theory and beliefs, based on the tremendous amount of research conducted in the region over the last 15 years. I note, for example, that both Hester and Gilmore dismiss Herman Smith's hypothesis of a Late Prehistoric Carib migration to account for the origin of the Karankawa along the Texas central coast. Their statements represent a consensus of the majority of Texas archeologists and ethnohistorians on this issue. Hester also cites recent research by Newcomb and Campbell to indicate that the Tonkawa, until recently believed to be tied to the Late Prehistoric Toyah phase of Central Texas, actually entered Texas from the Oklahoma region early in the seventeenth century, citing their recent manuscript submitted for publication in the Smithsonian's forthcoming Plains volume of the *Handbook of North American Indians*

Hester now dates the introduction of the bow and arrow to the Texas-Mexico borderlands as "after A.D. 500-700" (page 193) but still maintains a fairly late date (A.D. 1200; page 215) for the start of Late Prehistoric times in the southern Texas area. He does recognize two forms (triangular and lanceolate) within the Guerrero arrowpoint type (pp 221-222 and Figure 13-1), which fully satisfies our friendly private dispute (but I still believe there is a trend to more of the lanceolate form nearer the coast, such as at Missions Rosario and Espiritu Santo [Figure 13-2]).

Overall, ***Columbian Consequences, Volume 1*** is clearly a superior effort. It contains in one volume a tremendous amount of information about the western Spanish Borderlands, which even the most widely read individual would have difficulty synthesizing from extensive and extremely divergent sources. It is not a work that can be absorbed in one sitting; rather, it will require rereading and restudy over a considerable amount of time to be fully appreciated. Therefore, this is not merely a commemorative volume; rather, it is a significant synthesis of currently available information that should serve as a baseline for future research and rethinking of borderlands history, archeology, and anthropology. The Editor and the Smithsonian are to be congratulated on this outstanding achievement.

Be sure to read David Hurst Thomas's "Cubist Perspective" essay (pp 1-14). Cubism in this instance refers to a more comprehensive, multidimensional, multivariate appproach to understanding and appreciating our rich and diverse Indian and Spanish cultural heritages. One should be wary of overly simplistic, unidimensional explanations of how the TexMex culture (and language) of today's borderlands came about, or what its evolution portends for the future of this region of the North American continent.

I look forward with anticipation to the publication of Volume 2, which will deal with the Eastern Borderlands. It will be particularly interesting to see how the new volume will be integrated with the present one, perhaps through some overlap in terms of the French-Spanish interaction in East Texas and Louisana, or the first cattle drives from the ranches along the San Antonio River to New Orleans during the American Revolution.

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J. B. Sollberger— see article by Patterson on p. 19.

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The *Bulletin of the Texas Archeological Society* (ISSN 0082-2930) publishes original papers in the field of American archeology. Emphasis is placed on Texas and adjoining areas in the United States and Mexico; papers on other ares also are considered. Articles concerning archeological technique, method, or theory are accepted. Preference is given to members of the Society.

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