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2. Technological Organization and the Structure of Inference in Lithic Analysis: An Examination of Folsom Hunting Behavior in the American Southwest

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Introduction

Many archaeologists have characterized lithic studies as trivial with a focus on methodological contributions at the expense of theoretical issues (Cross 1983; Dunnell 1980; Thomas 1983; Torrence 1989a). However, the publication of a seminal series of articles on technological organization by Binford (1983a, 1983b) has resulted in a great deal of theoretical development in the study of stone tools (e.g., Bamforth 1986; Bleed 1986; Keeley 1982; Nelson 1991; Shott 1986). In particular, the growth of theory in lithic studies has been encouraged by the adoption of a perspective that views technology as a buffering mechanism for the effects of subsistence risks (Edmonds 1987; Jochim 1989; Torrence 1989a, 1989b). One particular danger that has arisen because of the introduction of theory into lithic studies that were previously empirical in character is the failure to consider the relationship of lithic data to theoretical concepts (Bamforth 1989).

The logical linkage of the conclusions drawn from observations about lithic artifacts is referred to as the structure of inference. An explicit linkage of inferences at each successively higher level of explanation is needed to strengthen arguments about past human behavior. This linkage is hierarchical with complex inferences ultimately founded on basic reconstructions of stone tool manufacturing and using behavior. Inferences about technological organization require more than the assignment of an artifact class to an organizational strategy (e.g., Gramly 1980). Little knowledge is gained when a concept such as tool curation is coopted as a method of inference. This type of inferential strategy is an attempt at taking a methodological shortcut. Concepts are important for advancing descriptions about empirical observations and serve as valuable tools to promote general understanding. Methods describe the manner in which concepts are articulated to provide accurate statements about the organization of past human behavior. Improvements in the study of technological organization require a focus on methodological problems rather than conceptual issues.

The greatest difficulty that lithic analysts face is attempting to accurately address theoretical issues while avoiding methodological pitfalls. The accuracy of increasingly sophisticated levels of inference is necessarily tied to the accuracy of reconstructions of past behavior and understanding of depositional history in the archaeological record. Successively higher levels of inference must be built from the ground up and inferential shortcuts must be avoided if lithic analysts aspire to confront processual issues in a productive manner. The relationship between technological organization and archaeological data is bridged by behavioral observations. An emphasis on reliable inferences about behavior is the cornerstone of technological studies (Bamforth 1991b; Bradley 1991; Collins 1975; Jochim 1989; Kuhn 1991; Nelson 1991; Sheets 1975; Torrence 1989a, 1989b). In order to achieve reliable inferences about behavior, it is necessary to build methodologies for diagnosing behavior from the archaeological record (Sabloff et al. 1987) as well as test implications from theoretical arguments. It is important to recognize that these inferential procedures are interactive (Binford 1989) and it is necessary to work back and forth between each domain to identify and verify patterning.

Several ingredients lead to strengthening inferences about technological organization. An accurate reconstruction of the behavioral context of tool use is the foundation of organizational studies. Odell (1980) previously argued for greater emphasis on behavioral inference in stone tool analysis. This paper links the call for a more behavioral approach in lithic analysis to the theoretical goals of organizational studies. In order to understand technological behavior, it is necessary to view tools in the dynamic context of use and discard rather than static typological classifications (Bradley 1991:369). While the study of stone tools is limited by a lack of suitable analogs, it is endowed with information about behavioral sequences. Because stone tool manufacture is subtractive (Collins 1975), the processes which have gone before are often manifest on the artifact but equifinality limits the depth of any technological reconstruction (Keeley 1980).

Technological operations applied in the manufacture of stone tools are often discernible and may reveal a sequence of procedures. Complex sequences such as biface manufacture are especially valuable sources of data on serial production (e.g., Ahler 1986; Amick 1985; Callahan 1979; Johnson 1989; Young and Bonnichsen 1985). Although evidence of earlier manufacturing processes are sometimes obliterated by later flaking, stone tool analysis provides inferences about the type of blank used and its mode of production, and the subsequent processes of manufacture. The raw material used to manufacture a stone tool reflects toolstone sources, procurement activities, and mobility ranges.

Because the sequence of flake removal and breakage during manufacture or use is identifiable on stone tools, it is possible to identify a sequence of behavioral events resulting in loss or discard. Beckett (1983) reports Folsom points of non-local stone at Rhodes Canyon in the San Andres Mountains of south-central New Mexico. Analysis of the sequence of events leading to the deposit of these artifacts provides much more information. One of these points was manufactured from Chuska chert which is only available in the Chuska Mountains about 390 km northwest of Rhodes Canyon. This point was broken by an impact fracture resulting in loss of this midsection fragment which remained on the surface long enough to acquire a thin patina. It is likely that this patina required at least a few thousand years to develop. This patinated artifact was then recovered and battered using the bipolar technique in an attempt to obtain functionable sharpedged flakes. The flake scars from the battering are unpatinated.

Interpreting this projectile point in terms of a behavioral sequence results in a stronger conclusion. The dynamic sequence of breakage and loss followed by later recycling undermines the static interpretation of this artifact as accurate evidence of Folsom occupation at this locality. The recycling evidence also compromises the significance of the non-local Chuska chert as a measure of mobility. This example is not comprehensive because analysis of stone tools in terms of a behavioral sequence may be conducted at many different levels. Nonetheless, placing artifacts within the context of behavior helps to avoid the inaccurate conclusions generated by static typological analyses.

The Rhodes Canyon example illustrates a small amount of the complexity of behavioral events between manufacture and discard of a stone tool. This concept has been expressed in terms of artifact "life-histories" (McAnany 1988); regional "reduction trajectories" (Johnson 1989); and the "flow of stone" through time and across space (Ingbar 1991, 1992). These types of analytical approaches aim to place tools within the context of behavioral sequences by focusing on the interrelationship of tool reduction and mobility. Technological dynamics occur at various scales ranging from regional landuse to intrasite spatial patterns.

At the Shifting Sands Site, a Folsom-Midland bison kill and campsite in western Texas, it has been suggested that the behavioral sequence of events at the site conditioned tool using behaviors (Amick et al. 1989; Amick and Rose 1990; Hofman et al. 1990). In this case, decisions were made to conserve or to consume stone tools in the context of anticipated needs. Shifting Sands appears to represent a bison kill and butchery event followed by hideworking, retooling, and other domestic activities. Flake knives and scrapers used in butchery are quite large and seem to have been conserved in anticipation of future tool needs. In contrast, the stone tools associated with domestic activities following the kill and butchery are often completely consumed. Casual flake tools are small and usually contain multiple working edges. Endscrapers are usually exhausted and several are smashed by radial fracture (Frison and Bradley 1980:97-99) to produce burin tools. Many heavy butchery tools were scuttled to reduce transport costs when the site was abandoned. Thus, this assemblage contains the paradoxical combination of both conservation and consumption of tools. Viewing this assemblage in terms of a changing behavioral sequence suggests that the perception of toolstone needs changed from conservation to consumption during the course of this occupation. These perceptions may have also depended on individual needs.

The use of artifact refitting and spatial analysis is often capable of defining the decision making that conditioned technological behaviors (e.g., Cahen et al. 1979). Refitting of resharpening flakes onto chopping tools at Stewart's Cattle Guard (Jodry and Stanford 1992), a Folsom kill/butchery site in south-central Colorado, demonstrates the utility of integrating lithic reduction sequences with spatial patterning to reconstruct an episode of tool using behavior. In this case, butchery was conducted in a systematic fashion as work progressed from one animal to the next, periodically pausing to resharpen the chopper which was discarded on the spot after butchery was complete. Although this example is limited, it provides greater insight into technological behavior than the simple association of a chopper with a bonebed.

Inferences about technological organization rely on accurate reconstruction of behavior. Behaviors related to procurement, design, maintenance, retooling, recycling, conservation, waste, caching, discard, and scavenging are commonly invoked in arguments about technological organization which makes it necessary to view the archaeological record in these terms also. Another useful strategy in the study of technological organization depends on building appropriate frames of reference (Binford 1991a) and distinguishing inferences about parts of systems from inferences about entire systems. Integration and comparison of lithic data with other (non-lithic) datasets is fundamental to improving the structure of inference in lithic analysis as well as being essential for making lithic studies relevant to archaeology. While specialization has the potential to improve the reliability of our methods, it is crucial that specialized studies be integrated with our knowledge as a whole. Gifford-Gonzales (1991) has recently emphasized this same position with respect to faunal analysis.

Folsom Land Use in the American Southwest

This paper considers the organization of Folsom hunting behavior in New Mexico and west Texas. The data used to investigate this problem were compiled from the firsthand examination of 375 Paleoindian site records and 1005 Folsom-Midland points, 307 Folsom preforms, and 879 channel flakes. The site record data were compiled from files at the Laboratory of Anthropology of the Museum of New Mexico during July 1991. Artifact data were gathered from numerous private and public collections. Folsom land use and hunting behavior are investigated from several aspects including large scale distributions of artifacts and toolstone use, comparison to modern hunter-gatherers, patterns of weaponry retooling, off-site activities, and variation in weaponry manufacture.

The use of weaponry related artifact classes in this study reflects some pragmatic constraints in the large scale study of Folsom settlement and technology. First, many of the artifact collections that were used to compile these data contained stone tools which were diagnostic of other time periods. The Laboratory of Anthropology holds records of 86 Paleoindian sites with artifacts diagnostic of Folsom occupation. Thirty-six of these sites represent isolated Folsom point finds and 31 of the remaining 50 Folsom sites contain multiple components. Points which are diagnostic of the later Paleoindian Cody complex are found at 17 of the Folsom multicomponent sites. Although the cooccurrence of Folsom and Cody points suggests an interesting correspondence in land use patterns, the mixture of these occupations is especially troublesome because of the numerous toolkit similarities shared by these two cultures (Frison 1987, 1991:125-136; Frison and Bradley 1980; Irwin and Wormington 1970; Wilmsen and Roberts 1978). Consequently, it cannot be certain that tool assemblages from Folsom sites without secure stratigraphic control are unmixed with later components.

The only reliable Folsom diagnostics are projectile points, preforms, and channel flakes. Examples of these artifact types are shown in Figure 1. These stone tools are related to weaponry which is used to infer hunting behavior as well as the lithic procurement and maintenance patterns associated with hunting gear. It remains to be demonstrated that Folsom and Midland points are not elements of the same toolkit (see Bradley 1991:373-379 and Hofman et al. 1990 regarding these arguments), as a result, both types are included in this analysis under the general category of Folsom. Further evidence of the technological relationship of these two types is presented later in this paper. Folsom points are typically distinguished by a broad longitudinal flute on at least one face while Midland points exhibit similar flaking technology but lack fluting. These stone points functioned as weapon tips and may have served as cutting implements. Folsom preforms are also characterized by fluting and represent artifacts which were shaped like projectiles but discarded before completion. Preforms usually represent failures that occurred during manufacture, especially during fluting. Channel flakes are the distinctive byproduct of Folsom fluting and indicate point manufacture.

Folsom Site Distributions

It is assumed that differences in land use and hunting behavior reflect a response to the environmental constraints that define Folsom adaptive patterns. New Mexico provides an excellent laboratory to address this problem because it contains a broad diversity of landforms across an area of 46,848 square kilometers. Eastern New Mexico is included within the Great Plains, southcentral and southwestern New Mexico are part of the Basin and Range, northwestern New Mexico is contained within the Colorado Plateau, and the southern Rocky Mountains extend into north-central New Mexico.

Evidence of Folsom occupation in the Basin and Range of New Mexico is restricted to lithic artifacts. Folsom campsites are known from the Basin and Range (Judge 1973), but it has generally been assumed that Folsom hunters are oriented toward the Great Plains where numerous bison killsites are reported (e.g., Hester 1972; Howard 1935; Sellards 1952; Wendorf and Hester 1962; Wormington 1957). In fact, Folsom adaptations in the American Southwest are considered to reflect a specialized economy centered on bison hunting (Irwin-Williams 1977:292; IrwinWilliams and Haynes 1970:63).

Figure 2 shows the distribution of Folsom sites in New Mexico according to the records of the Laboratory of Anthropology. This figure includes data gathered from the 86 Paleoindian sites in New Mexico reported to contain Folsom points (Midland points are not included in these totals). Each Paleoindian site record was reviewed and scored according to the reported frequency of Folsom points. Scores ranged from one to nine using the following formula: 1=isolates and sites with one

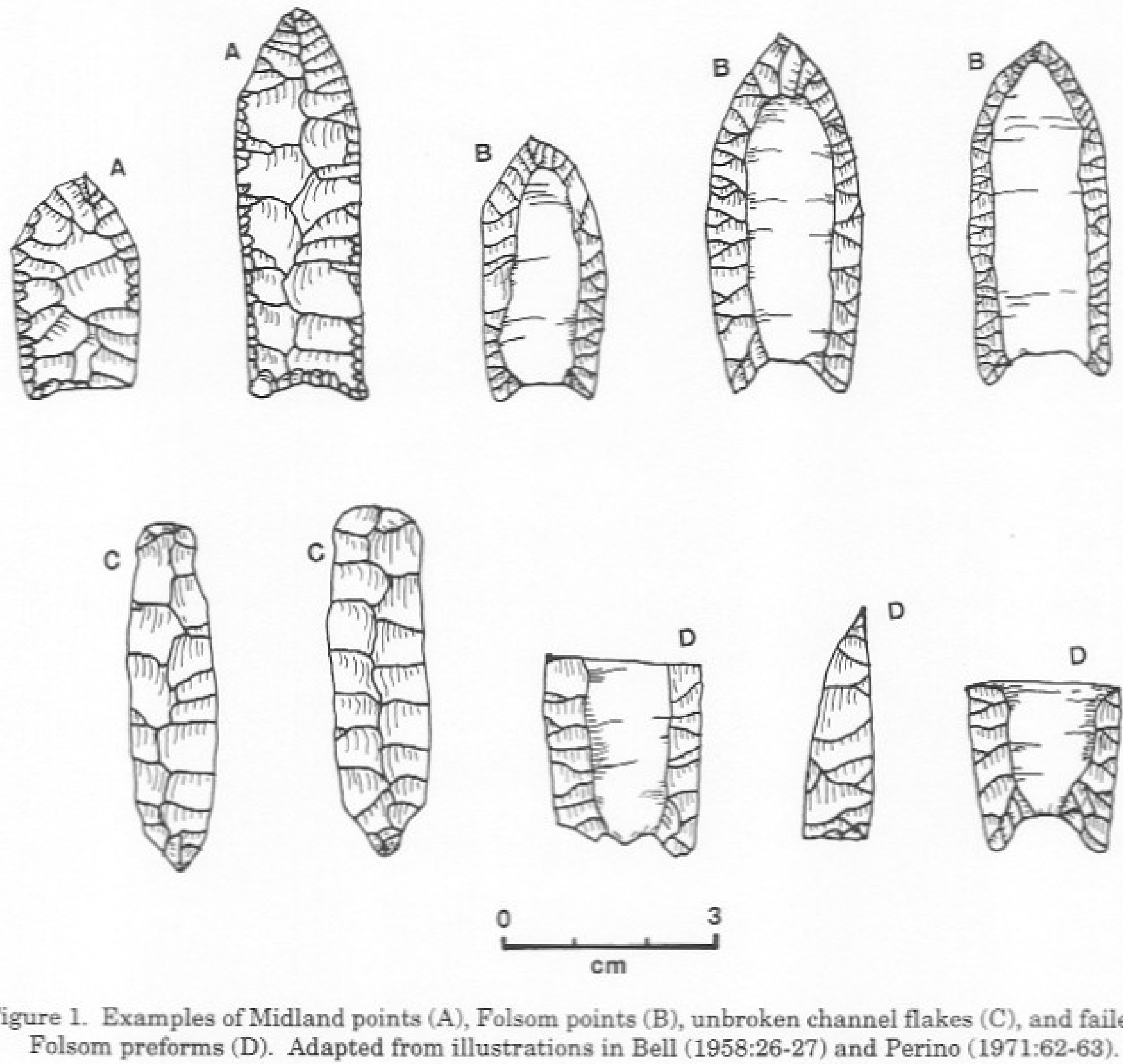

Figure 1. Examples of Midland points (A), Folsom points (B), unbroken channel flakes (C), and failed Folsom preforms (D). Adapted from illustrations in Bell (1958:26-27) and Perino (1971:62-63).

point, 2=two points, 3=three or four points, 5=five or six points, 7=seven to ten points, 9=more than ten points.

The recorded distribution of Folsom sites suggests a predominance in the San Juan Basin of the Colorado Plateau province in northwestern New Mexico and in the Great Plains region in eastern New Mexico. Additional concentrations are present in the Rio Grande Valley and adjacent basins lying within the Basin and Range province. Finally, a scatter of Folsom campsites are reported along the front range of the Southern Rockies. The apparent absence of Folsom sites in southwestern New Mexico is most likely a function of the generally poor survey coverage in this part of the state (Stuart and Gauthier 1988:222-226). While the distribution of Folsom sites is probably biased by uneven survey coverage and variable land surface erosion,

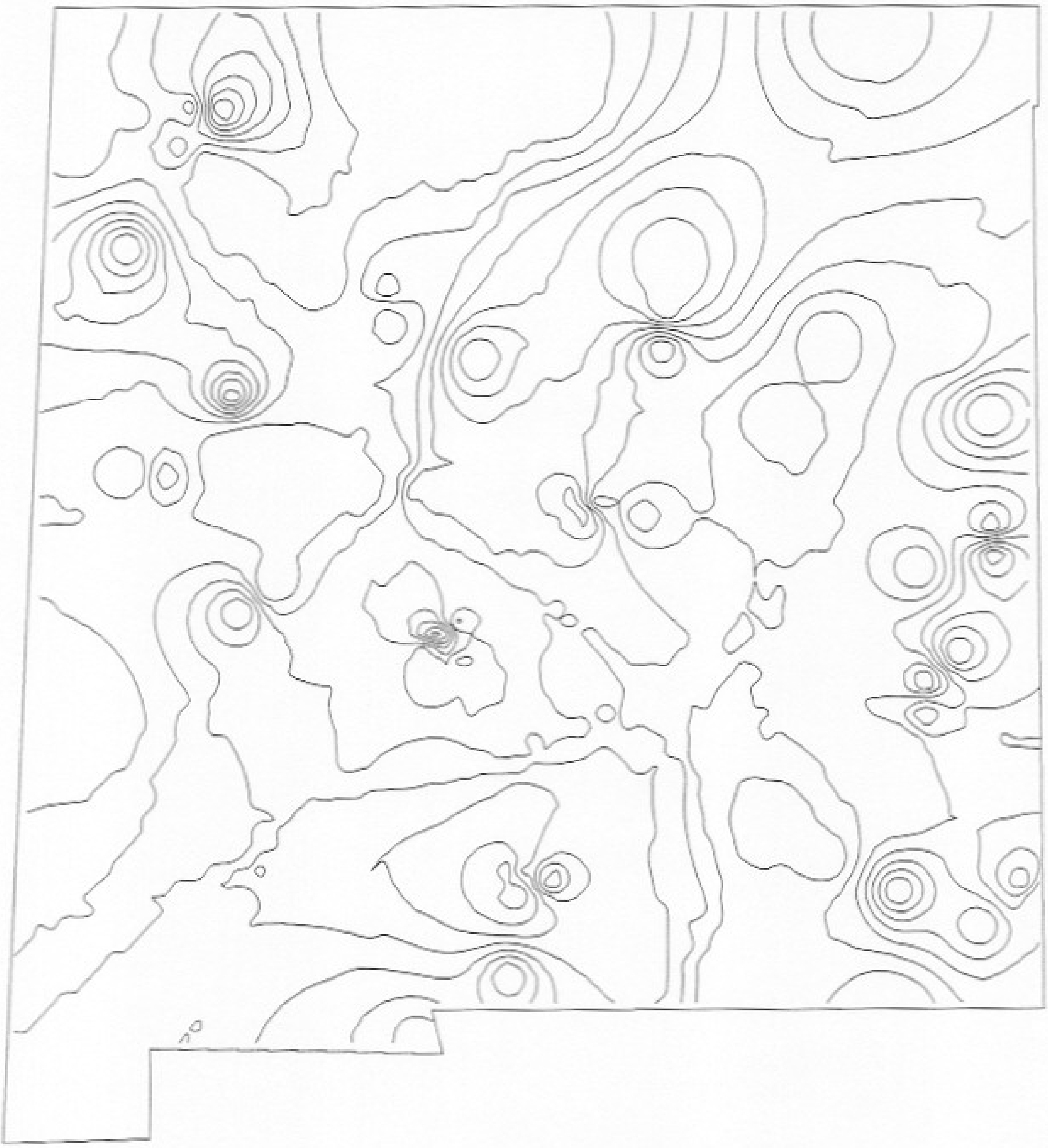

Figure 2. Distribution of Folsom points in New Mexico from records at the Laboratory of Anthropology.

this map suggests that Folsom groups used all of the major physiographic provinces in New Mexico.

Recent evidence of the use of upland and montane areas by Folsom and late Paleoindian groups has been noted in the Northwestern Great Plains and central Rocky Mountains (Frison 1988; 1991:480; Frison et al. 1986; Naze 1986). Successful occupation of these highland areas requires exploitation of upland game animals (e.g., deer, elk, and bighorn sheep) and plant resources. Examination of the Folsom sites recorded in New Mexico suggests that there is little evidence of highland occupations which might relate to alternative land use patterns. Figure 3 presents a histogram of the number of Folsom sites recorded by the Laboratory of Anthropology by 1000 foot intervals of elevation AMSL. Although the accurate assessment of environmental setting depends on the site location, these data suggest that highland areas were rarely used by Folsom hunters in New Mexico.

New Mexico is an uplifted plateau which dips to the southeast where elevations drop to about 3000 feet AMSL. Forest vegetation is found above 7000 feet and mountain ranges commonly rise above 10,000 feet with a few extending to 12,000 feet AMSL. The data illustrated in Figure 3 show that no Folsom sites are found above 8380 feet AMSL. All of the Folsom sites recorded above 7320 feet AMSL are isolated artifacts. For the most part, Folsom sites in New Mexico are found in basin, plain, and foothill settings with elevations reflecting local base level changes. A few small upper elevation sites (above 7000 feet AMSL) are clustered in the highland areas south and east of the San Juan Basin (Broster 1983; Broster and Harrill 1982; Broster and Ireland 1984). Folsom sites are found between 6000 and 6999 feet AMSL in the San Augustin, San Juan, and Estancia Basins, and the central mountain foothills. Eleven Folsom sites are recorded between 5000 and 5999 feet AMSL and these sites are found in the central mountain foothills and the lower elevations of the San Juan Basin. Numerous Folsom sites are found between 4000 and 4999 feet AMSL in the lowlands of south-central New Mexico and the plains of eastern New Mexico. A few low elevation sites (below 4000 feet AMSL) are restricted to the plains of southeastern

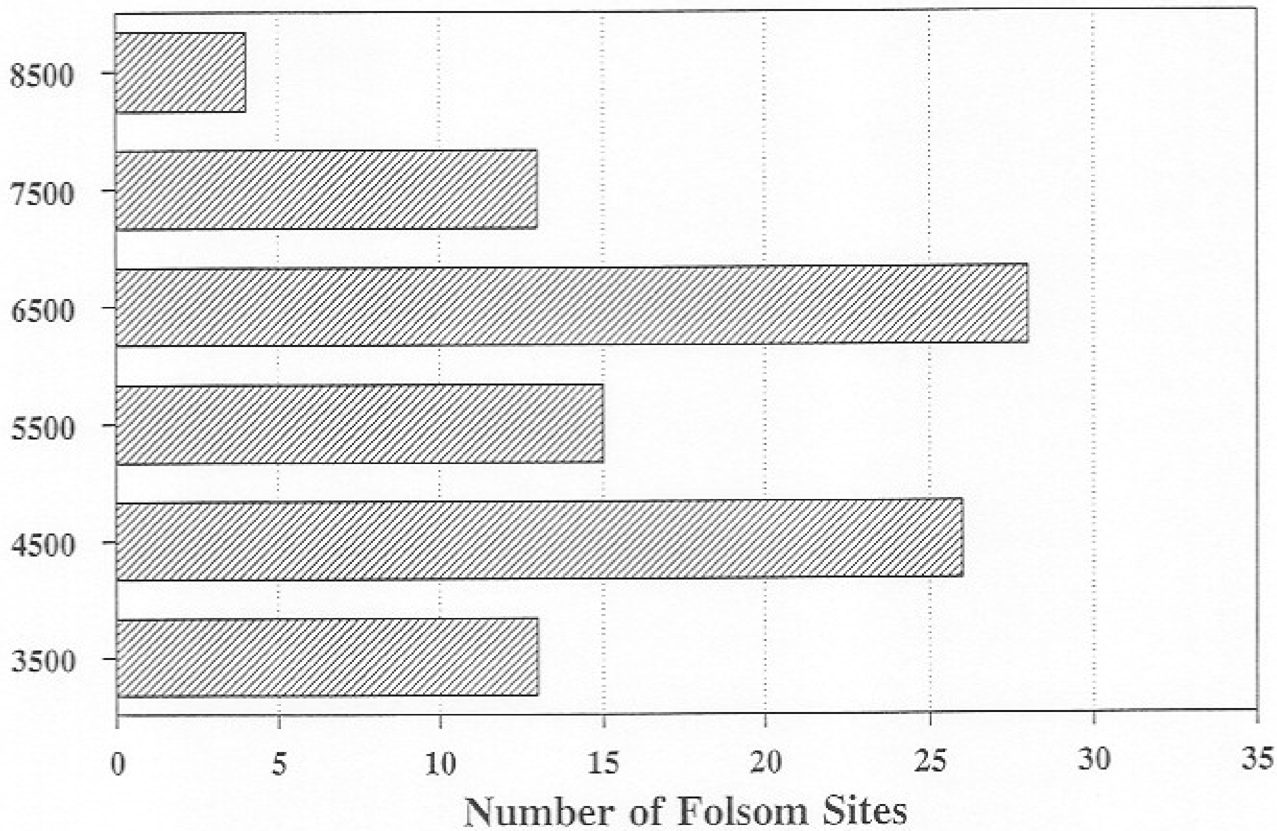

Figure 3. Histogram of the number of Folsom sites recorded in New Mexico according to elevation.

New Mexico. The current survey data fail to indicate any notable use of upland areas by Folsom hunters. It is possible that highland resources are more limited in New Mexico where mountain ranges are generally lower in elevation, narrower and more arid than the central Rockies.

Intensive archaeological survey of Cebollita Mesa, a tilted tableland in west-central New Mexico provides the most notable record of Folsom occupation in an upland situation (Broster 1983; Broster and Harrill 1982). Cebollita Mesa is characterized by elevations of around 8000 feet AMSL and is dotted with a series of small ponds. Fifteen Folsom points (including four Midland points) were collected from the Cebollita Mesa survey. An unusual characteristic of these points from Cebollita Mesa is the frequency of thermal fracture and evidence of reworking into late prehistoric arrowheads. In order to provide a baseline for comparison, the evidence of burning and recycling on the Cebollita Mesa points is contrasted with the remaining dataset of 990 Folsom and Midland points from low altitude settings throughout New Mexico and west Texas.

Thermal fractures indicative of severe burning (e.g., Purdy 1975; Rick 1978) are found on only 4.9% (n=49) of the low altitude sample of Folsom points compared to 40% (n=6) of the Cebollita Mesa points. These surface artifacts may have been burned by forest fires or in the hearth fires of later occupants. Recycling is evident on only 1.7% (n=17) of the low altitude points compared to 20% (n=3) of the points from Cebollita Mesa. Although the size of the Cebollita Mesa sample is limited, these data tend to suggest considerable recycling of Paleoindian artifacts at Cebollita Mesa. One Folsom point midsection from Cebollita Mesa was thermally altered and then reworked into a small side-notched arrowpoint. While the original flake scars on this point are smooth and waxy, the reworked flake scars exhibit a sugary texture characteristic of stone which has been "overcooked" by thermal exposure. This association of unsuccessful thermal alteration with artifact recycling suggests that later occupants were unfamiliar with the properties of Paleoindian raw materials.

Closer examination of the Cebollita Mesa Folsom points sheds doubt on their reliability as a record of Folsom occupation of an upland area. Most of the Folsom points from Cebollita Mesa are isolated finds or isolates at later component sites. There is evidence of heavy use of the mesa by later Pueblo groups which may account for this unusual pattern of Folsom point burning, recycling, and discard. Finally, Cebollita Mesa is a well-watered prairie-parkland rather than a montane forest and the location of these Folsom points indicates a hunting pattern focused on waterholes. This pattern does not differ from Folsom land use in nearby lower altitude situations. While it is doubtful that Cebollita Mesa contains a secure record of Folsom occupation in the New Mexico highlands, it is certain that these data do not offer a different pattern of Folsom land use.

A recent study of the distribution of Folsom sites and Folsom points across Texas concluded that patterning was the result of differential intensity of archaeological investigations rather than regional differences in Folsom settlement (Largent and Waters 1990; Largent et al. 1991). Texas contains a variety of physiographic regions but true montane settings are rare and the environment can generally be characterized as prairie-plains. Although Texas is 2.2 times larger and contains 11.2 times more people than New Mexico, 780 Folsom points are reported from New Mexico in this study compared to 329 reported from Texas by Largent et al. (1991). Despite several biases which make direct comparison of these figures difficult, the trend suggests higher Folsom concentrations exist in the diverse landscapes which are characteristic of New Mexico.

The total number of Folsom finds in New Mexico is probably underestimated because many sites remain unrecorded. However, nearly 81.8% (n=638) of the Folsom and Midland points reported in this study were collected along the Rio Grande Valley between Albuquerque and El Paso. Most of these artifacts were found by private collectors. In fact, these investigations suggest that the majority of Paleoindian artifacts from New Mexico are privately owned. Over 90% (n=708) of the Folsom (and Midland) points recorded from New Mexico in this study are currently in private hands, the remaining points (n=72) are stored at museums, universities, and government agencies.

While it is difficult to obtain an accurate picture of Folsom distributional patterns, this reconstruction of the New Mexico data indicates concentrations along the Rio Grande Valley and its adjacent basins. In general, the distribution of Folsom materials in New Mexico corresponds with late Pleistocene grasslands. Cordell (1979:132, 1984:126) has noted that Folsom materials in New Mexico are usually associated with erosional landscapes. It is probably significant that most erosion in the American Southwest was induced by overgrazing near the turn of this century (Neilson 1986;

Van Devender 1990). Consequently, the modern association of Folsom sites with erosional landscapes suggests a previous correspondence with grasslands.

The distribution of grasslands in the western half of New Mexico was discontinuous because of the Basin and Range topography which characterizes the region. In addition, modern precipitation patterns indicate decreasing moisture west of the Great Plains. The desertification of New Mexico was underway by Folsom times and proceeded from southwest to northeast (Harris 1989; Van Devender et al. 1984, 1987; Wendland et al. 1987:460). Given less contiguous grasslands and less effective moisture in the basins of western New Mexico, the distribution of waterholes and pastures in the Basin and Range is assumed to have been patchier than the arrangement on the Great Plains. This greater patchiness is expected to have reduced the forage available for grazing animals in the Basin and Range and may have resulted in smaller and more mobile bison herds (Bamforth 1988). This difference in bison ecology may have affected Folsom hunting strategies

Context of Terrestrial Hunter Comparisons

It is currently established by radiocarbon dating at a number of sites that Folsom occupations occurred during the Younger Dryas period of the early Holocene between 10,950 and 10,250 years ago (Haynes et al. 1992:96). Mean annual temperatures in the grasslands of New Mexico were about 3 degrees (Celsius) cooler than today based on paleoclimatic reconstructions of this time period (Elias 1990; Van Devender et al. 1984, 1987). However, climatic seasonality has decreased in the American Southwest since the early Holocene. As a result of the less equable climates of the early Holocene, effective temperatures may have been slightly cooler than today.

Effective temperature (ET) measures the length of the growing season and the intensity of solar energy available during the growing season which in turn reflects environmental productivity (Bailey 1960) and has been shown to be a useful tool for comparing hunter-gatherer adaptations (Binford 1980; 1990). Modern ET values range from 25 degrees C in tropical latitudes to 8 degrees C in the arctic. In New Mexico, the modern ET values range from 11.6 degrees C in the Sangre de Cristo Range of the Southern Rocky Mountains to 15 degrees C on the southeastern portion of the Southern Plains (Cordell 1978:Map 2). It is possible that the ET ranged from 12 to 14 degrees C in the grassland plains and basins of New Mexico during Folsom occupations. Binford (1990:Table 9) reports 68 historically recorded hunter-gatherer groups living within this ET range. Plant resource dependence is 30-50% among most of these groups (n=54, 79%).

This comparison helps to place Folsom behavior within the context of other hunter-gatherers and predicts that Folsom diet relied heavily on plant resources. The archaeological record does not support this prediction based on current knowledge about Folsom subsistence remains, settlement technology, and tool inventories (Bonnichsen et al. 1987). Analysis of Folsom behavior from all of these viewpoints indicates an adaptation focused on bison hunting with other species taken when the opportunity arose. While it is likely that greater variability exists within Folsom adaptations, the evidence for a significant plant component in Folsom diet (e.g., Kornfeld 1988) remains undemonstrated.

There is considerable empirical support for the assumption that Folsom subsistence is characterized by bison hunting. Unfortunately, there are a lack of relevant modern analogs for terrestrial hunters in a temperate latitude. Historically recorded terrestrial hunters are most commonly known from high latitudes and are characterized by logistical mobility and the exploitation of large territories (Binford 1990:137-139; Kelly 1983:280-281). While Folsom groups exhibit large territories, the settlement system is based on residential rather than logistical mobility (Kelly and Todd 1988). It is useful to consider Folsom within the context of hunter-gatherers in similar environments although these cases do not provide direct analogs.

The bison and elk hunting Crow and Piegan (Blackfoot) from the northwestern Plains appear to be the closest analog to Folsom in terms of environment and subsistence (grassland bison hunters), the high frequency of residential mobility, and high annual mobility (Kelly 1983:Table 1; Binford 1990:Table 12). ET is 13 degrees C for the Crow and 11.4 degrees C for the Piegan. Settlement and subsistence patterns for these groups are biased by reliance on horse transportation and moved residences 28-38 times per year for a total annual distance of 640-840 km. Size of the group range is estimated at 8500 to 61,880 kilometers squared which reflects the value of horses as a transportation aid. Settlement organization among the Crow and Piegan differs from the inferred Folsom pattern in that these groups were semi-nomadic and relied on food storage at winter camps to overcome inclement weather and seasonal resource shortfalls. In other words, the Crow and Piegan did not practice a year-round foraging strategy. Seasonality required the use of logistical strategy during the winter months.

One group of fully nomadic people (foragers) who were dependent on terrestrial hunting are important to mention. The Ona lived as hunters of guanaco, rhea, and seal in Northern Tierra del Fuego (ET=9.1). Kelly (1983:280-281) reports that Ona groups made about 60 residential moves per year, and although the annual distance of these moves is unknown, Binford (1990:138) suggests 790 kilometers squared as an estimate of group range. The Ona are significant because they represent an exceptional case of "pedestrian hunters unaided by either pack dogs or draft animals" who "practice little storage as an overwintering strategy" (Binford 1990:138). In addition, the Ona exhibit a residential mobility pattern characterized as "foragers" who move consumers to resources while nearly all other hunter-gatherers known from high latitudes are characterized as "collectors" who move resources to consumers (sensu Binford 1980). The case of the Ona is significant because as Binford (1990:139) notes: "(f)oraging strategies may have been more common in temperate and cold settings in the past."

Based on patterns of raw material movement, it appears that Folsom residential mobility is quite high. It is not uncommon to find raw material in Folsom assemblages that has moved up to 500 km from its source (Hofman 1991; Stanford 1991; and this paper). Since pedestrian routes of travel are rarely linear, this transport distance is probably even greater. It is difficult to know the actual relationship of this distance to annual mobility, but if 500 km is assumed as a minimum estimate of annual mobility, then Folsom groups rank among the most mobile of known hunter-gatherers and the nearest modern comparisons are fully nomadic or semi-nomadic hunters of terrestrial game who rely on transportation aids.

Regional Variation in Toolstone and Land Use Patterns

Regional Toolstone Patterns

The assemblage of 1312 Folsom-Midland points and preforms from New Mexico and western Texas provide a comparison of regional differences in the use of selected toolstone types. Comparison of the lithic materials used to manufacture these weapon tips provides a partial measure of group mobility. As Ingbar points out in this volume and elsewhere (1991, 1992), the relationship of toolstone material proportions to settlement mobility may be quite complex. Although trading of stone may have occurred among Folsom groups, the patterns suggested by Meltzer (1988) to signify exchange of lithic material are not found in these data. Figure 4 shows the location of the toolstone sources and the relationship of these sources to the regional study areas. Four regions are defined which are used to contrast the Great Plains with the Basin and Range along the Rio Grande Valley: 1) the Southern Plains, centered around the Llano Estacado; 2) the Tularosa Basin, located adjacent to the Rio Grande Valley; 3) the Jornada del Muerto, located along the Rio Grande Valley and northwest of the Tularosa Basin; and 4) the Albuquerque Basin, located along the Rio Grande Valley and immediately north of the Jornada del Muerto.

Four distinctive stone types (Banks 1990) are used to illustrate the relationship of toolstone use among these regions. Edwards chert is a high quality, flinty material which is abundant along the southeastern margin of the Southern Plains. Rancheria chert is an elastic cryptocrystalline silica which often contains characteristic banding and fossil inclusions. It is available from various Mississippian formations in south-central New Mexico and appears to be concentrated in the mountain ranges west of the Tularosa Basin and at the south end of the Jornada del Muerto. Socorro jasper is a secondary silica deposit found in the volcanic mountains near the northern end of the Jornada del Muerto. The utility of Socorro jasper is limited by brittleness which reduces edge strength. Chuska chert is an opaline stone usually characterized by pink color and greasy luster. As a toolstone, it is hampered by relatively soft edges which are easily damaged. Chuska chert is found in vein deposits among altered volcanic rocks in the Chuska Mountains on the west side of the San Juan Basin in northwest New Mexico.

Table 1 presents a summary of the proportion of these toolstones among the points and preforms within each regional study area. The last category in this table is listed as "various other toolstones" which includes a residual group. In the Southern Plains assemblage, the various other toolstones are largely composed of Alibates agatized dolomite and Tecovas jasper, two major toolstone sources on

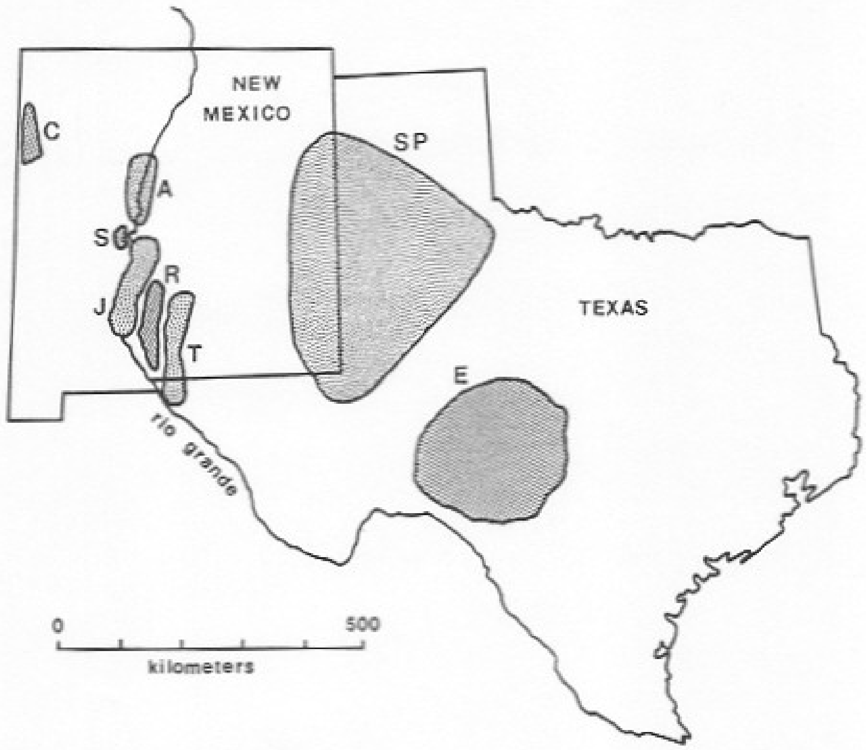

Figure 4. Location of primary study areas and toolstone sources. Study areas: A=Albuquerque Basin; J=Jornada del Muerto; T=Tularosa Basin; SP=Southern Plains. Toolstone sources: C=Chuska chert; S=Socorro jasper; R=Rancheria chert; E=Edwards chert.

Table 1. Use of selected toolstones among Folsom-Midland points and preforms from the Rio Grande Valley and Southern Plains.

	Region			
Toolstone Type	Albuquerque Basin	Jornada del Muerto	Tularosa Basin	Southern Plains
Chuska Chert	13.3% (n=22)	6.3% (n=15)	1.0% (n=5)	0
Socorro Jasper	2.4% (n=4)	10.9% (n=26)	1.9% (n=10)	0
Rancheria Chert	10.8% (n=18)	28.5% (n=68)	46.8% (n=241)	0
Edwards Chert	0.6% (n=1)	5.9% (n=14)	8.2% (n=42)	82.3% (n=242)
Various Other Toolstones	73.5% (n=122)	48.5% (n=116)	42.1% (n=217)	17.7% (n=52)
Total Number	166	239	515	294

the northern margins of the Llano Estacado (Banks 1990). Within the Rio Grande Valley assemblages, the various other toolstones are probably derived from the axial gravel deposits known as the Santa Fe Formation which are found in the terraces along the Rio Grande. These materials include a diverse mixture of cherts, jaspers, chalcedonies, silicified wood, and obsidian from the rock formations of northern New Mexico and the southern Rocky Mountains.

Hofman (1991) has recently shown that use of Edwards chert predominates among Folsom-Midland assemblages from the Southern Plains. The data from the Southern Plains in Table 1 corroborates that pattern with 82.3% of Folsom-Midland points and preforms (n=242) made on Edwards Chert. The presence of Edwards chert into the Basin and Range of New Mexico is most significant in the Tularosa Basin which lies about 500 km west of Edwards source areas. Folsom assemblages in the Rio Grande Valley are characterized by the use of local materials, but 8.2% (n=42) of the Tularosa Basin points and preforms are made of Edwards chert. In the Jornada del Muerto which lies about 575 km northwest of Edwards sources, the percentage of Edwards points and preforms decreases to 5.9% (n=14). In the Albuquerque Basin located about 625 km northwest of Edwards sources, there is a single Folsom point made of Edwards chert representing 0.6% of the points and preforms.

Three discrete assemblages in the Tularosa Basin and Jornada del Muerto are distinguished by unusually high proportions of Edwards chert among the FolsomMidland points and preforms. These percentages of Edwards chert are 29.4% (n=10/34) at the Aleman locality in the southern Jornada del Muerto, 25% (n=14/56) at the Moody Tank locality in the Tularosa Basin, and 18% (n=20/112) at the Tres Hermanos locality (which includes Moody Tank) in the Tularosa Basin. No other single locality in the Rio Grande Valley area contains more than two percent Edwards chert among the Folsom-Midland points and preforms. As mentioned earlier, this clustered distribution of nonlocal toolstone has been suggested to indicate the direct movement of people rather than toolstone exchange (Meltzer 1988). This evidence indicates movement into the Tularosa Basin and Jornada del Muerto by Folsom groups from the Southern Plains.

On stone tools, the degree of resharpening provides an estimation of relative use-life (Kuhn 1991; Shott 1989). Hofman (1991, 1992) has used the length of Folsom projectile points to estimate toolkit depletion on the Southern Plains. Resharpening on Folsom points occurs at the tip rather than the lateral margins, thus, resharpening reduces the length of the points. Assuming that Folsom points are originally made with a specific length requirement, the reduction in length of complete Folsom points may provide an estimate of use-life history. Although this assumption may not hold for individual specimens, it is reasonably applicable to groups of Folsom points. While the length of most Edwards points on the Southern Plains range from about 30 to 50 mm (Hofman 1991, 1992; and data collected for this paper), the three complete Edwards points in the Rio Grande Valley do not exceed 25 mm in length. These data are limited but appear to reflect an exhausted Folsom toolkit made of Edwards chert from the Southern Plains which enters the Rio Grande Valley near the Tularosa Basin. This exhausted toolkit may have been replaced with local materials in the Rio Grande Valley.

Table 1 shows that toolstones from the Basin and Range are not present in Folsom artifacts found on the Great Plains. Although, it should be noted that Hofman (1990:20) has reported a Folsom point made of Rancheria chert from Southwestern Oklahoma. Folsom groups equipped with toolkits made from Edwards chert are operating on the Plains, but Folsom groups from the Rio Grande Valley are not carrying locally produced stone tools onto the Plains. This pattern suggests that Folsom groups along the Rio Grande are operating within a separate mobility system or that these data refer to a small part of a very large system of land use. Examination of the patterns of Rio Grande toolstone use provides some insight into the possible nature of this land use pattern.

Rancheria chert is one of the most commonly used materials in Folsom assemblages in the Tularosa Basin where it accounts for 46.8% (n=241) of the points and preforms. Use of Rancheria decreases to 28.5% (n=68) in the Jornada del Muerto and 10.8% (n=18) in the Albuquerque Basin. Chuska chert use is most common in the Albuquerque Basin which is about 200 km from the source area. However, Chuska chert drops rapidly from 13.3% (n=22) in the Albuquerque Basin to 6.3% (n=15) in the Jornada del Muerto and 1% (n=5) in the Tularosa Basin. Socorro jasper occurrence is highest near its sources in the Jornada del Muerto with 10.9% (n=26) and Socorro jasper use declines rapidly in the Albuquerque Basin to the north with 2.4% (n=4) and in the Tularosa Basin to the southeast with 1.9% (n=10).

These patterns of local stone use show significant differences from the use of Edwards chert in the Rio Grande Valley. In the Tularosa Basin, sources of Chuska and Edwards chert are both about 500 km away, but Edwards chert is over eight times more common than Chuska chert among the Folsom points and preforms. This example shows that toolstone materials are differentially transported within the Rio Grande Folsom assemblages. Use of Edwards chert indicates movement from the Plains into the southern corridor of the Rio Grande Valley near the Tularosa Basin. The changing proportions of Chuska chert from the San Juan Basin in the northwest indicate that it probably enters the Rio Grande Valley near the Albuquerque Basin. Although Chuska chert is used in the Basin and Range country along the Rio Grande, its use declines rapidly away from the Albuquerque Basin.

Socorro jasper shows the highest frequency of use near its source in the Jornada del Muerto. Use of Socorro jasper declines dramatically in the Albuquerque Basin and Tularosa Basin which are located about 100 to 150 km away from the source area. The relatively rapid decline in Socorro jasper and Chuska chert use may be related to the inferior edge holding properties of these stones. Decline in Rancheria chert use in the Albuquerque Basin located about 225 km north of the source area is accounted for by the use of various other toolstones found in the abundant gravel deposits. The use of various other materials is highest in the Albuquerque Basin (73.5%, n=122) and shows a decrease southward along the central Rio Grande.

Various patterns of Folsom movement along the Rio Grande Valley are suggested by these distributions of toolstone. The easy availability of toolstone throughout the Rio Grande Valley allows for procurement of stone as needed. Suitable sources of toolstone (i.e., Edwards chert) are more restricted on the Southern Plains. Folsom tools may have been replaced more readily in the Rio Grande Valley than on the Southern Plains as a result of these differences in toolstone availability. Evidence that a lesser quality material like Socorro jasper is rare outside of its immediate source area supports this observation. In addition, some stone types in the Rio Grande Valley (like Chuska) appear to have been preferred over others (like Socorro jasper) resulting in transport over greater distances before discard. In summary, these patterns indicate movement throughout the Rio Grande Valley but fail to provide substantial evidence of movement onto the Plains from the Basin and Range of New Mexico. Stanford (1991) has indicated similar regional patterning in Folsom toolstone use.

Variation in the Weaponry Retooling

Patterns of point to preform ratios between regions is used to examine weaponry retooling. Judge (1973:201-203) classified Folsom sites in the Albuquerque Basin with low point:preform ratios as armament stations. He noted that these weapon preparation sites are often located near overviews and usually served as hunting stands where activities focused on final point production. This pattern is contrasted with Folsom basecamps which contain high ratios of points (especially bases) to preforms (Judge 1973:199-201). Although basecamps are characterized by a diverse tool assemblage, the weaponry component centers on the discard of broken point bases. Presumably, hunting weapons are usually equipped with new points at the armament camps.

Table 2 presents the frequency of weaponry components recorded for each of the four regional study areas. The differences in the point:preform ratios between these regions are related to the availability of suitable toolstone. As toolstone becomes less available, the ratio increases. In the Albuquerque Basin, the Santa Fe gravels are ubiquitous and the point:preform ratio is quite low. Toolstone sources become increasingly less accessible in the Jornada del Muerto and Tularosa Basin and the ratios increase. An exceptionally high ratio of points to preforms is found on the Southern Plains where toolstone sources are especially rare. These data are somewhat inflated by the inclusion of 154 points and no preforms from the Blackwater Draw area (Broilo 1971; Hester 1972; and private collections) but the omission of these points still results in a point:preform ratio that is three to six times higher than the Basin and Range regions. Hofman's (1991:342) data from the Southern Plains show a point:preform ratio of 326:38 or 8.58 which is similar to these estimates. It should be noted that the Adair-Steadman Site is a significant armament locale on the eastern margin of the High Plains (Tunnell 1977) which may have a low point:preform ratio but a comprehensive description of this assemblage is not yet available.

Regional variation in these point:preform ratios suggests that toolstone availability strongly affects the organization of Folsom weapon retooling. In places like the Albuquerque Basin where suitable toolstone is widespread, the replacement of weapon tips occurs more frequently and the distinction between armament stations and basecamps is diminished. The Tularosa Basin is more removed from toolstone sources and weapon tips are replaced at less than half the rate of the Albuquerque Basin. In addition, the functional distinction between basecamps and armament stations is greater in the Tularosa Basin. For example, the Lone Butte Site, an armament station situated at a prominent landmark with a commanding overview, accounts for 32.6% (n=43) of the Tularosa Basin preforms (Amick and Stanford 1993). The point:preform ratio at Lone Butte is 0.67. Greater functional differentiation of weapon retooling sites appears to occur when toolstone procurement is constrained by mobility patterns.

Constraints from the pursuit of unpredictable mobile resources while distantly removed from toolstone sources is expected to result in a technological strategy of "tool curation" (Bamforth 1986). Evidence of Folsom weapon retooling is sparse on the Southern Plains which suggests that lithic materials were usually conserved. Comparison of data across different regions demonstrates that the degree of curatorial behavior in Folsom weapon retooling is dependent upon the availability of suitable toolstone. When toolstone is locally available, weapon retooling occurs more often at basecamps and functionally discrete armament stations are less common. When weapon retooling depends on the use of transported toolstone, Folsom technological organization is more curatorial and Folsom settlement organization is more specialized or logistical.

Off-site Distributions of Folsom Weaponry

Most of the Folsom artifacts available to this study were found at site locations which limits complete understanding of land use strategies. Evidence of the off-site component of Folsom land use activities is provided by a systematic surface survey of 991 km^2 at the Fort Bliss Military Installation in the Tularosa Basin (Carmichael 1986). This survey produced 27 Folsom points, two Midland points, and four Folsom preforms found as off-site isolates or single finds mixed in later component sites (Amick 1991; Amick and Stanford 1993). These isolated finds provide a picture of Folsom off-site activities which have not been previously described.

Most of the isolated points (n=21, 60%) are distal fragments or complete points. About 83% (n=29) of the isolated points exhibit impact damage which suggests these Folsom isolates represent weapon tips that were broken or lost while hunting. Folsom hunting is usually considered to focus on killsite locations where small groups of animals were ambushed (Frison 1991:158-164). The scattered pattern of these weapon tips indicates that some wounded animals may have escaped the ambush killsites and died in the brush or that stalking of individual animals may have formed a significant component of Folsom hunting strategies. The high ratio of isolated points to points from sites (29:19) in the Fort Bliss survey suggests that unless Folsom hunters were usually unsuc-

Table 2. Regional frequencies of Folsom weaponry elements.

Region	Points	Preforms	Point:Preform Ratio
Albuquerque Basin	97	69	1.41
Jornada del Muerto	167	72	2.32
Tularosa Basin	383	132	2.90
Southern Plains*	280	14	20.00

*Folsom artifacts from the Blackwater Draw area contributed 154 points and 0 preforms to this total. Removal of the Blackwater Draw data changes the point:preform ratio to 9.00.

cessful, individual stalking strategies rather than wounded animals are primarily responsible for the dispersed point tips.

Each Folsom site at Fort Bliss produced at least two points or preforms. The projectile points from these sites contain a high proportion of basal fragments (n=13, 68%) indicating repair of broken hunting gear at small temporary camps. All of these bases exhibit impact damage which implies that they were bound in a foreshaft that was usually retrieved and returned the campsite. Broken point fragments were then removed from the foreshaft and discarded. The Fort Bliss Folsom site assemblages exhibit a point to preform ratio of 1.0 (19:19) suggesting that manufacture of replacement points usually occurred at camps. The ratio of points to preforms among the Fort Bliss isolates is 7.25 (29:4) which is at least four times higher than Folsom assemblage data presented by Judge (1973:202) from the Albuquerque Basin and almost 50% higher than any of the localities known in the Tularosa Basin (Amick and Stanford 1993). Thus, the manufacture of points and replacement of hunting gear usually took place at campsites rather than in the field.

Although the record of Folsom off-site activities is limited, individual kills appear to have been an important aspect of Folsom hunting in the Tularosa Basin. Folsom killsites are currently unrecognized in the Basin and Range of New Mexico (Judge 1973:43, 66). In contrast, 27 of the 35 Paleoindian sites documented by Wendorf and Hester (1962) on the Great Plains are classified as killsites. The absence of Folsom killsites in the Basin and Range of New Mexico may be explained by hunting behavior which relies less on cooperative ambush of herds and more on culling of individual animals.

Manufacturing Variation

Folsom Fluting and Risk Reduction

Variation in the finishing of points is expected to reflect situational constraints on Folsom weaponry. Successful fluting of Folsom projectile points requires exceptional skill and the frequency of fluting is compared between regions in Table 3. These data show that the occurrence of fluting is lowest on the Southern Plains. Although there is disagreement about the actual fluting technique used by Folsom tool makers, it is commonly recognized that fluting is a risky procedure that often results in manufacturing failure (Akerman and Fagan 1986; Flenniken 1978; Gryba 1988). The cost of manufacturing failure is highest when there is a need to conserve toolstone.

Limited toolstone sources and high mobility place significant constraints on Folsom groups in the Southern Plains. These constraints are relaxed in a region where toolstone is widely accessible like the Albuquerque Basin. Table 3 shows that the frequency of fluting on both faces of Folsom points is highest in the Albuquerque Basin. Fluting rates are lower in the Jornada del Muerto and the Tularosa Basin where toolstone sources are more distant. The unfluted points in this sample are characterized by a variety of finishing treatments such as basal thinning, collateral thinning, and pseudofluting (the use of a flake surface to emulate a flute). The ratio of fluted to unfluted points is about 10 times higher in the Albuquerque Basin than the Southern Plains. In the Jornada del Muerto and Tularosa Basin, this ratio is about 5 times higher than the Southern Plains.

Subsistence based on the pursuit of herd animals places severe restrictions on Folsom technology due to "resource incongruences" (sensu Binford 1980) between the location of herds and toolstone sources as well as "time stresses" (sensu Torrence 1983) between hunting and lithic procurement activities. Because Folsom fluting requires considerable skill and fluting failure rates are significant, the risk of failure increases when toolstone is not locally available or when the scheduling of toolstone procurement is subservient to other activities. These two conditions which lead to increased risk of technological and subsistence failure are characteristic of Folsom groups on the Southern Plains. The less frequent occurrence of projectile point fluting on the Southern Plains is viewed as an expectable outcome of risk reduction behavior by Folsom hunters.

Variation in Point Size and Functional Implications of Weaponry

Consideration of Folsom weapons is important because weaponry technology strongly affects hunting behavior (Larralde 1990; Odell 1988:337). An interesting facet of variation in Folsom projectile points is the tight uniformity in base width (Judge 1973:164-165, 175-176). This tendency indicates that the basal morphology of Folsom points was restricted by a relatively consistent hafting arrangement. The exact nature of this hafting arrangement remains uncertain but experimental work suggests that a wooden foreshaft which was tapered on one end to fit a socketed mainshaft and notched on the other end to accommodate a stone point was adequate (Frison 1991:211-212, 293-295). Mastic and sinew were probably used to bind the point to the foreshaft. It is generally assumed that Folsom hunters used a spear thrower (atlatl) to propel these darts (Frison 1991:293-295; Judge 1973:176). Most direct evidence of Folsom weaponry is limited to the stone points but Frison and Zeimens (1980) have reported points made from long bone splinters found in the Folsom bonebed at the Agate Basin Site. These bone points which may have ranged up to 30 cm long (Frison and Zeimens 1980:233) reflect some of the diversity in Folsom weaponry.

In this study, it was possible to measure base width on 391 Folsom points and 95% of these measurements do not vary more than 5.1 mm. The mean base width is 18.1 mm and the median is 18.3 mm. Figure 5 compares the distribution of base width measurements between Folsom and Midland points and shows that the dispersion and central tendency patterns of these two types are similar, although Midland bases are slightly narrower. Outside of the unimodal tendency for uniformity in base width, the small points indicated by the left-hand tail of this distribution are notable. There are 14 (3.6%) points with a base width of less than 13 mm (two standard deviations below the mean). Miniature Paleoindian points are commonly interpreted to represent toys or ceremonial objects (Bonnichsen and Keyser 1982; Storck 1991:156-158), but the small points in this study show evidence of use. Impact damage is found on half (n=7) of these small points, of the remaining seven small points, six are unbroken and one was broken during manufacture by an overshot fracture.

It is generally assumed at later prehistoric sites that small points are used to tip arrows propelled by bows. The occurrence of several small points in this sample which appear to have served as functional weapon tips leads to a reconsideration of the weaponry used to launch Folsom points. Preserved bows and arrowshafts are known from the Upper Paleolithic of northern Europe about 8 to 11 thousand years ago (McEwan et al. 1991) and the use of stone arrowpoints may be as ancient as 18-20 thousand years in Europe (Gamble 1986:122, 236-239; McEwan et al. 1991). Direct evidence of the bow and arrow in North America does not extend beyond about 3500 years (Aikens 1970; Webster 1980) and it is generally thought that the bow and arrow was adopted by prehistoric Americans only 1500–2000 years ago (Blitz 1988; Frison 1991; Reeves 1990). Recently, Odell (1988) has suggested that bow technology may have greater antiquity in North America than previously believed. At Napoleon Hollow, an Archaic campsite in Illinois which is about 4000 years old, he identified small flakes with impact fractures which he suggests were used

Table 3. Frequency of fluting on projectile points by region.

Region	Unfluted	One Side Fluted	Both Sides Fluted	Total
Albuquerque Basin	9 (09.3%)	15 (15.5%)	73 (75.3%)	97
Jornada del Muerto	30 (18.0%)	20 (12.0%)	117 (70.0%)	167
Tularosa Basin *	51 (15.5%)	56 (17.1%)	221 (67.4%)	328
Southern Plains *	73 (53.3%)	14 (10.2%)	54 (39.4%)	137
Totals	163	105	465	733

*A total of 55 points from the Tularosa Basin and 143 points from the Southern Plains are omitted from these tabulations due to missing data caused by incomplete recording.

to tip arrows.

The proposition that Folsom points are ideal arrow points was made over 50 years ago by Jim Browne (1938, 1940), an experienced archer familiar with prehistoric weaponry. Although it is not possible to determine weapon technology based on stone points alone, use of the bow and arrow may account for the size variation among Folsom points. There are several lines of evidence which suggest that Folsom hunters may have used the bow and arrow. First, there is historical precedent for the use of the bow and arrow in European Paleolithic technologies. Second, even the smallest Folsom points in this sample appear to have been used as projectile tips. The damage patterns on these points resembles experimentally produced impact damage (Barton and Bergman 1982; Bergman and Newcomer 1983; Odell and Cowan 1986; Titmus and Woods 1986).

In addition, the size of Folsom points compares well with ethnohistoric arrowpoints. Thomas (1978) measured 142 stone tips found on arrow and dart shafts and developed a discriminant function which provided 86% correct classification of the original sample. The classification function by Thomas (1978:470) requires measurements of maximum length, width, and thickness, and neck width (equivalent to Folsom base width) and was used to define arrowheads and dart points using data available from 80 unbroken Folsom points. Seventyfive (93.8%) of these Folsom points were classified as arrowheads while only five (6.2%) were classified as dart points. This result is provocative but since Thomas' original sample did not include lanceolate types, its applicability to Folsom points may be questionable. Regardless of these limitations, this classification demonstrates the potential suitability of many Folsom points as arrowheads.

Finally, from the standpoint of hunting behavior and technological organization, there is support for the view that Folsom hunters used the bow and arrow. It is possible that the bow and the atlatl were used contemporaneously during Folsom times. Examples of the use of multiple weapon systems are known from the prehistoric (Odell 1988:338) and historic records (Larralde 1990). Eskimo hunters used the atlatl for hunting sea mammals and birds while using the bow and arrow for caribou hunting (Bandi 1969:11). The coexistence of two or more weapon systems during

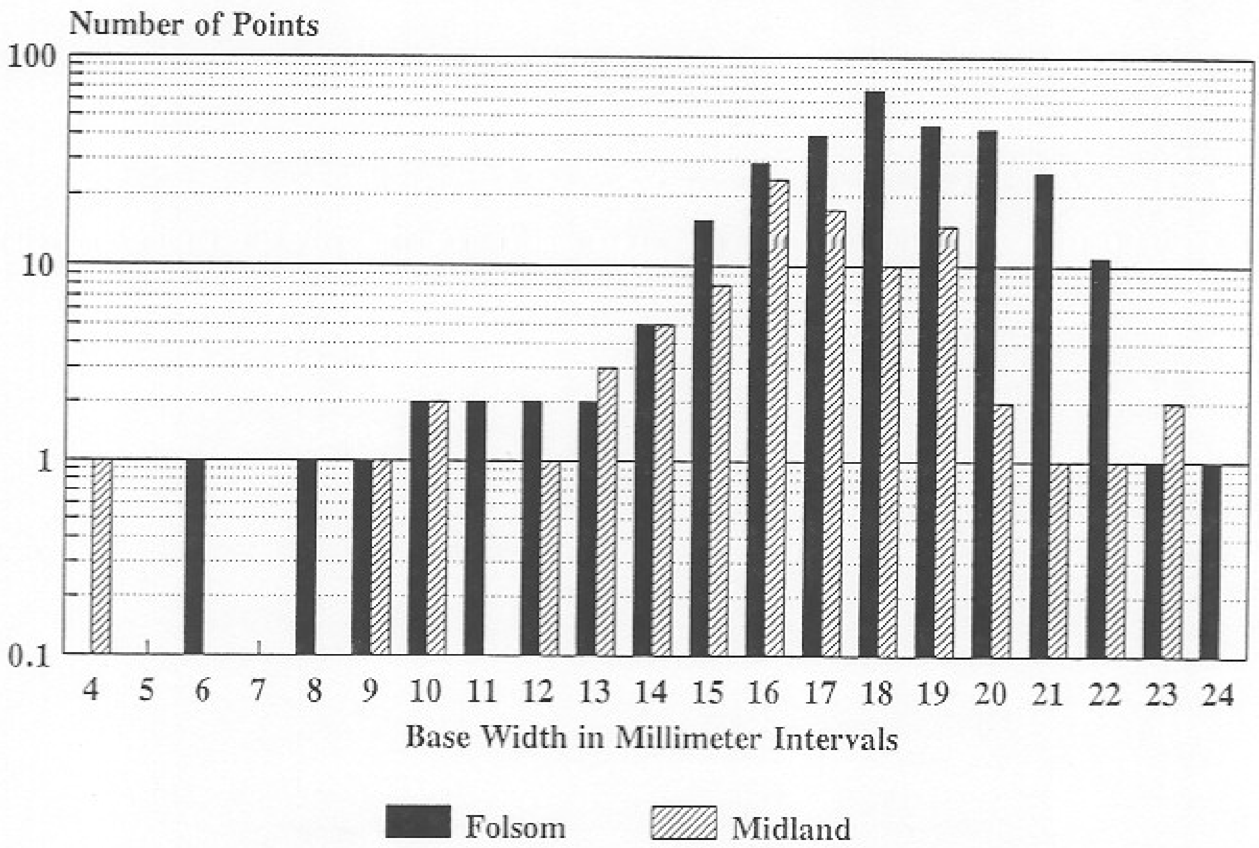

Figure 5. Histogram of base width measurements from Folsom and Midland points.

Folsom times is not unexpected under the arguments about technological evolution by Basalla (1988). He suggests that technological change occurs through selection for variation rather than invention and diffusion. There is probably diversity in Folsom weaponry that is responding to variable hunting needs. The bow is a relatively simple device and given the sophisticated nature of Folsom technology, it is doubtful that the bow was unknown.

Experimental evidence suggests that the bow is a superior weapon in most aspects to the atlatl (Christenson 1986:122; Frison 1991:211-212). In terms of hunting strategy (see Larralde 1990), the bow is designed for stealth while the atlatl is a high-impact weapon. Frison (1991:232-237) has observed that a primary characteristic of bison behavior affecting hunting strategy is the tendency for aggression and unpredictability. As a result, the use of stealth weaponry like the bow and arrow has considerable advantage in bison hunting because it does not require the hunter to reveal himself or to make violent movements. It is difficult to determine the type of weapons used by Folsom hunters without direct evidence, but this analysis suggests that Folsom weapon technology remains an unresolved issue. Consequently, long-term trends in the size and design of weapon tips may reflect organizational constraints related to decreases in manufacturing time and toolstone availability rather than weaponry changes (Gamble 1986:246-247).

Conclusions

There is an absence of large Folsom killsites and campsites along the Rio Grande which indicates an absence of communal hunting. This settlement pattern indicates small-group hunting (Bamforth 1985) or individual hunting which is characterized by low archaeological visibility (Kooyman 1990; Landals 1990). It is likely that individual or small-group hunting provided the bulk of Folsom subsistence returns (Driver 1983; Frison 1991:155; McCartney 1990). This hunting pattern is accentuated in the Folsom occupation of the Basin and Range of New Mexico where communal hunting of bison was less profitable because of the patchy grassland distribution. Folsom technological organization along the Rio Grande is characterized by an ever-ready strategy reflected by persistent maintenance of the hunting toolkit. This strategy reflects a reliance on opportunistic game encounters rather than periodic gearing up associated with planned hunting trips.

Folsom hunting strategies are typically characterized by opportunistic ambush at pond locations in low dunefields (Bonnichsen et al. 1987). Although bison is always involved at Folsom killsites, there is usually some diversity of game species represented (Bonnichsen et al. 1987) and species diversity at killsites usually indicates the efforts of individual rather than communal hunters (Kooyman 1990:334). McCartney (1990) has demonstrated that the Cody bonebed at Lamb Springs in Colorado resulted from repeated use of an advantageous hunting location. Recent work by Todd (1987, 1991a, 1991b, Todd et al. 1990) has indicated that Paleoindian bison kills in the Southern Plains exhibit broader seasonality than Northern Plains kills which are typically fall and winter events. Evidence for year-round hunting of bison may indicate that environmental factors outside of seasonality are conditioning Folsom land use patterns in the Southwest. Large killsites indicative of communal hunting are found on the Plains which demonstrates that differences exist between land use patterns on the Plains and the Basin and Range. These distinctions are also evident in technological organization which is responding to the differential distribution of toolstone as well as subsistence behavior.

Ethnographic cases of highly mobile terrestrial hunters are characterized by some interesting evidence that is poorly represented in the archaeological record. Following Binford's (1990) recent analysis of mobility, housing, and environment among hunter-gatherers, low investment in housing is common among highly mobile groups. The use of hides and grasses to produce circular or semicircular huts is typical. Although few Folsom structures are known, circular areas of cleared and packed earth are known from New Mexico at the Rio Rancho Site (Dawson and Judge 1969), and from Wyoming at the Hell Gap Site (Irwin-Williams et al. 1973), the Agate Basin Site (Frison 1982:39-44), and the Hanson Site (Frison and Bradley 1980:9) which have been suggested to represent house floors (Frison 1991:137). The evidence of Folsom housing is undeniably sparse and ephemeral. However, this pattern is predictable in relationship to ethnographic records of highly mobile hunter-gatherers. The ethnographic comparisons suggest that Folsom housing was probably portable.

Ethnographic cases of terrestrial hunters with high mobility ranges are aided by pack animals. Walker (1982b:291-294) has identified domesticated dog remains in the Folsom level at Agate Basin and considering the high mobility of Folsom groups, it is likely that dogs were used as transportation aids. Recent papers by Crabtree and Campana (1987) and Morey and Wiant (1992) provide reviews of the evidence for dog domestication by late Pleistocene and early Holocene hunter-gatherers. Folsom dogs may have also served as an occasional source of meat and hides as indicated by the cut marks on the dog ulna from the Agate Basin Site (Walker 1982a:273)

As Binford (1990:138-139) has explained, the difference between foragers and logistically organized peoples is the differential cost of transport. There is abundant evidence of the use of transported toolkits by Folsom groups including strategies aimed at reducing transport costs such as large bifacial cores (Kelly and Todd 1988), and systematic reduction, rejuvenation, and recycling strategies (Hofman 1991, 1992). Butchery evidence from Paleoindian killsites suggests that a "gourmet" strategy is used that focuses on high meat yielding parts with considerable waste (Todd 1987). Transport decisions seem to be characterized as moving consumers to the kill where limited occupation occurs followed by group movement to the next kill. This classic form of foraging strategy (sensu Binford 1980) suggests that Folsom provides a prehistoric case of highly mobile, terrestrial hunters engaged in foraging behavior. Therefore, inferences about Folsom behavior have the capacity to greatly enrich current understanding about hunter-gatherer organization because historical documents provide few analogs for this pattern of land use. One factor that is critical to maintaining this type of system is a toolkit that responds to toolstone availability but is designed to be flexible and transportable.

There are several studies which suggest that Folsom interassemblage variation is related to differences in individual toolkit maintenance. Spatial analysis at the Stewart's Cattle Guard site (Jodry 1987, 1991; Jodry and Stanford 1992) indicates that individuals engaged in retooling of personal gear at hearthcentered work stations. Hofman (1991, 1992) has proposed that Folsom assemblage variation on the Southern Plains reflects differences in the system states of individual toolkits relative to tool using events and toolstone procurement opportunities. Finally, Bamforth (1991b, 1991c) has suggested that variation in the skill levels of Paleoindian flintknappers may account for some of the differences between assemblages.

The foraging pattern of small-group hunting is expectable with the patchy resource structure in the Basin and Range of New Mexico. Smaller and less predictable resource patches (in the form of grassy playas) results in smaller and more mobile human groups for at least two reasons. First, mobility costs are greater for larger groups (Perlman 1985). Second, data on the relationship between hunting efficiency (number of animals per hunter) and hunting party size indicates that smaller hunting parties are more efficient (Binford 1991b:108). If resources are less predictable on the discontinuous grassland margins, then subsistence risk increases and technologies respond accordingly. In this case, the response included persistent toolkit maintenance while keeping group size small and focusing hunting strategies on individual kills. Hunting weaponry may have included the bow and arrow.

This paper has attempted to expand the understanding of Folsom technological organization from the perspective of hunting behavior. It is argued that organizational studies rely on the linkage of inferences with theory and that the methods used to make these linkages depend on accurate behavioral reconstruction. Consequently, this analysis has emphasized the context of technological behavior. It is useful to work from artifacts toward theory as well as from theory toward artifacts. This study has used both of these strategies to explore the relationship of Folsom stone tools to hunting behavior.

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