
Exploring Paleoindian Site-Use at Bonfire Shelter (41VV218)

Ryan M. Byerly, David J. Meltzer, Judith R. Cooper, and Jim Theler

ABSTRACT

Bonebed 2 at Bonfire Shelter (41VV218) has long been interpreted to be the site of a Paleoindian (ca. 10,080 radiocarbon years B.P.) bison jump (Dibble and Lorrain 1968), although in recent years it was suggested that it might instead represent a secondary processing site (Binford 1978). To explore these different interpretations more thoroughly, in 2003 we began a multi-pronged study of the site, including Geographic Information Systems (GIS) analysis and reanalysis of the bison skeletal remains (Byerly et al. 2005). While our GIS analysis did not reject the possibility that Bonfire Shelter was a jump kill, our zooarcheological analysis indicated that the types and frequencies of elements recovered suggested a processing site assemblage.

However, if Bonfire Shelter was a processing locality, it raises several additional questions: namely, why are lithic artifacts so rare? where did the kill take place? and, how and in what form were carcass parts transported into the shelter? To address these questions, we conducted additional field research at Bonfire Shelter during the summer of 2005. We present those results here, which include new radiocarbon dates from the site, as well as gastropod data recovered from a sediment column.

BONFIRE SHELTER: SITE-USE INTERPRETATIONS AND QUESTIONS

Bonfire Shelter is located near the northeastern corner of Mile Canyon neighboring Langtry, Texas, on the Stockton Plateau (Figure 1). The site has paleontological and archeological components, three of which (Bonebed 2, Bonebed 3, and the Fiber Layer) are unambiguously cultural, and range in age from ca. 10,000 to 1,500 years B.P. (hereafter, B.P.; Dibble and Lorrain 1968; but also see Bement 1986). The earliest of those cultural deposits, Bonebed 2, was interpreted by Dibble and Lorrain (1968) to represent three separate jump kill events totaling 120 or more *Bison antiquus*. They inferred that hunters stampeded a herd (or, on several occasions, different herds) of bison over the cliff edge through a cleft in the cliff face directly above the site. The animals died on the talus cone below, where their carcasses were subsequently butchered.

A jump kill, as recognized archeologically, includes many tactical variants (Brekke 1970; Forbis 1962; Frison 1991, 2004; Hornaday 2002; Malouf and Conner 1962; Polk 1979; Verbicky-Todd 1984;

Witkind 1971). However, general consensus holds that bison jumps were a communal hunting strategy in which hunters drove animals over precipices to injure or kill them (Byerly et al. 2005:599; Frison 2004; Hurt 1962). While Paleoindian hunters were capable of driving and trapping large bison herds across the Great Plains (Hill 2001), it is not apparent that a jump strategy was ever utilized on the Southern Plains or as early as the Paleoindian period. Indeed, virtually all mass bison jump kills occur on the northern and northwestern Great Plains, and are Archaic (the oldest being ca. 5,700 B.P.) to Historic in age (Byerly et al. 2005: Figure 1; see also Barsh and Marlor 2003; Buehler 1997; Dibble 1970; Dyck and Morlan 2001; Fisher and Roll 1999; Forbis 1969; Reeves 1978). Being Late Paleoindian in age (ca. 10,080 B.P.) and located on the Stockton Plateau, Bonebed 2 thus represents the earliest (by some 4,300 years) and southernmost (by nearly 1,800 km) jump kill (or kills) in North America. The next earliest jump is the Middle Archaic deposit at Head-Smashed-In (Reeves 1978), and the nearest in distance, other than Bonebed 3 at Bonfire Shelter, is the Roberts Buffalo Jump in Larimer County, Colorado (Witkind 1971). Recent geomorphological

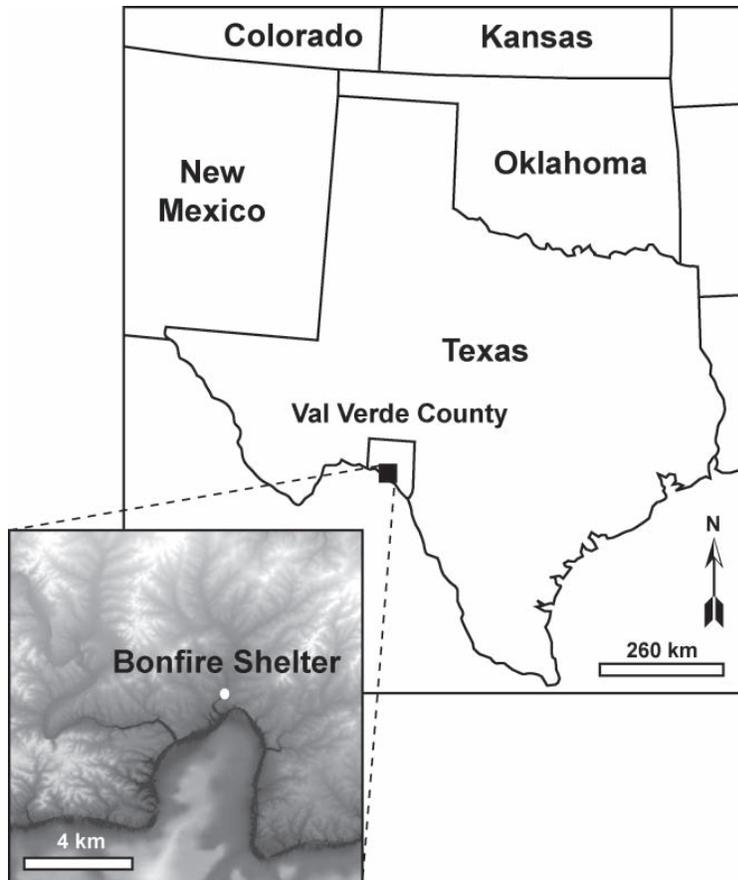


Figure 1. Location of Bonfire Shelter.

data suggest, however, that the Late Archaic Certain site in western Oklahoma may also be a jump kill (Bement and Buehler 2005). While this possibility would render Bonfire Shelter less of a geographic anomaly, Bonebed 2 would remain inconsistent with the known jump kill chronology for the Great Plains.

A jump kill interpretation was favored by Dibble and Lorrain (1968) because of the spatial confinement of Bonebed 2 around the talus cone; the preponderance of projectile points and the lack of butchery tools, fire features, and burned rock in the deposit; and the inferred implausibility of prehistoric hunters driving animals up Mile Canyon to slaughter and then dragging large carcass portions approximately 18 m uphill from the canyon floor into the shelter for further butchery (Dibble and Lorrain 1968). Binford (1978:476) subsequently advocated an alternative hypothesis. Citing a correlation between published bone frequencies and a model of bone abandonment at Nunamiut caribou processing sites, he argued that Bonebed 2 better resembled a secondary processing area—a place

where carcass parts were transported to from a kill locality and rendered for food—than the site of a kill.

To test these competing interpretations, we conducted several analyses—in both the field and the laboratory—in 2003 and 2004, the results of which were recently published (Byerly et al. 2005). Since the completion of that article, we have conducted additional work at the site and on site collections, which we report on here, along with a brief summary of our previous analyses, which included two main elements: a GIS study of the local topography to assess the viability of this locality as a jump kill, and a reanalysis of the faunal remains recovered from the 1963-1964 excavations by Dibble and crew.

GIS Analysis

Dibble (1968) argued that the Bonfire Shelter deposits likely resulted from jump kills because the flanking upland terrain was conducive for jumping bison. This interpretation was made largely on a visual inspection of the landscape. In recent decades, Geographic Information Systems (GIS) technology has become available and permits fine-resolution mapping and modeling of landscapes. Using this technology and detailed field mapping of the site and surrounding area, the primary goal of our analysis was to systematically assess whether the terrain could have supported a jump kill during Bonebed 2 times.

To evaluate the viability of a jump kill at Bonfire Shelter, we turned our attention to other archeological examples of jump kills (Brekke 1970; Frison 1991, 2004; Polk 1979; Verbicky-Todd 1984; Witkind 1971). These sites share certain traits that might have played an integral role in the success of the kill. These include: (1) proximity to water and grass; (2) a long, level path linking a bison gathering area to a jump point that would allow the herd to reach a certain speed but without chance for escape; (3) a herd large enough to gain sufficient momentum in the approach; (4) an obscured jump point; (5) a cliff face orientation coupled with a prevailing wind

direction that ensured the bison were upwind of the hunters; and (6) a cliff edge steep and sharp enough to guarantee the bison died or were severely maimed in the plunge. We acknowledged that these traits were not requirements, but that they might have improved the chances of a kill, and that their co-occurrence at Bonfire Shelter could at least support the possibility of a jump kill.

We assessed the viability of a jump kill first using published data and then by performing a detailed terrain analysis. A spike in grass pollen during Bonebed 2 times suggests suitable bison forage was in close proximity to the site (Bryant and Holloway 1985:Figure 3), and, while the climate is extremely arid, the Rio Grande is less than 1 km away, making water permanently available. As for a concomitant wind direction and cliff face orientation, we were unable to estimate wind direction during Bonebed 2 times, but concluded that the hunters could have chosen a day in which winds were favorable. Based on either published count (Lorrain 1968:80-81), there were enough animals in Bonebed 2 to execute a jump kill (Frison 1991:218). The estimated height of the fall, from the cliff edge to the top of the talus cone, would have been approximately 23 m (Dibble 1968:13, 70), a fall sufficient to kill or severely maim an animal.

Our terrain analysis indicated several corridors within the region that might have served as an effective drive lane. Of those, only the route approaching Bonfire Shelter led to an ideal jump point: one where a cliff was present, but the height and location of that cliff did not make carcasses exceedingly difficult to access. That same route also proved to be the least-cost path to approach the proposed jump point, or in other words, the path where both distance and terrain ruggedness were minimized. Finally, using a line-of-sight analysis, we concluded that, if the bison herd approached along that proposed path, the cliff edge would have been obscured until the herd was 25 m from the edge, and thus would have made it difficult for the entire herd to escape the fall.

In sum, we concluded that Bonfire Shelter met most of the criteria outlined above and was better suited to support a jump kill than other localities in the immediate area. However, while we grant that a jump kill *could* have occurred (and apparently did in the Late Archaic) we turned to zooarcheological evidence to determine if a jump kill *did* occur and was responsible for the Bonebed 2 deposit.

Zooarcheological Analysis

The original analysis of Bonebed 2 bison by Lorrain (1968) is one of the seminal studies (along with Frison [1974], Kehoe [1967], and Wheat [1972]) upon which modern bison bonebed analyses are modeled. However, the original Bonebed 2 bison bone frequency data (in Dibble and Lorrain 1968) are hard to interpret in contemporary zooarcheological vernacular, and are therefore difficult to use for analytic comparisons with other bison kill-butcher assemblages. Thus, we re-analyzed the bones from the 1963-1964 excavations to update bone frequency and taphonomic data and to evaluate the remains in terms of nutritional return and carcass transport models for bison (see Emerson 1990, 1993).

The updated bone element frequencies, when compared to bison food utility indices, showed a strong 'bulk-utility' profile (both for individual elements and carcass portions); such a profile is thought to be an indicator of selective hunter-gatherer transport of carcass parts (Binford 1978). Extensive disarticulation and limited green-bone fracturing also implied butchery activities geared towards meat removal and marrow processing. These patterns were not biased by carnivore activity or bone density. If this was indeed a locality to which carcass parts were transported, it makes certain intuitive sense: after all, its topographic setting is not just suitable for jumping bison, it is also a well-protected setting in which hunters could process transported elements. Given this was interpreted as a summer kill (Byerly et al. 2005), the site may have provided welcome shade and cooler temperatures, and some protection from meat spoilage.

Likewise, it seems apparent, based on a tight clustering of Age Group 3 individuals (2.2 to 2.4 yrs.; Byerly et al. 2005:Table 3), that Bonebed 2 represents a single event, rather than three separate kills as hypothesized by Dibble and Lorrain (1968). Furthermore, it does not appear it was a kill on the scale originally proposed: our Minimum Number of Individuals (MNI) estimates indicated that 24-27 animals is probably a closer approximation than the projected 120. These data suggested that the extant bison bone assemblage does indeed resemble a butchery site.

While this reanalysis confirmed Binford's site-use hypothesis in terms of the faunal component, questions about the nature of the lithic assemblage, the location of the kill, and the logistics of carcass transport persisted. Specifically:

- 1) If the bone assemblage indicates a butchery area, why are butchering tools and small resharpening debris so rare? Such remains ought to be abundant where intensive butchery occurred.
- 2) If the shelter was not the kill site, where did the kill take place? Was it on the upland surface, or perhaps on the canyon floor below?
- 3) And, finally, how and why were large carcass portions transported into such a difficult-to-reach location from either the upland surface or canyon floor?

Several hypotheses were posited to address these questions:

- 1) Small resharpening debris were not recovered from Bonebed 2 because: (a) water pouring from the notch reworked and removed small lithic debris indicative of tool production and maintenance activities; (b) tool production and maintenance, if it occurred at all, took place in an isolated, still unexcavated area of the shelter (such has been found to be the case at other Paleoindian bison kill-butcherries [Matthew G. Hill, personal communication 2005]); and/or (c) coarse screening methods employed during the 1963-1964 excavations biased the recovery of debitage.
- 2) The kinds and frequency of bone recovered within the shelter suggests that the kill was very close to the site. The closest probable location of the kill would have been the canyon floor. Previous work on cemented gravels in Mile Canyon (David J. Meltzer, unpublished data 2003) raised the possibility that the floor of the canyon may have been much higher during the Late Pleistocene and Early Holocene. If so, the perceived difficulty of dragging bison carcasses into the shelter is exaggerated. Evidence of ancient canyon floor levels should be present in extant deposits outside the shelter.

We conducted fieldwork at Bonfire Shelter in the summer of 2005 to test these hypotheses. Our investigations focused on evaluating whether coarse screening methods biased lithic recovery and if ancient canyon floor levels were observable outside the shelter.

2005 FIELDWORK

Backdirt Screening: Lithic Debitage

The analysis of chipped stone debris, and the integration of those data with stone tool analysis, is critical to understanding lithic production activities at archeological sites, and is ultimately essential to understanding prehistoric lifeways (Carr and Bradbury 2001:126-127). Experimental data indicate that the majority of lithic debris produced by tool production and maintenance activities is small (less than 6.35 mm in size; Baumler and Downum 1989). Indeed, the tens of thousands of small unmodified flakes recovered from prehistoric camp and bison processing sites like Big Goose Creek (Frison et al. 1978), Cattle Guard (Jodry 1999; Jodry and Stanford 1992), and Clary Ranch (Hill et al. 2002) speak to the intensity of tool production and maintenance activities that probably occurred at these locations over their respective use-histories. Unfortunately, detailed collection strategies geared towards the recovery of such small debitage, as exemplified in the archeological work conducted at these sites, has been implemented less often in field research elsewhere.

The screens used during the 1963-1964 excavations of Bonfire Shelter were, for example, coarse-grained ($\frac{1}{4}$ and $\frac{1}{2}$ inch [6.35 and 12.70 mm]) and used only on occasion (Dibble 1968:19-20). Although this approach, along with constant inspection, satisfied the excavators that "little was lost" (Dibble 1968:19), this strategy probably biased against the recovery of small lithic debris (Baumler and Downum 1989).

To see if this was so for Bonfire Shelter, a sample of back dirt from the excavations was dry-screened through $\frac{1}{16}$ inch (1.59 mm) mesh. At this capture size, most small lithic debris present in sampled matrix should be recovered. Three back dirt piles remain from the 1963-1964 excavations. In the summer of 2005, four hand-dug trenches (approximately 1 x 0.5 x 0.5 m) and seven auger holes were placed in the northernmost and largest of these piles (Figure 2). This effort yielded 1.38 m³ of back dirt, primarily deriving from excavation units N98/W40, N110/W30, N110/W40, and N120/W30 (Elton Prewitt, personal communication 2005). Although this was an area of the site where artifact and bone recovery from Bonebed 2 were sparse (Bement 1986; Byerly et al. 2005; Dibble and Lorrain 1968), this back dirt was

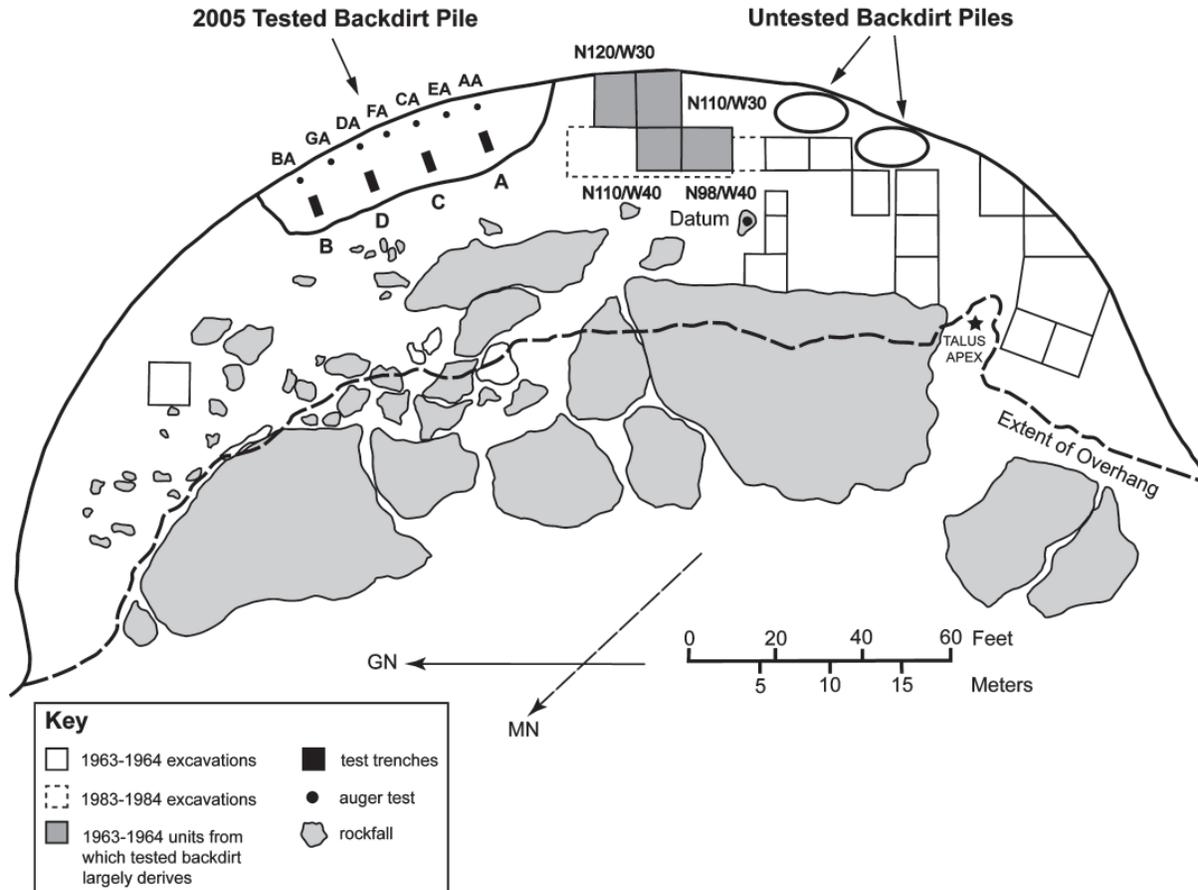


Figure 2. Plan map of 1963-1964 excavations of Bonfire Shelter showing tested and un-tested back dirt piles. Adapted from Dibble and Lorrain (1968:Figure 6).

chosen in the interest of protecting still open and unstable excavation units from potential work-related damage. All observed lithic and faunal material was recovered from the screens (Table 1). Recovered lithics consisted entirely of unmodified flakes.

Because sampled back dirt was a mix of cultural deposits, and because no comparison with the original lithic assemblage could be conducted (most of this material is currently unaccounted for; see Byerly et al. 2005:624), it was impossible to separate recovered lithic artifacts by component. Therefore, to compare our lithic findings to published lithic data, flake densities were calculated by summing the unmodified flake yield from *all* cultural layers of each excavated unit and dividing that by an estimated unit volume derived from published plan maps and profiles (see Dibble and Lorrain 1968). Although admittedly crude, this method sufficiently displays the spatial distribution and relative frequencies of the artifacts.

The back dirt sample contained approximately 1% of the total unmodified flake yield of the site from all cultural components, representing a sample volume little more than 0.5% of that of unmodified flake-bearing units (Table 2). Yet, this represents nearly twice the total flake density and six times the average density of the 1963-1964 excavations, if outlier units (e.g., N20/W50; $n = 293$; $D = 49.91$ flakes per m^3) are removed. Clearly, some artifacts

Table 1. Items recovered from back dirt testing.

Item	No.
unmodified flakes	5
macrofauna (large mammal, bison)	3158
microfauna (rodents, reptiles, birds)	341
gastropods	68

Table 2. Summary of unmodified flake density data.

	1963-1964	2005
total unmodified flakes	479	5
sample volume	223.15 m ³ *	1.38 m ³
total unmodified flake density	1.77 fk/m ³ *	3.62 fk/m ³
average flake density	6.75 fk/m ³ *	—
average flake density	0.59 fk/m ³ **	—

* Excludes data from N30/W50 and N225/W95 for which unit volume could not be estimated; total unmodified flakes = 396.
 ** Further excludes data from N20/W50; flake density = 49.91 flakes/m³.

were overlooked during the 1960s excavations. However, while these data reveal what could have been missed during the original excavations, they only partially bear on tool production or maintenance activities within the shelter as size is also an important variable to consider (Table 3).

Again implementing Baumler and Downum's (1989) experimental data, it is apparent the flakes recovered from back dirt testing are on the upper size range of material expected from tool production and resharpening activities. Yet, these flakes are also well within the capture range of 1/4 and 1/2-inch mesh (Byerly et al. 2005). These data imply that while screening did not bias the recovery of small lithic debris in this area of the site, they did bias lithic recovery as a whole. This begs the

question, assuming lithic reduction or production activities associated with intensive bison processing occurred: where did the small lithics go? If screens captured only the minority of what should be produced from tool production in an area of the site where artifact densities are lowest, where is the majority? Did minor localized water runoff originating from the notch remove small lithic debris from cultural deposits? Was tool production perhaps conducted in an isolated area of the site? Or conversely, did lithic reduction activities never occur within the shelter, at any point in time?

An elevation model of Bonebed 2 shows a clear north-trending gradient decline in the excavated area (Figure 3). If small lithic debris were

at one time winnowed by a minor water flow, the debris may have been funneled past the excavated area to the northern end of the shelter near the back wall. However, excavations conducted north of the northernmost 1963-1964 units, 20 years after Dibble's work at Bonfire Shelter, failed to yield any lithic artifacts (Bement 1986). Although this matrix was again passed through 1/4-inch mesh, the fact that it was also floated and again sorted greatly reduces the probability that artifacts were overlooked and discarded (Bement 1986). It is possible that lithic debris was transported beyond this later excavation block—two unworked flakes were recovered in test unit N225/W95 at the far northern end of the shelter during the 1960s excavations (see Figure 4)—and perhaps further excavation in this

Table 3. Dimensions of back dirt-recovered unmodified flakes.

Specimen	POR	MLEN (mm)	MWID (mm)	MDEP (mm)
C-1	proximal	9.29	7.94	1.60
C-2	midsection	11.80	11.02	2.67
C-3	proximal	20.45	15.26	6.02
D-1	complete	9.00	6.46	0.85
D-2	proximal	12.87	8.18	3.21

POR = flake portion; MLEN = maximum length; MWID = maximum width; MDEP = maximum depth.

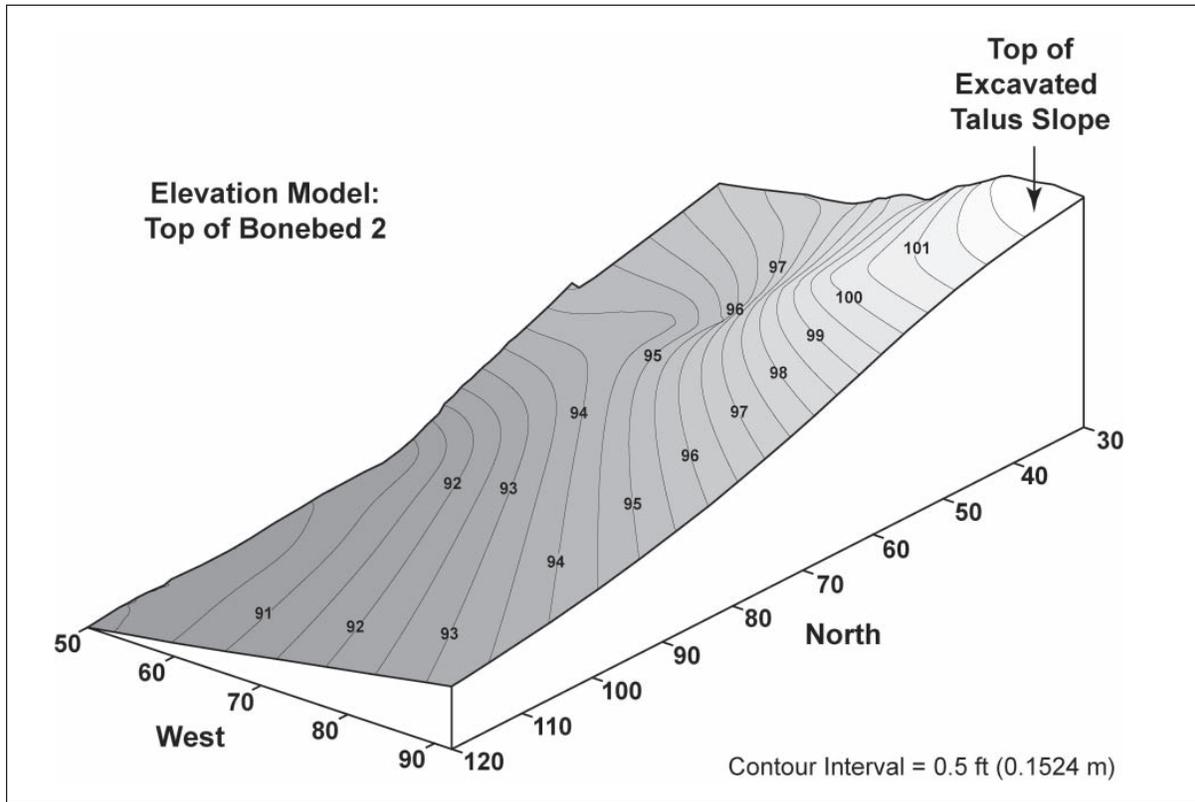


Figure 3. Contour elevation map of the top of Bonebed 2. Data derived from Dibble and Lorrain (1968:17, 21-23, 25). Figure adapted from unpublished data compiled by Jason M. LaBelle.

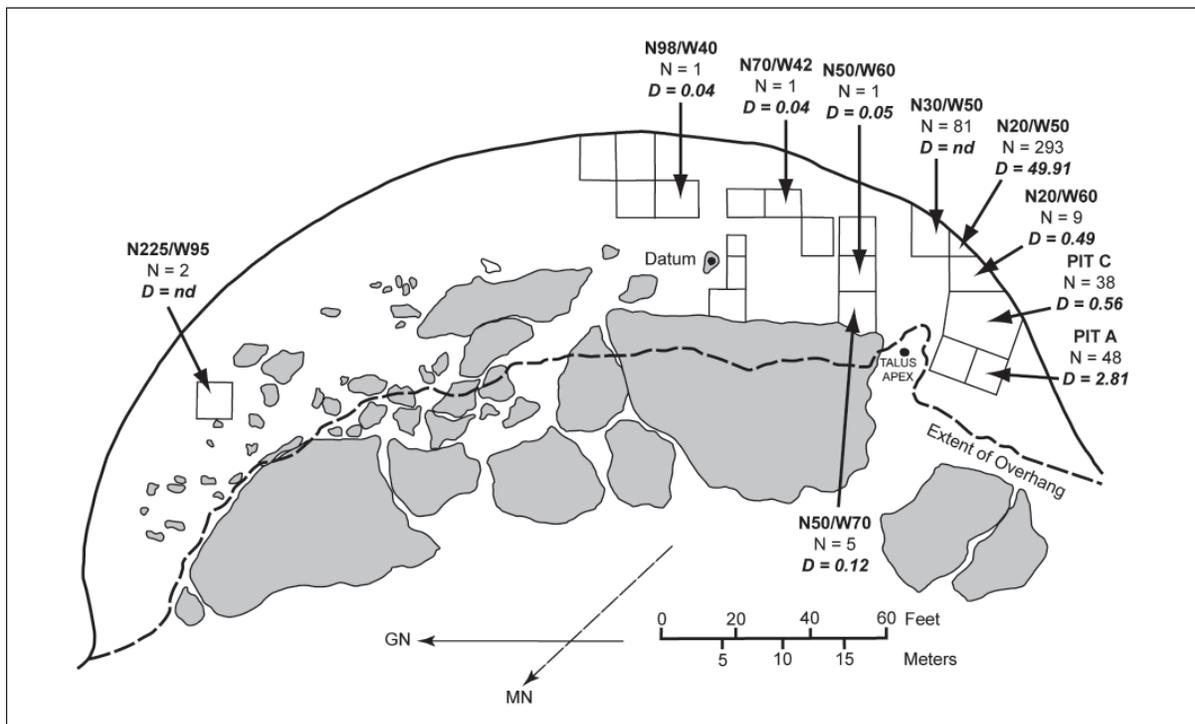


Figure 4. Plan map of 1963-1964 excavations of Bonfire Shelter showing combined unmodified flake frequencies and densities. Data from Dibble (1968). Adapted from Dibble and Lorrain (1968:Figure 6).

Table 4. Element frequency data for bison bone recovered from back dirt.

Element*	NISP	MNE
CRN	1	1
MR	1	1
CE	1	1
RB	1	1
SA	1	1
CA	5	5
HM	1	1
CPI	1	1
CPR	1	1
MC	1	1
IM	1	1
TRF	1	1
TRC	1	1
AS	6	2
CL	1	1
MT	1	1
PHF	4	3
PHS	1	1
SEP	1	1
Total	31	—

*See Byerly et al. (2005:608-609) for element codes.

northern end would yield high concentrations of lithic debris, either due to water flow within the shelter or clean-up by the prehistoric occupants of the site. Future work should concentrate on testing these possibilities.

Backdirt Screening: Bone

A total of 31 bison bones were identified from the 3000+ large mammal bones recovered from the tested back dirt; the identified elements are primarily carpals, tarsals, vertebrae, and phalanges (Table 4). Most are heavily burned and deformed, similar to bone from Bonebed 3 (see Lorrain 1965, 1968). The selective sampling of bone elements during the 1963-1964 excavation, owing to time and budget pressures, is noted in Dibble (1968:19). While no specific reference is made to which elements were discarded, other than to say the “better preserved” and “more diagnos-

tic” bones were selected (these probably included limb epiphyseal ends; Elton R. Prewitt, personal communication 2005), it was subsequently found that in Bonebed 2 selection bias was primarily against lower axial elements and innominates, at least in the near-talus area of the excavated deposits (Byerly et al. 2005:606).

Lorrain (1965:30) further states that Bonebed 3 suffered more from this sampling strategy than did Bonebed 2. Regardless, those elements recovered from the tested back dirt, again probably deriving mostly from Bonebed 3, are the lowest frequency elements recovered from Bonebed 2. These data imply that if a similar bias intensity occurred in Bonebed 2, an inference of site-use based on bone frequency alone may be suspect. However, testing this is contingent upon a specific demonstration (in terms of skeletal element representation) of the extent to which excavator selection biased the extant Bonebed 2 bison bone assemblage. Future work concentrated on rescreening back dirt

piles nearer the Bonebed 2 excavations around the talus cone should help resolve this issue.

Ancient Canyon Floor Levels

During our 2003 fieldwork we examined a 49 m long and 7 m high section of cemented sediment and gravel located high on the wall of Mile Canyon downstream of Bonfire Shelter and north of Eagle Cave. Although no dateable material was recovered, a fossilized *Equus* metapodial associated with the deposit suggested a Late Pleistocene age. It was posited that this feature represents the remnant of a Late Pleistocene fill that served as a semi-stable floor of Mile Canyon (Byerly et al. 2005:625). Given this assumption, and interpolating the elevation of this deposit up-canyon, it is probable that the Late Pleistocene or Early Holocene floor of Mile Canyon in front of Bonfire Shelter was much higher than it is at present, and the difference in

elevation between the canyon floor and Bonfire Shelter much less. Thus, Bonebed 2 bison carcasses conceivably could have been dragged into the shelter from the canyon floor with relative ease (Byerly et al. 2005:625); for that matter, this may also help explain how the mammoth, horse, and other Bonebed 1 fauna entered the shelter (Bement 1986; Dibble and Lorrain 1968). They may have walked in.

The paleohydrologic history of this region of Texas is reasonably well-recorded, owing to the preservation of cemented gravels and alluvial slack water deposits in the canyon lands along the Pecos River (Kochel 1982; Kochel and Baker 1982; Patton and Baker 1976; Patton and Dibble 1982). Such features in Seminole and Presa canyons record over 10,000 years of large-scale, high-intensity flooding. Obviously the hydrological histories of these canyons are not necessarily the same as that of Mile Canyon; they do, nonetheless, represent a reasonable proxy for understanding flooding in Mile Canyon. In addition to these events, smaller-scale and more frequent flooding can also be quite powerful. For example, while conducting research in Mile Canyon in June 2003, 1.2 inches of rain fell in Langtry within the span of an hour, causing extensive flash flooding in Mile Canyon. This downpour represents four times the average

amount received in early June that year (NOAA 2003). Although there was insufficient time or wherewithal to measure the force of the water being funneled into the canyon from its upland tributaries during this storm, it was sufficient to turn the otherwise dry Mile Canyon into a rapidly-flowing river (Figure 5). The canyon, subject as it was to multiple high-energy floods, has probably suffered numerous fill and scour events since the Late Pleistocene, raising and lowering the levels of the canyon floor. That the canyon floor was closer to Bonfire Shelter in Late Pleistocene times is certainly a testable possibility.

Bonfire Shelter is unique amongst rock shelter deposits in Mile Canyon because of the massive rock fall (portions of the cliff face) that obscures the opening of the shelter, and which at the shelter's north end have protected deposits from any flood scouring since at least the Late Pleistocene (Bement 1986; Dibble 1968). Of course, floodwaters hitting that rock fall may have also scoured out remnants of ancient stream gravels and traces of the one-time elevation of the valley floor. So, to assess whether portions of the Late Pleistocene valley floor are present as fill or gravels, we turned to the southern (downstream) end of the exterior of the shelter, since deposits ought to be protected from fluvial erosion in that area. A total of seven auger holes



Figure 5. Mile Canyon during the June 13, 2003 flash flood: (left) during, and (right) after.

was placed in a 4 x 3 m clearing in the exterior deposits surrounding Bonfire Shelter at the estimated upslope elevation of the cemented gravels (Figure 6). Auger holes penetrated an average depth of 0.84 m and were terminated at the point when the auger no longer turned. Unfortunately, no evidence of valley fill or gravel was recovered from these auger holes. Instead, all matrix consisted of a poorly-sorted, large colluvial talus debris that could not be breached beyond 0.95 m below surface. This obviously does not preclude the possibility that remnant Late Pleistocene gravels are present here, for this impenetrable colluvial drape could be relatively recent and assuredly masks older deposits. It does mean, however, that substantial excavation beyond our limited augering will be required to find such.

RESEARCH IN PROGRESS

As part of a continuing research endeavor to elucidate the paleoecological history of Bonfire Shelter and Mile Canyon, a sediment column (2 x 0.2 x 0.05 m) was removed from the southeast corner of N98/W40 to search for gastropods (Figure 7). Gastropod remains are unreported in previous fieldwork at Bonfire Shelter and have the potential to add significantly to the extant paleoenvironmental record of the site (Bryant and Holloway 1985; Robinson 1997). Presently, dry sorting of this matrix has yielded no lithic artifacts, but did surrender Bonebed 1 and Bonebed 3 bone, charcoal, as well as gastropods from Middle Archaic (4340 ± 40 B.P.) deposits to the surface.

Sampled sediment contained a total of 877 snail shells. Terrestrial taxa account for 874 specimens, of which 20.3% (n=177) are unidentified juveniles. Nine taxa are represented in the 697 individuals identifiable to species, genus, or family. Of these, five taxa are represented by more than one individual. These include Succineidae (n=368),

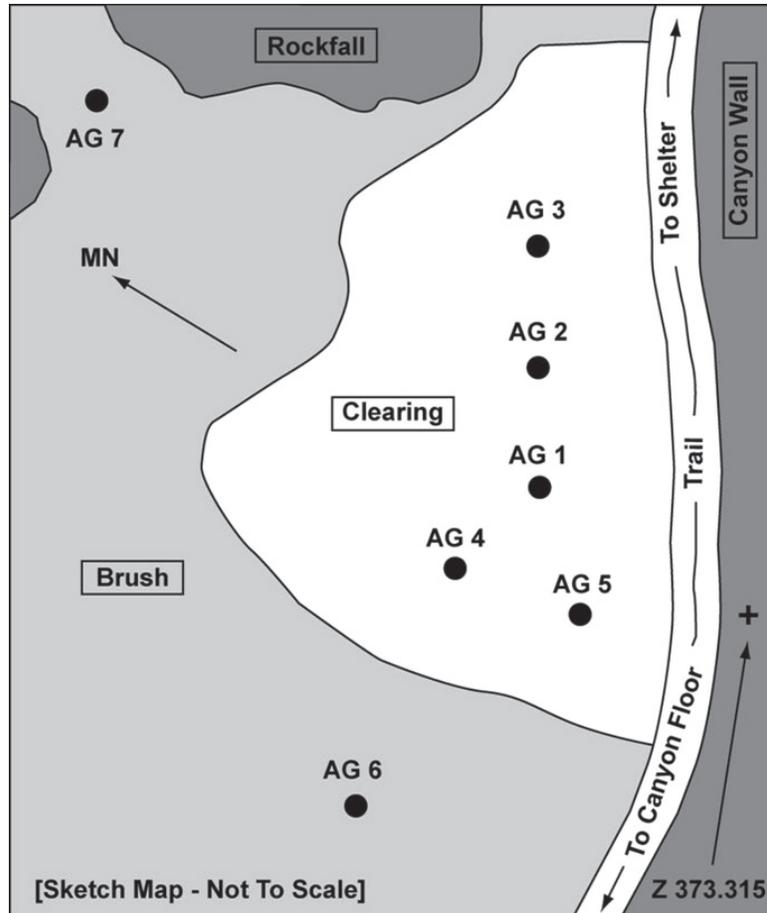


Figure 6. Sketch map of auger-hole locations on the talus slope outside the southern entrance of Bonfire Shelter.

Helicodiscus singleyanus (n=134), *Hawaiiia minuscula* (n=87), *Gastrocopta pellucida* (n=67), and *Rabdotus alternatus/Rabdotus* sp. (n=37). Four taxa are represented by single individuals and include *Gastrocopta pentodon*, *Vallonia* sp., cf. *Helicodiscus nummus*, and *Millerelix* cf. *M. mooreana* (Table 5). Aquatic snails are represented by two individual specimens of the genus *Gyraulus* sp. and one individual of the family Physidae, all three of which are juveniles.

The excellent preservation of the majority of shells recovered at Bonfire Shelter suggests rapid burial in calcareous sediments with little solar exposure. This indicates that most specimens were living near where they were recovered and probably did not arrive as empty shells carried by water runoff or gravity from the upland surface. The protected nature of the talus cone would have offered an ideal habitat for most of the common species recovered at the site.

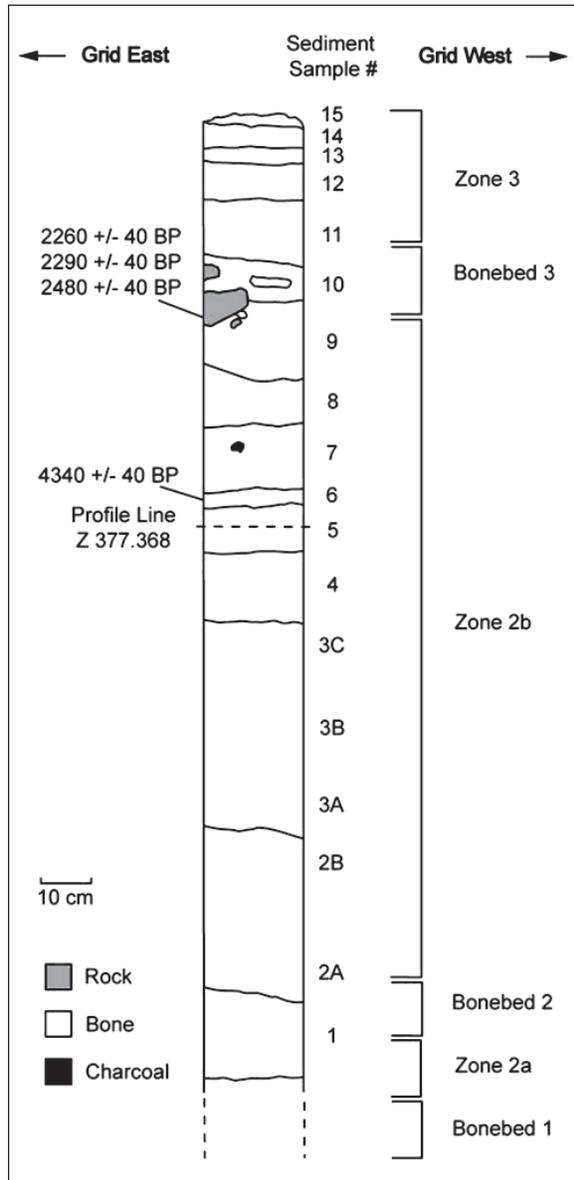


Figure 7. Profile of the sediment column taken from the south wall near N98/W40. Radiocarbon dates are from adjacent strata in the east wall near N98/W40.

The episodic runoff of water and organic detritus onto the debris cone coupled with little direct sunlight would produce an ideal habitat for Succineidae, *Helicodiscus singleyanus*, and *Hawaiiia minuscula*. The continuous distribution of these taxa from Sample 14 to Sample 4 indicates the presence of a suitably moist micro-habitat and their paucity or absence from Sample 3C to Sample 1 suggests a drying of that habitat (Figure 8). These data support previous palynological (Bryant and Holloway 1985) and geologic-based (Dibble 1968) paleoclimatic interpretations for the Early Holocene

of southwestern Texas as a whole and Bonfire Shelter specifically. Sample 13 shells were encrusted with a carbonate-like mineral, perhaps acquired in a very moist environment.

Gastrocopta pellucida is found in Samples 14 and 13 and again in Samples 8 through 3C. The distribution of *G. pellucida* may represent periods of higher precipitation with an increase in vegetation above or at the shelter. This interpretation for the *G. pellucida* 'zones' closely correspond with peaks in overall snail density and taxa diversity at the shelter.

The distribution of *Rabdotus* is restricted to Sample 14 through Sample 7, with the highest density in Samples 12 and 11. A single adult shell of *Rabdotus alternatus* was recovered, with the remaining 36 *Rabdotus* individuals being either unidentifiable juveniles or fragmented shell apices. This is a genus that is characteristically found in large colonies and their distribution indicates a local colony that may have flourished during the period represented by Samples 12 and 11. The fragmented *Rabdotus* apices are perhaps the result of predation by small mammals. The single individuals of *Vallonia* and *Chara* are from Sample 5 and have the opaque character of sub-fossils and may derive from an older deposit.

DISCUSSION AND SUMMARY: OF KILL SITES AND BUTCHERY SITES

Prehistoric hunter-gatherers utilized a variety of tactics to procure bison on the Great Plains. Owing to their size and archeological visibility, mass trap and jump kills have received the most attention in the literature, although isolated, smaller-scale kills were probably more typical of hunter-gatherer subsistence strategies (Fisher and Roll 1999; Frison 1973; Hill 2001; Landals 1990; McCartney 1990). Depending on the size of these kills, the number of people involved, and their location, any number of satellite butchery sites may have been generated. Initial butchery probably occurred at the site of the kill, with large carcass portions subsequently transported to other locations for more intensive disarticulation and meat and marrow procurement (Metcalf and Barlow 1992). These processing areas may have represented short-term hunter-gatherer camps or larger residential hubs, located very near the site of the kill or situated some distance from it (Hofman 1999a). Because

Table 5. Summary gastropod data.

Gastropod Shell NISP: sieved sediment less than 2 mm																	
Sample*	1	2A	2B	3A	3B	3C	4	5	6	7	8	9	10	11	12	13	14
Volume (Liters)	1	1	1	1	1	1	1	1	0.6	1	1	1	1	1	1	0.6	0.7
Terrestrial Taxa	N																
<i>Gastrocopta pellucida</i>	1	6	13	11	19	3	8	6	67								
<i>Gastrocopta pentodon</i>					1												1
<i>Vallonia</i> sp. [juvenile]**					1												1
<i>Rabdotus</i> sp. [juveniles/fragments]						1	1	1	1	1	1	1	1	1	8	3	18
cf. <i>Helicodiscus nummus</i>																	1
<i>Helicodiscus singleyanus</i>					11	10	10	7	11	2	25	23	17	4	14	134	
Succineidae				6	6	41	56	14	34	28	24	18	19	28	15	12	301
<i>Hawaia minuscula</i>	1	8		4	18	8	1	3	5	2	1	21	7	4	4	87	
terrestrial juveniles	2	2		1	22	24	9	30	11	5	16	23	3	17	12	177	
Terrestrial Subtotal	3	10		6	12	98	112	45	94	59	34	61	87	63	51	52	787

Aquatic Taxa																
Physidae [Juvenile]												1				
<i>Gyraulus</i> sp. [Juveniles]												2				
Aquatic Subtotal												3				
Terrestrial & Aquatic Total	3	10	6	13	98	113	45	94	59	34	61	87	64	51	52	790
<i>Chara</i> sp.**																
																1
Gastropod Shell NISP: hand-picked sediment greater than 2 mm																
Terrestrial Taxa																
<i>Rabdotus alternatus</i>																N
<i>Rabdotus</i> sp. [juveniles/fragments]																1
<i>Millerelix</i> cf. <i>M. mooreana</i>																17
Succineidae																1
terrestrial juveniles																1
Terrestrial Total	1	1	1	15	5	5	3	6	6	5	11	11	2	2	2	67
Sample Total	4	10	6	14	114	118	45	100	65	40	68	102	84	53	54	877

* See Figure 7 for sample location.
 ** Possible reworked sub-fossil.

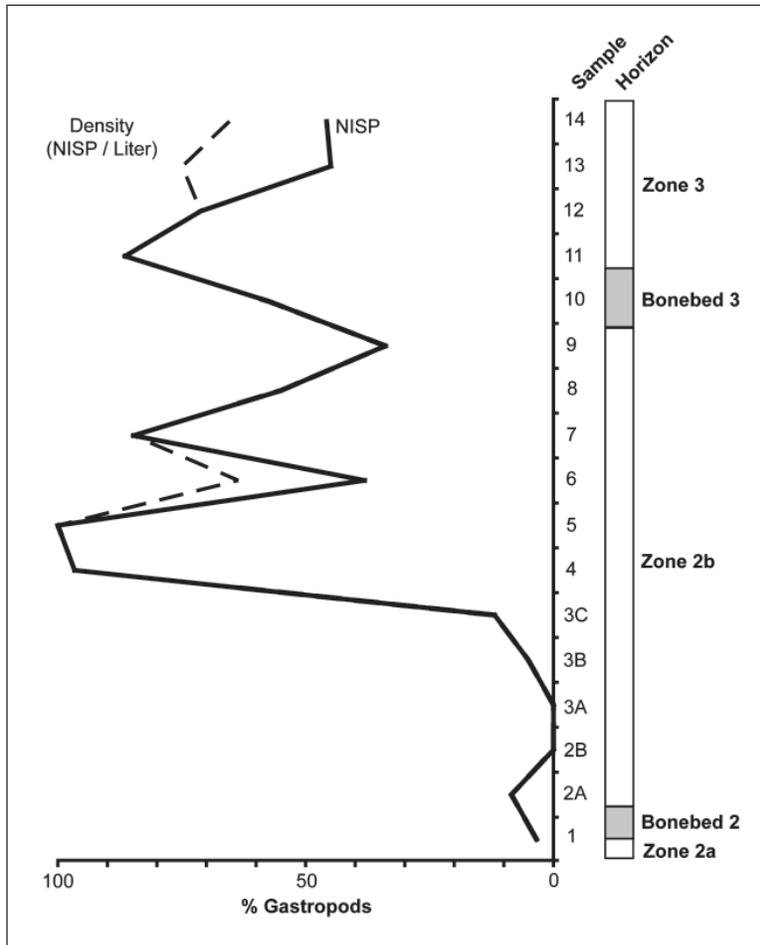


Figure 8. Sample gastropod data summarized by %NISP and %NISP Density.

different levels of activity occurred at each site, each would in turn produce their own unique material record (Binford 1980).

Amongst Great Plains bison kill-butchery sites, Bonfire Shelter Bonebed 2 occupies a middle ground in terms of inferred site-use (Figure 9). Bison kills are, by and large, expected to: (1) be in association with a natural or artificial trap; (2) display low artifact diversity with hunting weaponry (i.e., projectile points) dominating the lithic assemblage; (3) have minimal evidence of cooking or processing (i.e., few fire features and heat-altered rock); (4) be marked by low species diversity; and (5) have a preponderance of whole bones, usually low-utility elements, and articulated skeletons. By contrast, processing and camp sites are expected to: (1) display a preponderance of butchering tools and lithic debris; (2) have fire features and heat-altered rock; (3) possibly demonstrate high species

diversity, depending on the type and length of occupation and the range of activities that occurred; and (4) consist of mostly broken, high-utility bones and have few articulated skeletons (Fisher and Roll 1997:432; Todd 1987a:231; Wheat 1978).

Indeed, comparing a sample of Great Plains kill-butcherries spanning the last 11,000 years, inferred kill sites are typified as having relatively greater projectile point and individual bison densities than inferred camp or processing sites (Table 6 and Figures 9 and 10), while non-projectile point tools and modified flakes are, on average, significantly more frequent in these camp and processing sites ($F = 23.664$, $p = .000^1$; Table 6 and Figure 10). This observation holds for unmodified flakes also ($F = 6.458$, $p = .019^1$), but the inconsistent strategies employed to collect these artifacts at each of these sites, as well as inconsistencies in reporting, challenge the validity of this relationship.

While these generalizations reflect observations of a wide-range of taphonomically-varied archaeological deposits, it is clear that Bonfire Shelter displays many of the traits consistent with other jump kill sites (Table 7). The lithic component of Bonebed 2 is seemingly dominated by hunting weaponry and lacks butchering tools or debitage, highly suggestive of a kill (Dibble and Lorrain 1968). At the same time, however, Bonebed 2 stands out amongst other 'classic' jump sites in having far more non-projectile point tools and modified flakes per projectile fragment (see Table 6), even those where intensive primary butchery probably occurred (e.g., Glenrock). Likewise, projectile point frequencies are generally low, as are point to bison ratios, surpassed only by, interestingly, Bonebed 3 at Bonfire Shelter (see Table 6). The Roberts Buffalo Jump is a noted exception to this, although data for this assemblage are not separated into kill and processing area components (see Figure 9; Witkind 1971). Features and fire-cracked rock, typically absent from jump kill sites, are rare,

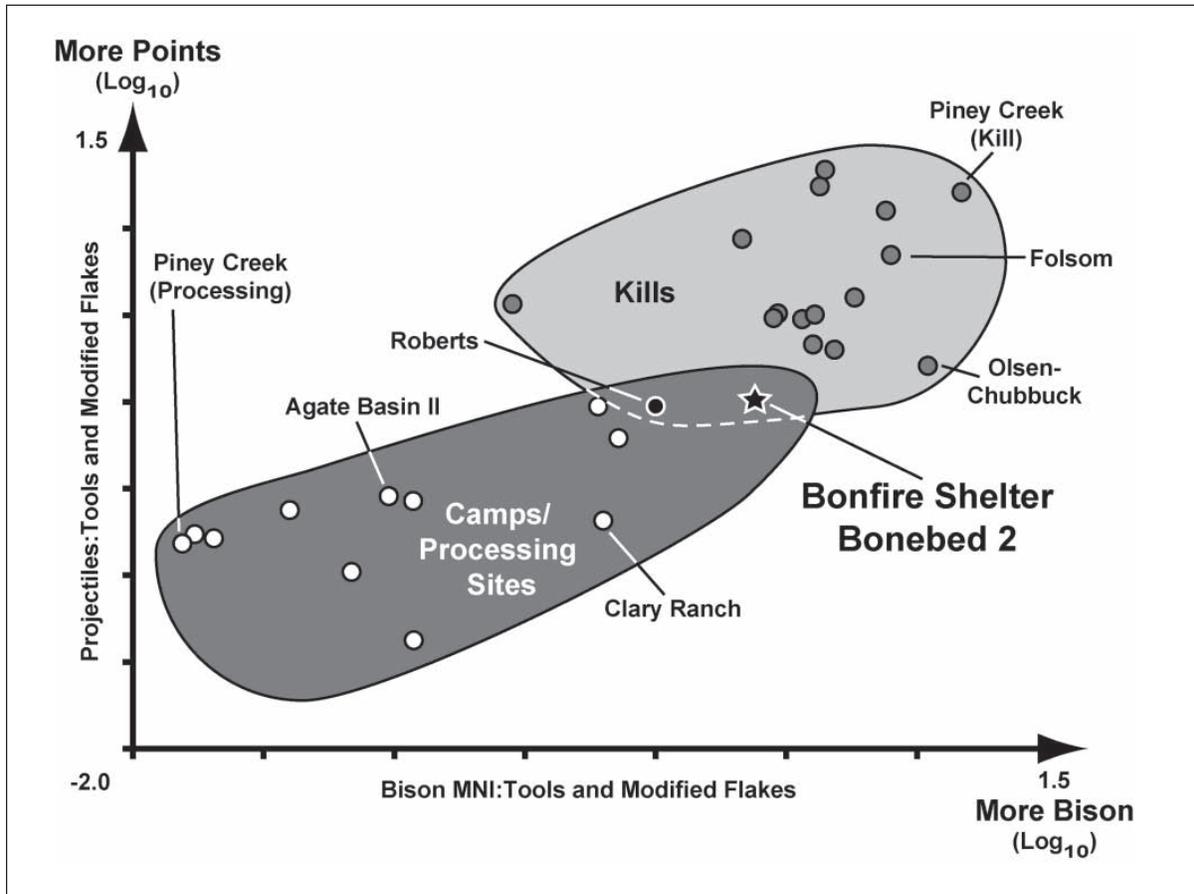


Figure 9. Scatterplot of \log_{10} normalized projectile point to non-projectile tool and modified flake (PP/TMF), and bison MNI to tool and modified flake (MNI/TMF), ratios (Table 6). PP tallies include published counts of complete and broken projectile points and fragments. Tools include all published counts of non-projectile chipped stone tools and tool fragments (e.g., scrapers, bifaces, knives, graters, drills, etc.) and otherwise modified flakes; core fragments and hammerstones are not included.

but present in Bonebed 2 (Dibble and Lorrain 1968). Although not unusual—Glenrock and Bonfire Shelter Bonebed 3 also have fire features—this does point to processing activities within the shelter.

Furthermore, of the classifiable projectile points from Bonebed 2, five different types are argued to be present (Folsom, Midland, Milnesand, and Plainview or Lubbock), ostensibly representing some 500 to 1,000 years of overlapping Southern Plains technological variation (Bousman et al. 2004:70; Cooper and Byerly 2005; Kerr 2000). This is all the more confusing given that the bison assemblage suggests a single event (Byerly et al. 2005). Indeed, overall, recovered bison remains appear to square better with a processing site interpretation (Binford 1978; Byerly et al. 2005). Arguably, the presence of so many projectile point types suggests multiple events or perhaps even cooperative activity among

several groups. Yet given the diverse array of interpretations for the small projectile point assemblage in Bonebed 2, including the overlap of Folsom and Plainview, or Plainview-like, points in the lowest deposits of Bonebed 2 (Component A, Dibble 1968), how much confidence can be placed in the idea that points equal people in this instance? This apparently diverse assemblage might instead represent the idiosyncratic handiwork of several individual knappers (Bamforth 1991), or reflect the tendency of archeologists to “split” variants of the same projectile point type into multiple types, thereby complicating the Paleoindian chronological sequence.

With the noted collection bias against the recovery of both lithic and faunal material at Bonfire Shelter, can one artifact class have more analytical weight than the other (Bamforth 2002)? Where is

Table 6. Summary data for select Great Plains kill-butchery sites.

Site	Site-Use	Area (m ²)	PP	TMF	UMF	MNI	References
Agate Basin II (Folsom)	C	243.82	24	84	nd	8	Frison 1982; Hill 2001
Big Goose Creek	CP	219.48	155	653	11364	26	Frison et al. 1978
Bootlegger Trail (BI, BII)	P	124.00	339	360	nd	224	Roll and Deaver 1980
Cattle Guard	P	238.00	64	392	17367	8	Jodry 1999; Jodry and Stanford 1992
Clary Ranch	C	192.00	13	63	12103	41	Hill 2001; Hill et al. 2002
Jurgens I	C	110.00	11	261	1421	31	Wheat 1979
Jurgens II	C	58.00	20	116	488	2	Wheat 1979
Jurgens III	P	84.00	29	47	98	35	Wheat 1979
Mill Iron	C	110.00	11	41	3	5	Bradley and Frison 1996; Todd et al. 1996
Piney Creek (312)	P	821.65	69	453	3270	7	Frison 1967
Wardell	P	195.47	35	335	5065	23*	Frison 1973
Big Goose Creek	K	35.69	61	7	nd	15	Frison et al. 1978
Bonfire Shelter (BB2)	KP?	215.48	11	10	17	24	Byerly et al. 2005; Cooper and Byerly 2005; Dibble and Lorrain 1968
Bonfire Shelter (BB3)	KP	215.48	38	23	22	197	Dibble and Lorrain 1968
Bootlegger Trail (D)	K	25.00	70	4	nd	17	Roll and Deaver 1980
Casper	KP	1088.00	81	5	308	74	Frison 1974; Todd et al. 1997
Cooper (All)	K	24.09	33	11	125	40	Bement 1999; Hofman 1999
Folsom	K	252.70	28	4	0	32	Hofman 1999; Meltzer 2006
Glenrock (All)	KP	247.40	152	47	3722	138	Frison 1970
Jones-Miller	KP	508.00	104	26	11500*	150	Stanford 1975, 1978, 1999
Kobold II	K	247.81	51	16	813	65	Frison 1970
Kobold III	K	247.81	70	23	1319	65*	Frison 1970
Kobold IV	K	247.81	220	60	3033	17*	Frison 1970

Table 6. (Continued)

Site	Site-Use	Area (m ²)	PP	TMF	UMF	MNI	References
Lipscomb	K	50.60	30	14	17	56	Hofman 1999
Mill Iron	KP	29.87	12	6	2	29	Bradley and Frison 1996; Todd et al. 1996
Olsen-Chubbuck	KP	112.74	27	13	3	143	Wheat 1972
Piney Creek (312)	K	180.17	190	15	1145	114	Frison 1967
Roberts	KP	111.48	17	18	2001	18	Witkind 1971
Wardell	K	81.29	436	20	250	89*	Frison 1973

* Values estimated. PP = complete and fragmented projectile points; TMF = non-projectile tools and modified flakes; UMF = unmodified flakes; MNI = minimum number of individual bison. C = camp; CP = camp/processing; K = kill; KP = kill/processing. Excavated area data are derived from published site plan maps or directly from text. Note: Excavated area for Bonfire Shelter Bonebeds 2 and 3 reflect only the 1963-1964 excavations.

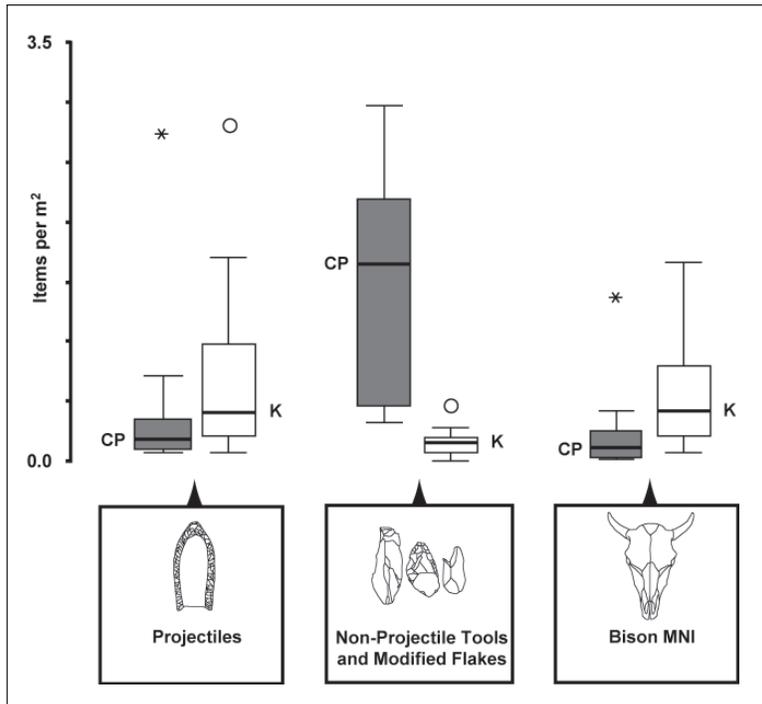


Figure 10. Artifact densities for those sites listed in Table 6, excluding Bonfire Shelter Bonebeds 2 and 3. CP = camp/processing sites; K = kill sites. Extreme outliers for projectiles and bison MNI from camp/processing sites represent the Bootlegger Trail site. Outliers for projectiles and non-projectile tools and modified flakes from kill sites represent the Bootlegger Trail and Cooper sites, respectively. An extreme outlier for kill projectiles representing the Wardell site is not shown.

the line drawn between sorting archeological sites into kills and processing localities based on these classes? Is drawing such a line even beneficial to understanding prehistoric hunter-gatherer behavior? Ultimately, little knowledge of past human behavior is gained by drawing such a line. Regardless of site use, it is clear that Paleoindian hunters at Bonfire Shelter (and elsewhere on the Plains) possessed the technological and organizational ingenuity to herd and dispatch large groups of dangerous, behaviorally-volatile animals with success (Frison 2004; Hill 2001). Indeed, whether Bonebed 2 is a processing site bears little on how the animals were killed (Byerly et al. 2005).

Artifact based site-use interpretations of Paleoindian bison kill-butcherries largely stem from the expectations of archeologists utilizing ethnographic and archeological examples of socio-economic systems probably far-removed

Table 7. Select data for some 'classic' bison jump kills.

Site	Cliff/Trap	Drive-Line	Fire	Articulated Skeletons	Burned Bone
Big Goose Creek (Kill)	■	■	nd	■	nd
Bonfire Shelter (BB2)	■	○	■	○	■
Bonfire Shelter (BB3)	■	○	■	■	■
Glenrock (All)	■	■	■	○	○
Kobold II	■	■	○	■	■
Kobold III	■	■	○	nd	■
Kobold IV	■	■	○	nd	■
Piney Creek (Kill)	■	■	nd	○	nd

■ = present; ○ = absent; nd = no data. No drive-line features were found around Bonfire Shelter but a GIS analysis does suggest that the surrounding topography is amenable to successful bison jumping (see Byerly et al. 2005).

from those actually practiced by Paleoindian peoples; a single fundamental artifact pattern characterizing the lifeways of ancient peoples does not exist (Hofman 1999a:123). It is important to remember that bison kill-butcherries existed within a continuum of activities against varied temporal and spatial scales, and their remains exist within dynamic taphonomic settings that have been subjected to varying degrees of analytical scrutiny (Todd 1987a, 1987b; Todd and Rapson 1999). The opportunity to use information gleaned from bison kill-butcherries to tactically enhance our understanding of the past (Binford 2001), and further enhance knowledge of prehistoric human behavior, comes in exploring why sites like Bonfire Shelter stand out in the archeological record. If Bonebed 2 was a Paleoindian bison jump, why is this strategy not utilized anywhere else on the Southern Plains (the Certain site, as noted, being a possible exception) or until the Archaic (perhaps Bonebed 3)? Further, if Paleoindian hunters had the technological and organizational capability to herd and kill bison, why are jumps not more prolific in the Paleoindian archeological record? Did regional and temporal differences in bison behavior discourage such a strategy, or was it simply not conducive to the lifeways of Paleoindian hunter-gatherers? Or, conversely, is it simply a matter of preservation stemming from the unique protection Bonfire Shelter offered from the destructive and continual erosional forces that affected areas like

the Caprock Escarpment of the Southern High Plains throughout the Holocene (see Boyd et al. 1991:9, 47)? The first step in answering these questions is making sure available lithic and faunal data from proposed jump kills are analytically comparable with other archeological assemblages. Our 2003-2005 fieldwork represents the first stage in updating relevant data at Bonfire Shelter so that Bonebed 2 can be more accurately placed within the spectrum of archeological bison kill-butcherries.

In this regard, we suggest that Bonebed 2 cannot be interpreted directly in terms of Bonebed 3, lest the issue of site-use be obfuscated by coincidence. These assemblages are separated by nearly 7,000 years of human technological innovation, landscape change, and bison evolution. They are independent phenomena which may have a common cause, but that must be demonstrated; it cannot be assumed. Spatial correlation aside, Bonebeds 2 and 3 share very little in terms of their respective material records and it is of little analytical use to assume they do because of a singular geographic/geologic commonality (i.e., the notch above the shelter). However, while a direct behavioral association may be inappropriate, these assemblages can be compared with respect to their individual formation and excavation histories, and it is via such a comparison that perhaps a more thorough understanding of the archeological record of Bonfire Shelter is possible.

The results of the 2005 fieldwork, aimed at investigating potential lithic recovery bias and evaluating evidence of Late Pleistocene to Early Holocene floor levels in Mile Canyon, are as follows:

- 1) Back dirt screening recovered a higher density of unmodified flakes than the total and average densities of flakes from all cultural components of the site, but these artifacts are neither of the size nor frequency expected from intensive resharpening or tool production activities. Recovered discarded bone, although probably from Bonebed 3, are the lowest frequency elements in the extant Bonebed 2 assemblage. It is not apparent that screening methods employed during the 1963-1964 excavations were biased against the recovery of very small lithic debris, but it did bias the recovery of lithic material overall. Likewise, if the intensity of bone discard employed in the recovery of Bonebed 3 bison was similar for Bonebed 2 material, this would shift bone frequency data away from the interpolated bulk-utility profile.
- 2) Gravels and sediments similar to those from the analyzed cemented gravels are not present in the sampled exterior deposits of the shelter up to a depth of 0.95 m. No evidence of ancient canyon floor levels was found during the 2005 season.
- 3) Taxonomic analysis of recovered gastropods is consistent with previous palynological and geological interpretations of the paleoecological conditions within the central interior portion of Bonfire Shelter (Bryant and Holloway 1985; Dibble 1968). The paucity of Succineidae, *Helicodiscus singleyanus*, and *Hawaiiia minuscula* in the lower sampled units (Sample 3C to 1, or mid-Zone 2B to 2A), in particular, suggests a dry or unstable habitat inhospitable to the proliferation of these taxa. Similarly, lower relative frequencies of gastropods in Samples 6 and 9, respectively (ca. Middle to Late Middle Holocene; see Figure 8), speaks to overall more arid conditions during these times. An increase in gastropod frequency coincident with the deposition of Bonebed 3 may further indicate a return to moister conditions during the Late Holocene and may also help explain the proliferation of bison in the region in sufficient numbers to conduct a mass kill(s) at this time.

These results suggest that further testing of back dirt piles, preferably those nearest the talus cone, will give a more accurate accounting of the size and frequency of lithic artifacts discarded or missed during the 1963-1964 excavations. Such testing will also give a better indication of what specific skeletal elements were discarded from Bonebed 2. Additional excavations in areas north of the 1963-1964 and 1983-1984 blocks may reveal if microdebitage was washed out of the bone bed concentrations, although available gastropod data indicate that even episodic runoff into the shelter may have been absent during Bonebed 2 times. Regardless, the rate of water runoff into the shelter during intense precipitation events, as well as experimental evaluation of the potential affect(s) of this runoff on shelter floor materials, must be empirically investigated before any conclusions about fluvial activity are made. Likewise, if tool production and maintenance activities occurred within the shelter, it is expected that such tasks would be relegated to areas outside the main activity area near the south entrance of the shelter. These additional excavations can also test this hypothesis.

Although no evidence of ancient canyon floor levels was found, continued testing of the talus slope or other areas around the shelter, deeper than that conducted during the 2005 season (greater than 1 m), are needed to resolve whether Late Pleistocene gravels are present and how they may relate to the floor level of Mile Canyon at the time of the Paleoindian occupation of Bonfire Shelter.

NOTES

1. Excludes data from Bonfire Shelter Bonebeds 2 and 3.

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