L'Alimentation des Hommes du Paléolithique, Liège, ERAUL, vol. 83, 1997, p. 23-57

COMMUNAL BISON HUNTING IN WESTERN NORTH AMERICA : BACKGROUND FOR THE STUDY OF PALEOLITHIC BISON HUNTING IN EUROPE

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RESUME

Cet article propose un bref bilan de l'état actuel de la recherche sur la chasse au bison en Amérique du Nord durant la Préhistoire. Un accent particulier est mis sur les nouveaux développements méthodologiques et théoriques apportés par les travaux nord-américains. Ceux-ci peuvent se révéler particulièrement intéressants pour les universitaires concernés par la chasse au bison en Europe durant le Paléolithique moyen et supérieur. Ainsi, les thèmes abordés ici portent-ils aussi bien sur les méthodes de boucherie, l'éventualité de transport de carcasses animales et leur mode de traitement, que sur leur potentiel nutritif.

ABSTRACT

This paper briefly reviews the current status of research on prehistoric communal bison hunting in western North America. Particular emphasis is given to theoretical and methodological developments in the North American work that may be of interest and value to scholars concerned with bison hunting in Europe during the Middle and Upper Paleolithic. Topics considered in the paper include seasonal timing of kills, methods of procurement, butchering and transport decisions, and nutritional value.

INTRODUCTION

There is a growing interest among Paleolithic scholars in the cognitive and behavioral capacities of Late Pleistocene archaic and anatomically modern humans (e.g., Bar-Yosef 1992; Frayer *et al.* 1993; Klein 1989a, 1989b; Mellars 1990, 1996; Mellars and Stringer 1989; Trinkaus 1987, 1989). Increasingly, archaeologists and paleoanthropologists are seeking insights into these capacities through studies of the manner in which pre-modern humans exploited large mammalian prey (e.g., Binford 1984, 1988; Chase 1986, 1989; Farizy and David 1989; Farizy *et al.* 1994; Grayson and Delpech 1994; Hoffecker *et al.* 1991; Jaubert *et al.* 1990; Klein 1978, 1979, 1989b, 1995; Peterkin *et al.* 1993; Stiner 1991, 1994; Straus 1987, 1990; Trinkaus 1987). In the past and particularly among North American scholars, this debate has sometimes been framed in terms of a rather simplistic dichotomy between hunting versus scavenging; Neanderthals were assumed to

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have been rather dim-witted, opportunistic scavengers, whereas anatomically modern forms were thought to have been more progressive, forward-looking "big game" hunters.

Although we remain far from a consensus on this issue (for example, compare Chase, 1989, Klein, 1995, and Stiner, 1994), recent faunal studies have begun to show that Late Pleistocene subsistence was probably far more complex, and that at least the later Neanderthals were already effective hunters of quite large and potentially dangerous prey (Stiner 1991, 1994). The discovery of Middle Paleolithic sites like Mauran, in France (Farizy *et al.*, 1994), with large numbers of bison bones tightly juxtaposed in a context very reminiscent of the "bone beds" in North American bison kills, adds further fuel to the debate, because such sites may imply that Neanderthals possessed considerably greater technological and organizational know-how than many of us heretofore have been willing to consider.

But what in fact does it take to be a communal bison hunter? What are the technological and organizational prerequisites for a successful kill? To what extent can we infer procurement strategies and decision-making processes from the form and content of a communal kill? And can these kinds of observations help us further delineate the nature of Neanderthal cognitive and behavioral capacities? Obviously, it would be presumptuous and far beyond my expertise to attempt an answer to all of these questions. My principal goal here is a much more modest one. I hope to provide European Paleolithic specialists with a concise yet reasonably comprehensive overview of the diversity of communal techniques that are known to have been used by Native Americans to hunt bison, and to pinpoint some of the key factors that determined the timing, location, and form of these kills. Ultimately, I hope through this review to provide a baseline framework against which European Paleolithic kill sites can be compared, evaluated, and interpreted. Perhaps the most important goal of this paper is to foster greater interchange between Old World and New World scholars who share a common interest in the role of large-mammal hunting in human evolution.

Bison were the pre-eminent resource of Plains Indians from Paleoindian times, roughly 12,000 years ago, right up into the 19th century. Throughout the Great Plains, a vast grassland sea stretching from the Rocky Mountains to the Mississippi River and from the fringes of the boreal forest to the Mexican border, it is nearly impossible to excavate an archaeological site, no matter what its time period or settlement type, and not find at least some bison bones. Hundreds of prehistoric kill sites are known, and dozens have been tested or excavated over the past half century. The bone beds in many of these sites are massive, containing the butchered remains of hundreds of bison, and the largest among these kills contain the carcasses of literally thousands of animals.

Given the prominence of bison in the roughly twelve-thousand-year-long archaeological record of the Great Plains, and the wealth of ethnohistoric sources that document in great detail how recent Native Americans hunted and used these animals, it is not surprising that bison studies have come to play an

important role in North American archaeology. Needless to say, there is a vast literature on prehistoric bison hunting, and the methods for analyzing and interpreting bison kill sites, and it would be impossible to survey all of this material in a brief overview such as this (e.g., Agenbroad, 1978; Anderson and Semken, 1980; Anell, 1969; Arthur, 1975; Bamforth, 1988; Bedord, 1974, 1978; Chisholm *et al.*, 1986; Clark and Wilson, 1981; Davis and Wilson, 1978; Dibble and Lorrain, 1968; Dillehay, 1974; Duffield, 1973; Emerson, 1990, 1993; Ewers, 1949; Fawcett, 1985; Forbis, 1962; Frison, 1970a, 1970b, 1974, 1978, 1982, 1987, 1991a, 1991b; Frison and Reher, 1970; Frison and Stanford, 1982; Frison and Todd, 1987; Frison *et al.*, 1976; Kehoe, 1967, 1973; Keyser, 1977; Kreutzer, 1992; Morgan, 1980; Morlan, 1991, 1994; Newton, 1983; Peterson, 1977; Rapson, 1990; Reeves, 1990; Reher, 1970, 1973, 1974, 1977, 1978; Reher and Frison, 1980; Roll and Deaver, 1980; Shay, 1971; Speth, 1983, 1991b; Stanford, 1978; Todd, 1986, 1987, 1991; Todd and Frison, 1992; Todd and Hofman, 1987; Todd *et al.*, 1990; Verbicky-Todd, 1984; Wheat, 1972; Wilson, 1980). Moreover, many of these studies, while of interest to Great Plains specialists, are unlikely to be of much relevance to European prehistorians. Hence, what I have opted to do here is to focus on those aspects of North American bison research that are most likely to be of use in the analysis of European Late Pleistocene bison kills.

THE IMPACT OF THE HORSE

Before discussing what is currently known about bison hunting in North America, a few baseline facts should be mentioned which may not be common knowledge among Old World scholars. First, all bison hunting in North America prior to the appearance of Europeans was done on foot. Horses were native to the New World during the Pleistocene but became extinct, along with mammoths, mastodons, camels, and others, at least 10,000 years ago. Horses were reintroduced by the Spaniards into the Southern Plains area of New Mexico and Texas in the mid- to late-16th century, but apparently were not ridden by Native Americans until sometime in the first third of the 17th century (Oliver, 1962; Secoy, 1953). Prior to about 1630, horses that escaped from the Spaniards were hunted by the Indians for food. The widespread use of horses in the Northern Plains began even later, perhaps not until the early part of the 18th century. Lacking both horses and wheeled vehicles, pre-contact Native Americans in the grassland interior of North America had to transport everything on their backs, or on the backs of dogs (Wilson, 1924).

The introduction of the horse brought about dramatic changes in Plains Indian lifeways (Ewers, 1980; Hanson, 1986; Holder, 1970; Oliver, 1962; Osborn, 1983; Secoy, 1953). A thorough discussion of these transformations is obviously beyond the scope of this paper, but a few points that relate directly to bison hunting are important to note here. First, the horse allowed hunters to exploit herds much farther from their home base than had previously been possible. The horse was also tremendously useful as a beast of burden, and allowed the Indians to transport more of the kill over much greater distances. These factors undoubtedly spurred a great increase in the intensity of bison hunting in the Plains, and dramatically altered the patterns of interaction and competition

among Plains Indians, and between bison hunters and settled village farmers along the margins of the Plains (e.g., Spielmann, 1991). The horse also allowed hunters to attack the herds in ways that would not have been possible in the pre-horse period. With horses, hunters could run alongside fleeing bison and shoot them from the saddle. This new ability allowed Indians to hunt bison in large numbers at times of year, particularly during the summer rut, when the disruptive or erratic behavior of the animals made communal procurement by pedestrian hunters exceedingly difficult, if not impossible. Thus, much of the ethnohistoric literature on communal bison hunting, which depicts hunts on horseback aided by firearms, must be viewed cautiously when used as a source of analogues for prehistoric hunting patterns.

IMPORTANCE OF ANIMAL CONDITION

The successful communal bison hunt was not just a matter of locating animals and killing them. At least two other factors entered into the calculus of the hunt that played critical roles in determining whether animals would be pursued or not and, once killed, whether they would be used in their entirety or only partially; these factors are the physical condition of the animals; and their behavior at the time of the kill, particularly their tractability or maneuverability in the context of a communal drive. In this section, I consider the importance of animal condition in the procurement strategies of North American bison hunters. The issue of bison tractability or maneuverability is discussed in a later section.

Numerous ethnohistoric and ethnographic sources make it eminently clear that bison were sometimes deliberately ignored, or killed but only partially utilized, if their condition was poor (see Speth, 1983 and references therein). Since this issue has been discussed in detail elsewhere, the full argument need not be repeated here (Speth, 1983, 1987a, 1987b, 1989, 1990, 1991a; Speth and Spielmann, 1983). A brief summary of the key points will suffice.

Both male and female bison lose body weight over the course of the winter, as forage quality deteriorates. Decline in physical condition is exacerbated if severe storms or heavy snow cover make existing forage difficult to find or get at. Pregnant cows, having the added caloric demands of a developing fetus, and then of a nursing calf, are often in poorest shape by spring, having depleted a substantial portion of their body fat reserves. Calves have very limited fat reserves to start with, and the stresses of a hard winter or spring may lead to high levels of mortality among these animals. The same is true of old or sickly animals that have difficulty obtaining adequate food or chewing it. Although adult bulls also lose weight over the winter, they are not burdened with a fetus or nursing calf and therefore often remain in better physical condition than cows. As a consequence, bulls tend to be the hunters' preferred targets during the late winter and spring. Once the summer rut gets underway, however, the sexually active bulls stop eating and lose a substantial part of their body fat reserves. In contrast, the condition of the cows reaches its peak in the late summer and fall, once their calves have been weaned and they have fattened up on a steady diet of

lush summer grasses. Thus, during the warmer months of the year, and extending into the early winter, cows, not bulls, become the hunters' preferred targets.

Fat in the body of most large ungulates is not uniformly distributed, but is concentrated in specific areas, such as in subcutaneous deposits along the animal's back, around various internal organs, in the marrow cavities of the limb bones and mandible, and in the cancellous tissue of limb and axial elements (for bison, see especially Brink and Dawe, 1989 and Emerson, 1990). Moreover, when fat is mobilized in a nutritionally stressed animal, depletion does not take place simultaneously and uniformly throughout the animal's body, but instead occurs in a fairly ordered sequence, beginning with the subcutaneous deposits, then progressing to the deposits within the body cavity and around major organs, and finally progressing to the marrow within the limbs (Speth, 1983).

Even within the marrow bones, the fat is mobilized in an ordered sequence, generally beginning in the limb elements closest to the body, and then progressing toward the feet. Mobilization of fat in the front and rear limbs may not be in synch. The precise sequence of marrow depletion in the limbs varies somewhat from taxon to taxon, and unfortunately has not been studied in bison. Fat deposits in the marrow of the phalanges, as well as in the mandible, may be among the last deposits to be mobilized in a severely malnourished animal. Given the small amount of marrow in these elements to start with, particularly in relation to the weight of the bones and the effort needed to extract the tissue, their extensive use in prehistoric contexts may provide a useful index of the level of subsistence stress affecting the hunters.

Finally, there are important deposits of lipids in the brain, and these persist even in the most severely stressed animal (Speth, 1990:152; Stiner, 1994:228-229, 267). Systematic removal of brains at a bison kill may again signal resource stress, although brains were also used in hide tanning (e.g., Belitz, 1973; Grinnell, 1972:213ff; Hiller, 1948; Mason, 1891).

Thus, the amount of fat in a bison varies significantly over the course of the year, depending on the age, sex, reproductive state, nutritional status, and health of the animal. Moreover, different anatomical parts within a single animal at any point in time contain different amounts of fat, and these amounts change depending on the severity and duration of nutritional stress. Finally, the fatty acid chemistry and melting point of fats in adipose tissue also vary by anatomical region within an animal, with low melting point fats concentrated in the marrow of the distal limbs (Binford, 1978; Speth, 1983 and references therein; Stefansson, 1944). Most foragers consider low melting point fats to be the best tasting ones, but they are also the ones most susceptible to rancidity and hence not the most easily stored (Speth, 1987:20 and references therein).

There is ample ethnographic and ethnohistoric evidence attesting to the close attention paid by Plains bison hunters to the physical condition of the animals they were hunting (Speth, 1983 and references therein). They had good reason to be concerned. Throughout much of the year, the hunters' diet was

limited in both lipids and total calories (Speth, 1991b). Thus, when the hunters relied heavily on bison, an animal that was extremely lean even under the best of circumstances (Anon, 1992; Cox, 1978; Deethardt, n.d.; Dickinson, 1976; Johnston, 1995; Koch *et al.*, 1995; Marchello *et al.*, 1989; Morris *et al.*, 1981; Speth and Spielmann, 1983), they had to deliberately target animals that were in good condition, select body parts in which the precious lipids had not yet been severely depleted, and often invest considerable labor rendering grease from smashed-up bones to assure an adequate yield of both meat and calories (Binford, 1978; Brink and Dawe, 1989; Leechman, 1951; Speth, 1983; Speth and Spielmann, 1983; Vehik, 1977). Animals that were in poor condition were sometimes ignored, or if their poor condition was discovered only after they had been killed, their carcasses were only partially butchered and processed, and occasionally were discarded intact.

Factors other than the animals' condition, of course, also played a role in the hunters' procurement and processing decisions. These included the nutritional status of the hunters themselves, the size of the hunting party and of the group being provisioned, distance from kill to camp, the need for hides or other non-food products of the hunt, the number of dogs that had to be fed, particular religious taboos or observances connected with the hunt, and the particular procurement technique that was being employed. This last factor is discussed in more detail below.

ANIMAL BEHAVIOR AND TRACTABILITY

If the hunters planned to use a communal technique of hunting, for example driving bison into a trap or over a cliff, the behavior of the animals, not just their physical condition, became a critical factor (Frison, 1978, 1991a, 1991b). Over much of the year, bison herds are divided into two principal sub-units, comparatively small "bull groups" and larger "cow-calf groups" or "nursery herds" (e.g., Berger and Cunningham, 1994; Fuller, 1960, 1961; McHugh, 1958, 1972; Meagher, 1973; Nelson, 1965; Norland, 1984; Roe, 1970; Reynolds *et al.*, 1982; Shult, 1972; Soper, 1941; Van den Brink, 1980:121). In the spring, the nursery herds are difficult to drive, because the behavior of both cows and calves is often quite erratic (Frison, 1978; Shult, 1972). For example, according to Shult (1972) cows with calves are far more wary and skittish than bulls, and are quick to bolt at any sign of danger. Bulls make more profitable targets than cows in the spring, because of their better physical condition, and because they are much more approachable than cows, often turning to face danger rather than running away from it (Shult, 1972). But this behavior also makes them difficult to maneuver, because they may be more inclined to charge an intruder than to move off in an orderly fashion. Moreover, bulls generally graze in groups that are too small and too widely dispersed to be effectively taken by cliff jumping (see below), a technique that is thought to require at least 50 to 100 animals to be successful. To take bulls communally, the hunters would have had to employ some sort of trap or surround (see below), techniques that are far more effective than cliff jumps when comparatively small numbers of animals are involved (Frison, 1991b). However, because of the generally intractable nature of adult bulls and the fact

that they can be approached more closely than cows, these animals for the most part were probably taken singly or in small numbers by ambush or encounter hunting.

During the summer rutting season, bison are again difficult to drive, this time because the bulls join the cow-calf groups and repeatedly try to cut females out of the herd for breeding (Frison, 1978). This disruptive behavior makes it nearly impossible for the hunters to maneuver the herd to a predetermined trap or jump location. Only when Plains Indians acquired horses could they attack these large herd aggregations with impunity, elevating the summer hunt to one of the most important events of the year.

The ideal time for large-scale communal bison hunting in the pre-horse period was during the fall and early winter, and adult cows were almost invariably the preferred targets (Frison, 1978, 1991a, 1991b). There are several reasons for this. First, by fall the rut was over and the disruptive bulls had withdrawn from the herd, their physical condition often significantly compromised. Second, the cows reached their peak condition at this time of year, enhanced by improved forage quality and quantity and by the weaning of their calves (Speth, 1983). Third, by fall the behavior of the calves was far less erratic, making both cows and calves more maneuverable. Fourth, the hides were in prime condition. And finally, fall and winter were the seasons when the hunters had to begin gearing up for the long, harsh winter on the Great Plains, acquiring vital stockpiles of dried meat and fat, as well as warm bison robes (Frison, 1978, 1991b). It is not surprising, therefore, that the vast majority of Plains bison kills, from earliest Paleoindian times onward, have turned out to be fall or early winter events that specifically targeted cows.

MORTALITY PROFILES

Archaeologists traditionally assume that the age structure of the animals taken in a communal kill will mirror fairly closely the age structure in the living population from which the animals were drawn; such an age structure is often referred to as a "catastrophic" mortality profile (e.g., Klein, 1978, 1979, 1982; Klein *et al.* , 1981, 1983; Klein and Cruz-Uribe, 1984; Lyman, 1994; Stiner, 1991, 1994). The other common type of mortality structure is often referred to as an "attritional" profile, in which young and old individuals are proportionately more common than they would be in the living population. Archaeologists expect attritional profiles when dealing with animals that were taken, for example, by small-group encounter hunting.

Interestingly, in prehistoric bison kills the youngest age classes (i.e., calves and yearlings) are almost invariably under-represented, often strikingly so (e.g., Reher and Frison, 1980; Driver, 1983), resulting in mortality profiles that do not conform to the expected catastrophic pattern. Their under-representation is commonly attributed to taphonomic factors, such as poor preservation of immature bones or destruction by scavenging wolves and coyotes. However, some archaeologists have attributed their scarcity to the activities of the hunters

themselves. According to this view, the hunters transported the carcasses of calves and yearlings to nearby campsites before butchering them (Reher and Frison, 1980). Driver (1983) noted that many of the campsites and processing areas associated with kills also yield inadequate numbers of immature animals, making this explanation unlikely.

Like Driver, I also question this view as a general explanation for the scarcity of young animals. Calves are noteworthy for their lack of body fat (Emerson, 1990; Speth, 1983). Thus, aside from serving as an occasional delicacy, or perhaps at times as a starvation food, I seriously doubt that hunters would routinely invest much effort in acquiring and processing these animals. Moreover, yearling bulls are already quite large and are not as easily schlepped to other locations as this view implies (Halloran, 1957, 1961). Driver (1983) suggested instead that young animals were under-represented in kills because they were similarly under-represented in local bison populations, due perhaps to stressful climatic circumstances that depressed levels of calf production. While an intriguing possibility, I think this scenario is also unlikely as a general explanation, since under-representation of calves and yearlings is nearly universal in communal kills, regardless of time period or geographic location.

There is another possible explanation for the under-representation of calves and yearlings that Driver acknowledged but did not explore, and this scenario hinges on the spatial distribution of age classes that emerges within a herd as it is stampeded into a trap or off a cliff. When bison travel through open country, for example enroute to a waterhole, they move in a long line, often in single file or two abreast (e.g., Fuller, 1960; Shult, 1972). The animals at the lead of the herd are generally adult cows (Fuller, 1960:7; Reynolds *et al.*, 1982:988). If the animals are moving away from a threatening noise, movement, or smell, perhaps an intentional disturbance made by Indians who are harassing the herd forward toward a kill site, the rear of the procession is often brought up by one or more prime-age bulls. Shult (1972:40) indicates that the placement of bulls at the rear of a line of fleeing bison may not be because they are protecting the herd, but because they are the last to run. When the bison break into a stampede, as would be done near the site of a jump, the column formation may persist or the animals may form a less coherent mass, but in either case, the lead animals are usually still adult cows, with adult bulls toward the rear, and members of other age classes (calves, yearlings, old-age adults) in the middle or lagging behind.

What happens when the stampeding herd reaches a cliff? Since the jump technique works by lead animals being forced off the precipice by unsuspecting animals bringing up the rear (see below), it is quite likely that prime adults (mostly cows in a fall/winter kill) will be over-represented in the death assemblage, whereas calves, yearlings, prime-age bulls, and old animals of both sexes are likely to be under-represented. In other words, cliff jumps (and probably large trapping operations as well) are likely to produce what Stiner (1994) refers to as a "prime-dominated" age structure, an unusual type of mortality profile that seems to be a distinctive hallmark of human hunting. Interestingly, if the arguments presented here are correct, it would appear that in the case of large communal drives a prime-dominant pattern is largely a byproduct of the

stampeding behavior of the animals, not the deliberate selective targeting of particular age cohorts by the hunters.

I must stress, however, that this conclusion is very speculative. First, it remains extremely difficult in most archaeological cases to prove that under-representation of younger age classes is not merely a product of taphonomic factors. There is also regrettably little published information on the spatial structure of stampeding bison herds, although this aspect of bison behavior is certainly amenable to study, given the many large, free-ranging herds that now exist in North America. In fact, such information probably already exists in the files of the parks that manage these herds (e.g., McHugh, 1958:11).

ARROYO TRAPS, CORRALS, JUMPS, AND SURROUNDS

Needless to say, communal bison kills are far more visible, and have attracted much more archaeological attention, than isolated kills of single animals. Some communal kills, particularly the jump sites, are truly spectacular. For example, the late prehistoric Vore Buffalo Jump in southeastern Wyoming is a large karstic sinkhole estimated to contain the remains of at least 20,000 animals, all killed within just a few centuries between about AD 1500 and AD 1800 (Frison, 1991b:116; Reher and Frison, 1980). Head-Smashed-In, located in southern Alberta, is another massive jump site, used for well over 5,000 years (Brink and Dawe, 1989; Reeves, 1990). Jumps usually involved bluffs or cliffs that were high enough for the fall to be lethal to the animals, or to at least severely injure many of them. Perhaps not surprisingly, therefore, projectile points at such sites are often comparatively scarce, since there was little need to shoot the animals (Frison, 1991b).

Most communal kill sites did not involve lethal jumps, however. Various types of trap were widely used (see summaries in Frison, 1978, 1991b). One of the most common techniques was to maneuver animals into the mouth of a deep, steep-sided erosional gully (called an "arroyo" in the western U.S.). The hunters chose an arroyo that terminated up-slope in a cul-de-sac with walls too steep for the animals to escape. The ideal arroyo was one that made a turn just before the cul-de-sac so that the approaching animals could not see the danger that lay ahead. At the bend, just as the animals turned toward the cul-de-sac, they were stampeded and in the ensuing confusion the milling animals trampled each other to death, or crushed animals that were pressed up against the walls of the arroyo. Survivors attempting to escape from the trap were picked off by hunters hiding on the rim of the arroyo above. As expected, projectile points tend to be far more common in this type of kill site than at cliff jumps (Frison, 1991b).

As noted earlier, the issue of projectile points is an interesting one, since the frequency of points can, by itself, provide some indication of the type of kill (Frison, 1978:243ff, 1991b). It should be borne in mind, however, that the quantity of points can be misleading, for at least in the historic period we have evidence that Native Americans often tipped their weapons with perishable wooden points, and even the sharp neck tendons of bison (Weitzner, 1979:240; Mason, 1894; Medicine Crow, 1978:251).

Both historic and prehistoric Native Americans also built substantial log corrals or pounds into which they drove bison (e.g., Frison, 1971, 1973, 1978, 1991b; Frison *et al.*, 1976; Verbicky-Todd, 1984). The entrance to the corral often involved a low jump, either from a natural bedrock ledge, or from a ramp artificially constructed from earth, logs, buffalo dung, or even snow. This small jump served to injure some of the animals, and it prevented them from escaping back out of the trap. Tennessen and Hudson (1977), evaluating the consequences of driving modern bison into a chute for vaccinations, observed that many serious injuries and fatalities occurred in the funnel area right at the entrance to the chute, inflicted by dominant adult bulls that gored and crushed sub-adults (yearlings and two-year-old animals) and cows in the crowded confusion.

In a number of prehistoric and historic corral traps, the Indians built log or brush wings that converged toward the entrance to the corral. The approach was designed so that the wings brought the animals toward the entrance at an angle that prevented them from seeing the danger until the last possible moment, at which point the animals were turned into the entrance and stampeded. Frison (1991b) has noted that projectile points first become numerous in some archaeological traps at the bend in the wings where the animals would first have been able to see the entrance. Harassing the bison at that precise moment would have provided added insurance that they would not turn around and escape.

A very dangerous but often used form of trap is known as a "surround", in which hunters gradually encircled a small group of unsuspecting bison. It was critical to the success of this technique that the animals not detect the scent of the approaching hunters. Human scent more than the direct sighting of the hunters would trigger an immediate stampede by the bison (e.g., Fuller, 1960:4).

"Bison will frequently permit a guarded approach by a person that they have detected either by sight or hearing, but I cannot recall an instance of hesitation once they had caught my scent".

Once the hunters were in range, several animals could be shot before the animals broke out of the circle. Unfortunately, the foot surround is poorly documented historically, because by the time Europeans observed communal bison hunting most Plains groups were already using horses to encircle the bison and many were using firearms. The foot surround was clearly a dangerous technique and one that depended on precise group coordination, careful monitoring of wind directions, and intimate knowledge of bison behavior. This technique would have been exceedingly difficult to employ successfully to hunt cow-calf groups in the spring because of the tremendous wariness of the cows (Shult, 1972). Bull groups, however, may have been much more approachable in the spring, although there was always the danger of being charged. In the fall, both bull and cow-calf groups could be taken in this manner.

Instead of corrals, Indians sometimes ran bison into parabolic sand dunes and even deep snow drifts (Frison, 1974, 1991b; McHugh, 1972). These traps again were not lethal, but by stampeding the animals at just the right time and, by shooting herd leaders, the hunters were able to kill quite a few animals in a

single event. Needless to say, snow drift traps and surrounds are very difficult to identify in the archaeological record. One 10,000-year-old Paleoindian kill in Colorado, the Jones-Miller Site, may have been a snow drift trap because there is no sign of a corral, arroyo, or cliff in close proximity to the massive bone bed (Stanford, 1974, 1975, 1978). Since there are several hundred animals in the bone bed, this site must have been the locus of repeated drives within a relatively short period of time.

Curiously rare in the North American archaeological and ethnohistoric record are communal drives into swamps or bogs. Although drives of this type would certainly have been feasible, Frison (1991:157-158) argues that the use of swamps and bogs normally would have been avoided because large numbers of animals mired in deep mud would have been difficult to butcher. I am not entirely convinced by this explanation, however, since carcasses piled several layers deep at the bottom of a steep-walled arroyo would have been equally difficult to handle. Thus, the apparent paucity of kills that took advantage of boggy areas strikes me as an issue that still needs further consideration.

Since suitable jump or trap localities were not uniformly distributed over the Plains landscape, it was frequently necessary to move an entire herd many kilometers from a grazing area to the place where the kill was to take place (Frison, 1987:196; McHugh, 1972:64-65). Historically, this difficult task was performed by a bison "caller" or "runner", a shaman whose intimate knowledge of bison behavior and terrain allowed him to maneuver the herd to the desired location. One technique commonly described in the ethnohistoric literature was for the caller to wear a bison hide disguise (McHugh, 1972; Verbicky-Todd, 1984). The shaman kept some distance from the herd, but allowed the lead animal, usually an adult female, to see him for a brief moment before he disappeared behind a low rise. He had to allow the bison to see him but not detect his human scent. Hence predictable wind directions were absolutely critical to the success of the kill. If the prevailing winds were blowing toward the herd from the kill or trap site, the technique would not work because the shaman's scent would be picked up by the animals. Once the lead animal of the herd had spotted this curious "bison," she would move forward to investigate its whereabouts and intentions, and the other animals would fall in line and follow her, very much like modern cattle on their way to the barn. The shaman then retreated some distance toward the kill or trap site and repeated this process. If he failed and inadvertently stampeded the animals, the bison would run from the danger, often placing themselves out of range for another attempt. The last few kilometers of the approach route or "drive lane" was often demarcated by two converging lines of widely spaced rock cairns (Brink and Rollans, 1990; Frison, 1978). The cairns in no way confined the animals but may have served as critical markers along the drive route that helped the hunters position themselves at precisely the right place at the right time. By standing up and perhaps holding out hides, the hunters could harass the animals just enough to keep them moving forward, but without frightening them to the point that they stampeded prematurely. Brink and Rollans (1990) have argued that the cairns were not markers for the hunters, but platforms on which brush cairns, so-called "dead men", were erected. The motion and gentle rustling sounds of leaves on these

brush markers may have been sufficient to keep the animals moving with little human intervention. If particular drive localities were used only intermittently, brush markers would have to be replaced. The stone cairns would provide the hunters with a permanent record of exactly where to re-erect the "dead men".

Once the animals reached the vicinity of the kill site, they had to be maneuvered toward the cliff or trap at an oblique angle so that they could not see the danger. If the bison were able to see the kill locality, they would turn and run. To assure that the trap or cliff remained invisible to the bison, the hunters often selected a place where the animals had to move uphill as they approached. As the animals neared the crest of the slope, close to the trap entrance or the edge of the cliff, the animals were turned directly toward the kill site and at that moment they were stampeded. However, to keep the animals from dispersing when they were stampeded, the hunters sometimes brought the animals to a point along the edge of the cliff where there was a steep-sided tributary gully or embankment. Thus, when the animals were stampeded they would run headlong into the gully or along the embankment, not up its sides. The animals at the front of the stampeding herd, upon seeing the danger in front of them, would stop abruptly and turn around, trying to retreat. There is no way they would voluntarily commit suicide just for the benefit of the hunters. What made the kill successful was that the stampeding mass of animals at the rear of the herd could not see the danger that lay ahead, and in their headlong flight to escape they inadvertently forced the lead animals over the cliff or into the trap. Incidentally, if the shaman was still at the front of the herd by this stage in the drive, he may have jumped into a specially prepared pit at the edge of the cliff so that he didn't become a victim of the stampede. If the animals were being driven into a corral, the shaman may have scaled the wall of the corral at the last moment or escaped through a small opening.

Not all animals were killed in a jump or large trapping operation. Many of the animals at the rear of the herd would escape. However, based on modern experiments with free-ranging bison, if the hunters left the survivors alone for several days, and if they were still within range of the kill, they often could be "called" and driven again. Thus, in a single season, bison hunters could repeatedly drive the same herd over the same cliff or into the same trap.

Communal drives, particularly the classic jumps, only worked if sufficient animals were involved. According to Frison (1991b), an experienced rancher as well as a leading specialist on prehistoric bison hunting, it is almost impossible for several experienced horse-mounted cowboys to force a bison off a cliff or into a trap. More than likely, the cowboys and their horses are the ones that will end up going over the cliff. Bison are far too big and too agile. The successful use of communal techniques depended on having enough animals in the stampeding herd to force the lead animals to their death. While it is impossible to specify a precise minimum number of bison needed for a successful jump, the figure is almost certainly on the order of 50 to 100 animals (Frison, 1987:196). In contrast, small arroyo traps could be used with as few as 20 to 25 animals (Frison, 1987:196). The absolute numbers given here are very rough estimates and should not be taken too literally. What is important is the contrast in minimum effective herd size when jumps or traps are used.

The cliff jump is by far the most spectacular type of bison kill and has certainly received the lion's share of publicity. But bison jumping probably was never the most common technique used by Native Americans. Most animals most of the time were probably taken in small numbers by stalking them, or by ambushing them at water holes. When communal techniques were employed, some form of natural trap, such as an arroyo or parabolic sand dune, or perhaps a foot surround, were most likely used. Interestingly, although the use of cliff jumps is documented quite early in the North American record, as at Bonfire Shelter in southwestern Texas (Dibble and Lorrain, 1968), this technique of procurement does not appear to have become commonplace until the later stages of Plains prehistory (Frison, 1991b). One reason for their comparatively recent fluorescence may stem from the fact that early Plains foragers were unable to muster the manpower needed to conduct a successful jump and process the masses of meat and hides that such a jump would have produced (see below).

There are other factors, however, that may also have made jumping less effective in the early phases of Plains prehistory (and perhaps in the European Paleolithic as well). Late Pleistocene/Early Holocene bison in North America were substantially larger than their modern counterparts (McDonald, 1981:250ff; Wilson, 1974, 1975; Frison, 1991b). Some scholars have suggested that the diminution in overall body size, and horn size, in North American bison over the last 10,000 years reflects a significant reduction in lethal forms of aggressive behavior and a concomitant increase in average herd size (e.g., Frison, 1987:215; McDonald, 1981:177). In addition, basing his arguments on morphological criteria, wounds in fossil specimens, and a variety of other evidence, Guthrie (1990:289) offers the interesting suggestion that Late Pleistocene bison, faced with large and ferocious predators, may have been extremely aggressive when threatened or wounded, engaging their attacker directly in fierce combat. He speculates that in this regard they may have been similar to the African buffalo (*Syncerus cafer*), one of Africa's most dangerous large mammals. In contrast, modern Plains bison commonly flee when harassed or attacked. These behavioral changes may have made mid- to late-Holocene bison much more maneuverable in large groups, and as a consequence more easily and effectively hunted using communal techniques.

The success of a communal bison hunt not only depended on having a sufficient number of animals, it also required the cooperation of a fairly large group of people. Historically documented communal jumps and large traps probably involved at least 20 to 30 adult participants and often many more (e.g., Frison, 1978; Wheat, 1972). For example, a number of hunters had to be stationed at strategic points along the drive route to keep the animals moving toward the kill. Many hunters were also needed at the kill locality itself, particularly if the bison were being driven into a trap, in order to dispatch animals that attempted to escape. And, of course, communal kills required a large labor force to butcher and process the carcasses, and transport the masses of meat, fat, and hides back to camp. A hundred or more 800 kg to 1000 kg carcasses piled in a tangled mass at the base of a cliff or in the bottom of an arroyo presented a daunting task for a group of hunters. The animals had to be dragged out of the pile, and then gutted and cooled quickly before the meat began to spoil. The meat then had to be cut

into strips and dried quickly before it became infested with fly larvae, if the kill occurred during the warmer seasons of the year, or before it froze, if the kill took place in the winter. Drying was also necessary to reduce the weight that had to be transported away from the kill. Jerked lean meat weighs only about one-fifth the weight of fresh meat (Wheat, 1972).

The 10,000-year-old Olsen-Chubbuck Site in Colorado provides a vivid example of the magnitude of the task that confronted North American bison hunters after a successful communal kill. About 190 animals were taken in a single event at Olsen-Chubbuck, yielding nearly 31,000 kg of fresh meat, tallow, marrow, and internal organs. Once dried, this mass would have reduced to about 6,000 kg, still a daunting quantity of meat for hunter-gatherers to transport away from a kill on foot. If the hunters consumed half of this meat (i.e., 3,000 kg) right at the kill, eating the incredible amount of 4.5 kg per person per day, it would have supported 100 people for 37 days. For these 100 individuals to transport the remaining 3,000 kg away from the kill, each would have had to carry over 40 kg of meat, a rather substantial load. This figure includes neither the weight of the bison hides nor the hunters' personal gear.

One thing is eminently clear from the historic and archaeological evidence. Communal bison hunting was anything but opportunistic. The location of the herd had to be carefully monitored, wind directions closely watched, other bands notified about the location and timing of the hunt, and leaders appointed to assure that no one "jumped the gun" and scattered the herd prematurely. Communal bison hunting also involved a considerable "up front" investment of time and labor. Tools and equipment had to be prepared so that the dozens or hundreds of carcasses taken in the kill could be gutted, butchered, and processed for transport and storage quickly and efficiently to minimize spoilage. In addition, corrals, entry wings, drive lanes, shrines, drying racks, stone-boiling pits, and numerous other facilities associated with the kill had to be constructed or repaired. The timing of the kill, and the selection of animals that were to be maneuvered into a trap or jumped from a cliff, were also anything but haphazard. The hunters deliberately targeted prime adult bison, usually cows, and usually in the fall or early winter. These procurement decisions assured that the animals taken were in peak or near-peak physical condition, and their behavior most amenable to driving. The primary objective of these kills, at least the later prehistoric ones (see below), was to produce bulk stores of meat and fat, as well as warm bison robes, for use over the coming winter.

USE OF LATE PREHISTORIC AND ETHNOHISTORIC ANALOGS

This last conclusion, that the primary purpose of fall/winter bison kills was to build up food surpluses in anticipation of winter, is compelling in its logic, and it seems to mesh well with both the ethnohistoric descriptions of bison hunting and the archaeological evidence from the late prehistoric period. Interestingly, however, the "winter storage" model does not stand up so well when applied to the Paleoindian evidence. Until recently, archaeologists simply assumed that the late prehistoric and historic pattern could be extended back to

the very beginnings of bison hunting in the Plains. This assumption has now been seriously challenged, and it is becoming increasingly clear that Paleoindian kills deviate in many important respects from those of more recent hunters (Frison, 1991b; Kelly and Todd, 1988; McCartney, 1990; Todd, 1987, 1991; Todd *et al.*, 1990). At both historic and late prehistoric kill sites, archaeologists generally find extensive processing areas where large quantities of meat and fat were prepared for bulk storage at a winter settlement. Typically, these processing areas are riddled with pits, some used for heating stones, others for stone-boiling. Dense scatters of highly fragmented bone are often found adjacent to the boiling pits, apparently the discarded residues from bone-grease rendering. In addition, skeletal element frequencies at both late prehistoric and historic sites vary widely, their frequency generally covarying inversely with their utility. Apparently the bison carcasses were thoroughly dismembered at the processing area, and carcass parts either transported away from the kill or discarded according to their food value.

The significance of stone boiling to late prehistoric and historic bison hunters can not be under-emphasized. Plains Indians smashed up the bones and boiled them to free the lipids from the cancellous tissue (e.g., Binford, 1978; Brink and Dawe, 1989; Leechman, 1951; Vehik, 1977). Much of this fat was then mixed together with pulverized dried meat (jerky) to prepare pemmican, a highly nutritious and light-weight food that was easy to transport and if kept dry could be stored for months. The ideal pemmican was about 25-30% fat and 70-75% protein (e.g., Stefansson, 1944, 1956). Pemmican was so vital to the survival and lifestyles of historic Plains bison hunters and fur trappers that "pemmican" wars were fought over control of its production and exchange.

In striking contrast to the late prehistoric and historic situation, stone-heating and stone-boiling pits are noteworthy by their scarcity or absence in sites of the Paleoindian period (and of course in Late Pleistocene sites as well). Moreover, while elements are often disarticulated and scattered, their frequencies are relatively uniform and do not covary very closely with utility. In addition, most limb elements yield MNI estimates very close to the maximum value for the site. In other words, only small numbers of limb bones were transported away from the kills, and those that were taken were removed as whole limbs, not as already segmented and selectively culled sub-units.

While interpretation of these contrasts between late prehistoric and Paleoindian kills remains far from certain, they seem to suggest that Paleoindian hunters were not bulk processing bison meat and fat for winter storage. Instead, they appear to have made relatively light use of the kills, stripping muscles from carcasses and opening some bones for marrow but doing little in the way of labor-intensive grease rendering at or near the kill. The absence of bulk storage for winter is probably an indication of extremely high levels of mobility. Other data, particularly the lithics, point to the same general conclusion. Paleoindian hunters moved over vast areas in their annual round, hunting and butchering bison with tools commonly made from cherts that had been obtained from sources up to several hundred kilometers away.

Much remains obscure, however, about the adaptations of these early bison hunters. In particular, how do we interpret the apparent absence of evidence for stone-boiling in Paleoindian sites? Does this imply that Paleoindians were unfamiliar with pemmican? It is hard to envision highly mobile foragers coping with the harsh winters of the Great Plains without pemmican. Either we are simply missing the processing localities or, as I believe to be more likely, we are dealing with an adaptation that has no obvious modern analog (see also Kelly and Todd, 1988). A better understanding of the Paleoindian pattern may also provide valuable insights into the adaptations of Late Pleistocene humans in Europe, since here too, at least prior to the Magdalenian, there seems to be very little clear evidence of systematic grease-rendering. This is obviously a topic where there is considerable room for productive interchange between Paleolithic and Paleoindian scholars.

FREQUENCY OF COMMUNAL BISON HUNTS

Another crack is beginning to appear in the foundations of the "classic winter storage" model. This model implies that communal bison drives would have been annual events. Recent work at the late prehistoric and protohistoric Vore Buffalo Jump in Wyoming has generated surprising evidence that casts doubt on the validity of this assumption. Vore is a large, steep-walled sink hole that was used repeatedly over several centuries as a communal drive site. As already noted, a small excavation in the deposits at the base of the sink suggests that some 20,000 animals may have been killed in this one site. The short duration of the site, only a few centuries, and the staggering number of animals that were killed there, are sufficient evidence to convince most archaeologists that driving occurred at Vore frequently, if not every year.

The challenge to this view comes from the nature of the sediments that enclose the butchered bison remains. These sediments, washed in from the rim of the sink, are distinctly layered, like varves, each layer representing an annual increment. Thus, the Vore Site provides a record of the number of years that elapsed between successive kill events, a degree of temporal resolution that is unattainable in other kill sites. Surprisingly, despite the incredible masses of bones in the site, only 22 major kill episodes are actually represented; in other words, roughly 25 years elapsed between kills (Frison, 1991b:226-228).

The varve-like layers vary in thickness and texture, forming a patterned sequence that probably reflects annual changes in runoff and precipitation. Kill events at Vore occurred three to seven years, or approximately one to two bison generations, after a peak in moisture. Frison and Reher (Frison, 1978, 1991b; Reher and Frison, 1980) see this pattern as evidence that driving activity was linked to periods of improved range conditions, and concomitant growth in local bison populations. The three-to-seven-year lag between moisture peak and kill event represents the amount of time needed for one or two generations of bison to reach sexual maturity and reproduce, presumably pushing local herd sizes to the critical threshold needed to make communal driving feasible and reliable (see Driver, 1990 for a contrasting view).

When range conditions once again deteriorated, activity at Vore ceased. One might assume that when conditions were less than favorable at Vore the hunters simply moved to another locality where bison could still be taken communally. However, Frison (1991b; Reher and Frison, 1980) feels that the fluctuations in precipitation, and therefore in range conditions as well, were broadly synchronous over vast areas of the Northern Plains. If so, it is unlikely that the hunters could simply have moved from one locality to another to continue "business as usual". Instead, these "big-game specialists" may have been forced to move their base of operations into the foothills adjacent to the Plains, and switch to a very different array of foods, about which we still know regrettably little.

This conclusion, of course, hinges on the still rather tenuous argument that periods of inactivity at Vore were similarly inactive periods elsewhere in the region. It also leaves a very interesting and important question unanswered. If large-scale communal bison drives occurred only infrequently, perhaps only three or four times in the life-time of any individual, why did they occur at all? We have no simple answer for this. It is obvious that these communal hunts provided massive quantities of food, but their infrequency, if real, would suggest that their primary function was not to meet day-to-day subsistence needs or provide surpluses for over-wintering. Instead, these large-scale operations may have had more to do with social and demographic needs of the community than with subsistence (Bamforth, 1988; Fawcett, 1985; Frison, 1991b). Perhaps communal drives were held primarily as a way of periodically underwriting large, but temporary aggregations of people who had to come together from time to time in order to maintain the social and reproductive viability of the population.

Interestingly, an early 19th-century explorer in the Great Basin observed that hunter-gatherers there had to wait up to a decade or more after a successful series of communal antelope drives before they could drive antelope again, because they so thoroughly decimated the local herds (Egan, 1917, cited in Steward, 1938:35).

"The Indians told me that the last drive, before this one at this place, was nearly 12 years ago and the old men never expected to see another at this place, for it would take many years for the animals to increase in sufficient numbers to make it pay to drive".

This kind of hunting strategy, if not a unique case, hardly sounds like the ideal way to economize a scarce meat resource, and again points to the likely importance of social and demographic, rather than nutritional, factors in the decision to hunt animals using large-scale communal drive techniques.

The picture emerging from the Vore Site is a fascinating one, and it is stimulating renewed thinking about Plains adaptations more generally. Nevertheless, Vore is still a single case, and it would be premature on this evidence alone to go overboard and conclude that communal hunting had little or nothing to do with routine subsistence.

SUMMARY AND CONCLUSIONS

How does all this information relate to the use of bison during the Late Pleistocene in Europe? Perhaps the bottom line is simply this. If the masses of bison bones at Middle Paleolithic sites like Mauran can be shown convincingly to be the remains of communal kills, we are clearly dealing with hominids who could not only kill large and potentially dangerous animals, but who possessed a fairly high degree of technological and organizational sophistication. Communal kills, no matter what their form, are planned and coordinated events. One does not simply wander around the landscape searching for bison and then, on the spur of the moment, somehow manage to frighten these powerful and agile beasts over a cliff or into a trap that just happens to be conveniently located nearby. Instead, the animals have to be carefully maneuvered, often over considerable distances, to place them in the right position for a successful kill.

If we accept that at least some of these Late Pleistocene "bone beds" are, in fact, communal bison kills, this should in no way automatically be taken to mean that they are cliff-jumps. The North American record shows very clearly that cliff-jumping was only one of a wide variety of communal hunting techniques used by Native Americans. Moreover, the fluorescence of cliff jumping occurred relatively late in the archaeological record and, even then, the technique was used far less frequently than other forms of communal hunting, particularly foot surrounds and natural land-form (i.e., arroyo) traps.

There are several important reasons why arroyo traps and surrounds remained the principal communal procurement techniques used throughout much of the Holocene in the Great Plains; these same reasons would appear to apply equally well to Late Pleistocene communal bison hunting in Europe : (1) arroyo traps and surrounds required little or no investment of labor for the construction and maintenance of permanent facilities such as corrals, wings, or drive lanes; (2) these techniques could be operated by relatively small human social groups; (3) they could be effectively used in the spring to take small bull groups, as well as in the fall and early winter to take larger cow-calf groups; and (4) they were better suited than jumps for handling the large-bodied and perhaps less gregarious bison of the Late Pleistocene.

Obviously, we cannot simply assume that the way bison were hunted by Neanderthals in Europe was analogous to the procurement techniques and strategies used by Native Americans 50,000 to 100,000 years later and half a world away. The value of the North American record is as a frame of reference, as a source of reasonable and potentially testable hypotheses that are grounded in a voluminous body of direct ethnohistoric and ethnographic observation and a well-preserved and extensively studied archaeological record.

ACKNOWLEDGMENTS

I am very grateful to Dr. Marylène Patou-Mathis for her generous invitation to participate in a very informative and stimulating international colloquium on "Nouveaux Regards sur l'Alimentation des Hommes du Paléolithique : Approche Pluridisciplinaire", held in Paris on December 4-5, 1995. I am also grateful to the Singer-Polignac Foundation for their generous support of the conference. My contribution benefited immeasurably from many helpful comments offered by conference participants.

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