ANTHROPOLOGIE * XXIX/3 * 1991

GARY HAYNES

NONCULTURAL MODIFICATIONS TO MAMMALIAN BONES IN SITES OF MASS DEATHS AND SERIAL PREDATION

ABSTRACT: This paper abstracts some patterns that have emerged from taphonomic field studies over the past 10 years documenting the death and post-mortem processes affecting bones of hundreds of large mammals (about 30 different taxa) in southern Africa, north central Canada, and central Australia. Bone densities are high in both mass-death sites and serial predation loci. Appendicular elements are well-represented; trampling by large mammals spirally fractures many limb-bones (proportions range from 0 % to 62 % of the total numbers of bones); false cutmarks (mimics created by noncultural agencies) are present in some assemblages; toothmarking is uncommon at death sites; bone weathering varies widely even within the same site. These site characteristics are similar to those found in archeological and nonarcheological sites from around the world, such as early hominid sites in Africa.

KEY WORDS: Taphonomy – Noncultural Bone Sites – Mass Deaths – Serial Predation.

INTRODUCTION

This paper briefly reports data from several large noncultural bone sites, all of which were created by the forces of nature since 1973 in National Parks or other protected areas where human activities are nonexistent. Details about the sites are available in several publications, and more descriptions are currently in preparation.

All of these bone sites are in or adjacent to stream channels or ponds or are located on floodplains. These sites do not represent a deliberate or partial sampling of any region, but rather the actual discoverable occurrences of all such sites in several large study areas. The sites were located through extensive searches on foot, by four-wheel-drive truck, and in light airplanes.

SITE LOCATIONS

In Zimbabwe (south-central Africa) four very large mass-death sites are currently under long-term study. Hundreds of elephants (*Loxodonta africana*) died *en masse* at these sites. At a separate site also in Zimbabwe, 40-50 African buffalo (*Syncerus caffer*) died en masse after falling over a 30 m high cliff above the floodplain of a second-order stream. Related longitudinal studies involve a serial predation site, Ngamo pan in Zimbabwe, where bones of wildebeeste (*Connochaetes taurinus*) and other ungulates are extremely abundant around a permanent water source in wooded savanna. In Botswana one mass death site is under study along the Chobe River, where 200 buffalo had been drowned, and their carcasses pulled from the water by wildlife authorities. In north central Canada, one mass death site has been found on the north shore of Lake Claire in Wood Buffalo National Park, where 3,000 bison (*Bison bison*) had been drowned in a flood: and one serial predation site is under continuing study in the Hay Camp Prairies, where a territorial pack of wolves (*Canis lupus*) preys on wild bison. Recent field studies in central Australia are focusing on mass-death sites of wild horses (*Equus equus*) affected by severe drought, and cumulative death sites of wild camels (*Camelus dromedarius*). For details about most of these sites, see Conybeare and Haynes (1984), Haynes (1981, 1982, 1983a, 1983b, 1985, 1987, 1988). *Figure 1* shows the locations of the study areas in North America, Africa and Australia.

NUMBER OF TAXA REPRESENTED AT THE SITES

All site inventories are dramatically dominated by a single taxon, which differs site to site, although a total of 30 different mammalian and avian taxa are represented by bones in all of the sites.

The maximum number of taxa represented at any one site is 14. This African site (Ngamo) is a grassland complex of waterholes where lion predation accounted for all (or nearly all) deaths, all of which occurred 2 years to 3 days before the bone inventory was taken by walk-over. This site is enormous (about 1 km^2 of which an 11 % area was sampled). Over 700 bones were counted in a single transect walked by one person; the bones represent mainly wildebeeste (*Connochaetes taurinus*), buffalo (*Syncerus caffer*), and zebra (*Equus burchelli*).

The next highest number of taxa, 13, represented at an African site (Shabi Shabi) where drought (leading to starvation and dehydration) accounted for nearly all deaths (1981 - 1987). Over 200 elephants (*Loxodonta africana*) died at this site (whose area is about 1 km^2), along with numerous other taxa (*Figure 2*).

An attempt was made to ensure that land areas inventoried for bones in the larger sites were similar in size, although this was not always possible, due to irregularities of topography, drainage, and vegetation cover. All mass death sites were 100 % sampled (in terms of bone inventories), while all serial predation sites were only partially sampled, so total bone counts, MNI's, etc., will be much higher in the entire serial predation sites than reported here.

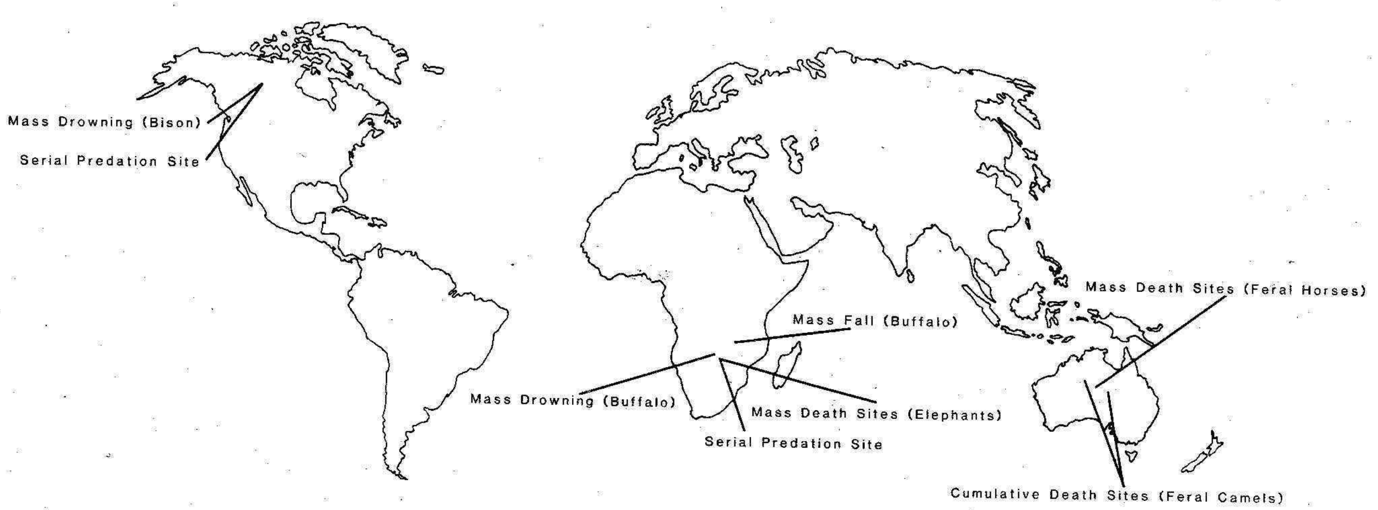

FIGURE 1. *Locations and types of bonesites under study.*

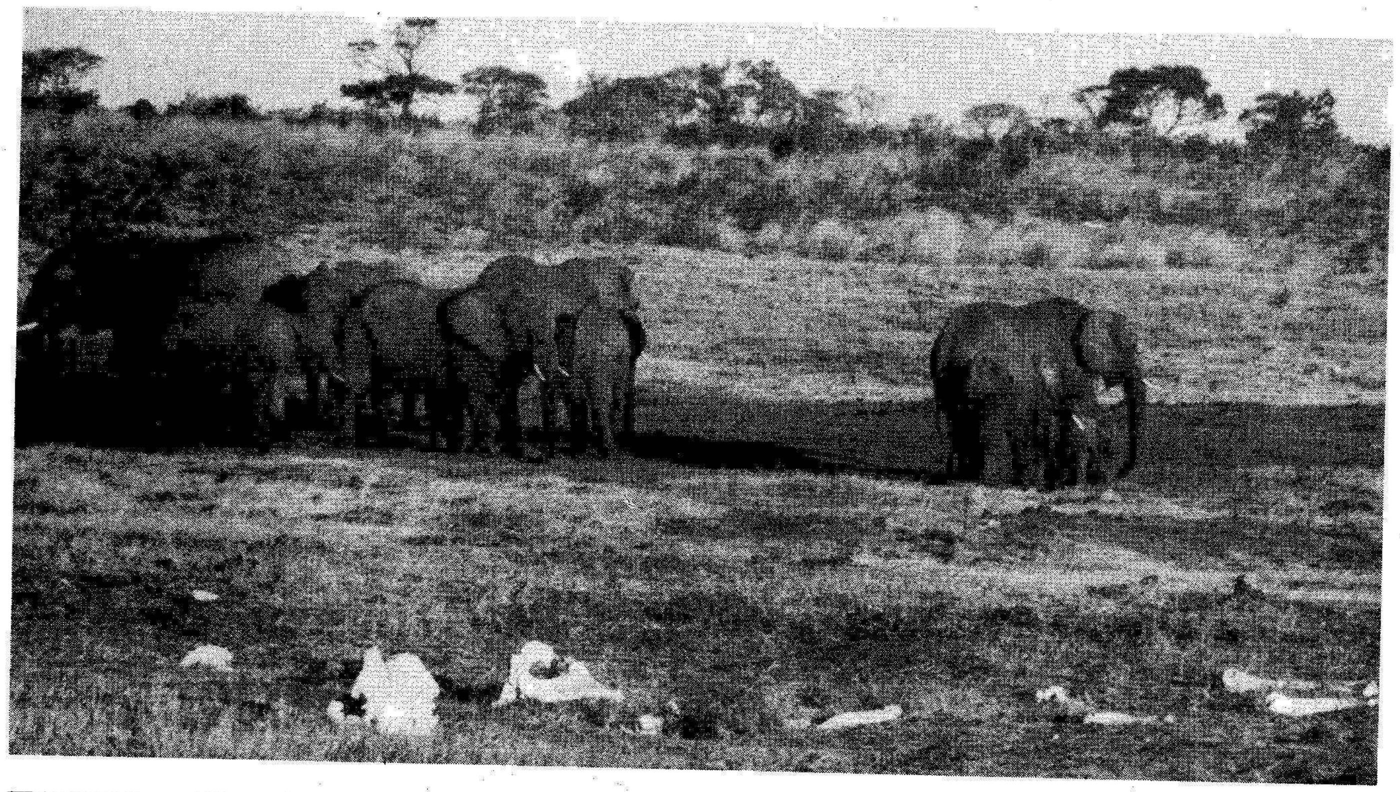

FIGURE 2. *African elephants congregating at a wilderness water source, the site of mass die-offs in drought years. Note elephant bones in foreground.*

NUMBER OF BONES

The mass death sites were created by large numbers of animals dying during a relatively brief interval of time. Hence, many carcasses were deposited in a restricted land area very quickly. Such an abundance of carcasses resulted in underutilization of each carcass by carnivores (see Haynes 1982 for a discussion of carcass "utilization").

FIGURE 3. *Sable antelope (Hippotragus niger) seeking water at the same site shown in Figure 2. Note bones of at least three elephants on the ground.*

The serial predation sites resulted from carnivores killing and eating individual animals from relatively unstressed populations over extended periods of time. Thus, in general carcass utilization was expectably full, as opposed to "light" or "heavy".

The density of bones ranged from 1 per 2 square meters to 1 per 153 square meters in mass-death sites, and from 1 per 100 to 1 per 125 square meters in serial predation sites. However, spot clusters of bones often approached 50 per m^2 in carcass loci, separated by several meters from other clusters. Hence these averaged numbers do not indicate how extremely dense bone deposits were in certain parts of the sites.

If the land areas surveyed in mass death and serial predation sites are converted to the same sizes, the typical number of bones per surveyed square meter in mass-death sites would be higher than in serial predation sites. Great variation does not allow generalizing rules or laws to be drawn up.

In mass-death sites, the number of individual animals per surveyed square-meter is much higher than in serial predation sites (the range in mass-death sites = minimum density of 1 individual per 1,378 square-meters, maximum of 1 individual per 21 square-meters; in serial predation sites, range = minimum density of 1 individual per 2,571 square-meters, maximum of 1 individual per 760 square-meters). The densest distribution of individual carcasses is found at noncultural sites dominated by elephant or by African buffalo. *Figure 3* shows part of one mass-death site in Zimbabwe; in the photograph, three elephants are represented by bones scattered in an area approximately 30 m^2. In *Figure 4*, an area about 100 m^2 contains bones of at least six elephants.

BONE REPRESENTATION

The averaged number of surface bones per individual animal ranges from about 21 in a site where lions killed nearly all the animals represented (mainly medium size ungulates), to about 7 in a site where starvation killed all the animals (nearly all are large

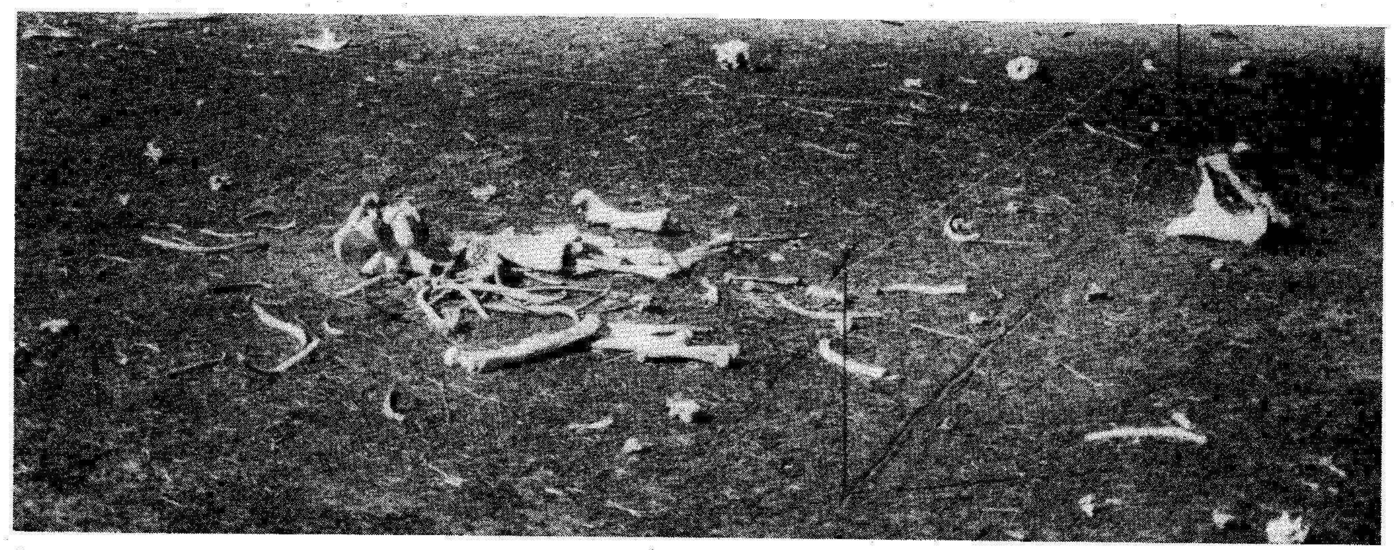

FIGURE 4. *Bones of at least six elephants at another water source in Zimbabwe, Africa. These animals died during severe drought years (1982 - 1983).*

herbivores), (*Tab. 1*). Note that in the sites where starvation killed the animals, heavy elephant trampling and digging buried many bone elements. Thus, the true number of bones per individual is undoubtedly much higher than the surface inventory indicates.

Innominates and skulls are the best-represented elements in both mass-death and serial predation sites in Africa, while in North America sacra and skulls are best represented. Patterns of bone representation in the Australian sites are similar to those in Africa.

Upper limb elements (i. e., scapula, humerus, femur) are better represented than lower limb elements (i. e., radius, ulna, tibia); foot elements are always very poorly represented. Ribs and vertebrae are also not well represented at any cumulative or mass-death site.

BONE MODIFICATIONS

Fresh-bone fracturing is very common in mass-bone assemblages, due to trampling especially. In mass-death sites, up to 62% of limb elements are spirally fragmented. The higher proportions are found in sites where elephants died *en masse* due to drought.

In serial predation sites, *prior* to trampling by large ungulates, the proportion of spirally fractured limb elements may be as high as 100 % for animals weighing up to 450 kg. In some cases, distal limb bones (i. e. metapodials, tibia, radius, ulna) may be completely fragmented even before skin and flesh have been eaten off the thoracic cage and upper limb elements.

Well known trampling incisions were introduced to the literature by Fiorillo (1984), but were first illustrated by Haynes and Stanford (1984). They were brought to the attention of many paleoanthropologists by Behrensmeyer et al. (1986), Andrews and Cook (1985), and others since then. These false cutmarks are caused by animals (a) stepping on upper bone surfaces; or (b) pressing the bone's lower surface on the ground and sliding it over sediment; a third cause is (c) manipulation by animals using the feet -- very commonly seen with elephants, which push, position, kick, turn over, or soccer-ball dribble bones.

The marks caused by (a) are generally on ridges or flat surfaces (*Figure 5*); the marks skip over depressions, and are found as parallel sets or single incisions. Marks caused by (b) are in the same places, but the incisions may follow into depressions; they may be single, parallel, or in several sets (*Figure 6*). Marks caused by (c) have unusual locations or surfaces -- for example, on the back of the skull (*Figure 7*), or tusk alveoli. They are usually parallel or subparallel.

Toothmarking or identifiable carnivore-marking (Haynes 1980, 1983a) may be uncommon or nonexistent, even when 100 % of limb bones have been carnivore-fractured into pieces that are 2 - 15 cm long. The epiphyses are usually consumed, and since these are the bone parts where tooth-marking is most common, few pieces remain with toothmarks. The proportion of long-bone shaft fragments that show identifiable toothmarks ranges from 0 % to about 33 % in assemblages that have been analyzed so far (*Tab. 2*).

The actual *flaking* of large elements is most frequently seen on elephant bone, 1 - 3 years *after* the carcass flesh had been naturally removed, but while the bones are still well preserved and greasy. The flaking

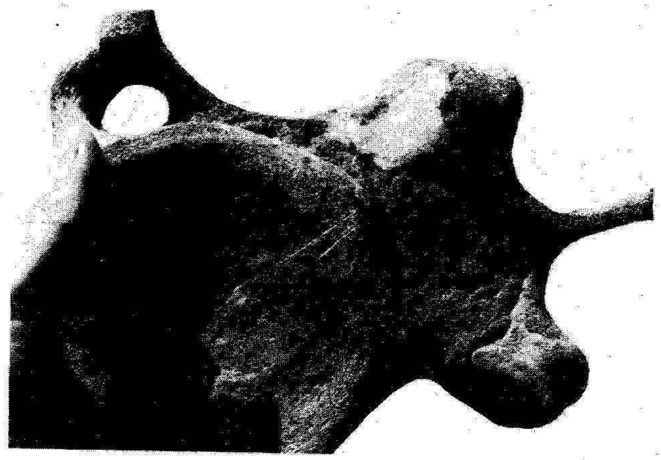

FIGURE 5. *Sharply incised trample-mark on an elephant vertebra, created by animal's hoof sliding over the exposed bone surface.*

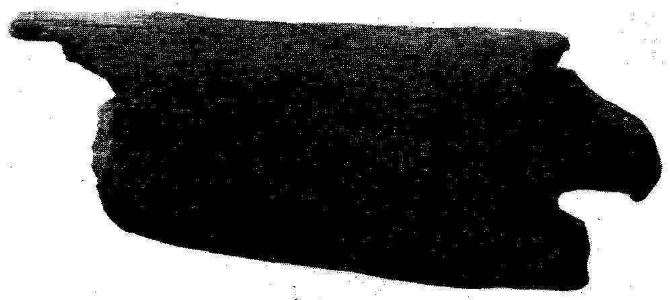

FIGURE 6. *Incised elephant rib-fragment, marked by being trampled against a silty sand substrate.*

TABLE 1. *Averaged Numbers of Bones (Including Fragments) per Individual Animal at each Site (latest counts)*

Site Name	No. of Bones	MNI (all taxa)	Averaged Representation Approx.
(Mass-Deaths)			
Shabi Shabi Main Locus	>1000	43	23 bones/individual
Shakwanki Main Basin	49	8	6 bones/individual
Lememba Pothole	48	5	10 bones/individual
Nehimba Main Basin	171	19	9 bones/individual
Lake Claire North Shore	440	49	9 bones/individual
(Cumulative)			
Hay Camp Prairie Slough	39	5	8 bones/individual
Ngamo South Area	720	35	21 bones/individual

TABLE 2. *Densities of Bones and Individual Animals at the Sites*

Site Name	No. of Bones	MNI	Area	Approx. bone Density	Approx. Density of Individuals
(Mass-Deaths)					
Shabi Shabi	>1000	43	150 m x 50 m	1 per 7 m^2	1 per 174 m2
Shakwanki	49	8	20 m x 20 m	1 per 8 m^2	1 per 50 m2
Lememba	48	5	12 m x 12 m	1 per 3 m^2	1 per 29 m2
Nehimba	171	19	20 m x 20 m	1 per 2 m^2	1 per 21 m2
Lake Claire	440	49	2.7 km x 25 m	1 per 153 m^2	1 per 1378 m2
(Cumúlative)					
Hay Camp Prairie*	38	5	95 m x 40 m	1 per 100 m^2	1 per 760 m^2
Ngamo	720	35	3.0 km x 30 m	1 per 125 m^2	1 per 2571 m^2

* (note: 1 widely separated specimen left out of count)

FIGURE 7. *Manipulation marks on the rear of an elephant's skull, created by a curious elephant using its feet.*

results from scavengers quarrying bones or harvesting nutrients from the defleshed skeletons.

The degree of bone weathering varies widely in any kind of site. For example, I have found differentially weathered *Camelus* phalanges over 2 decades old, in the very arid, hot Australian semi-desert; weathering on one phalanx from a single foot was stage 5, while weathering on another phalanx from the same foot was 1 - 2 (*Figures 8 - 9*). Such differences in weathering of bones from one carcass are extremely common in Africa, as well as in North America.One of the factors differentially affecting bone surface deterioration is fire: during the early rainy season in Zimbabwe, lightning-strikes set off brush fires that burn through bone deposits. Dry bones may be carbonized or scorched, or in other cases may be calcined from high heat. Greasy bones may be selectively burned where the most oil remains, and dried soft tissue may burn or smolder when the rest of the dry bone does not burn. Hence, patches of burnt bone are created on elements that are otherwise little affected. These patches may be blackened, but the carbonized tissue crumbles away or is blown and washed off in rains or due to animal trampling (*Figures 10 and 11*). About 2 - 3 years after a grass fire, bones that were lying in the grass may not clearly appear to have been burnt anymore. However, parts of the assemblage may appear to be weathered to stage 5 (Behrensmeyer 1978), while other parts remain in stages 1 or 2.

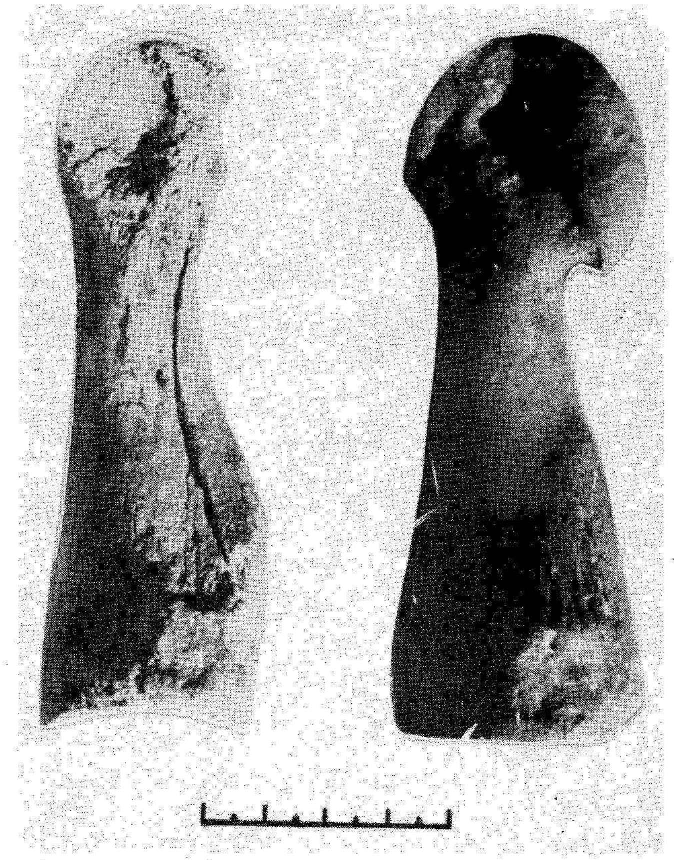

FIGURE 8. *Two Camelus phalanges from one animal that died 26 years before the bones were photographed in central Australia. The bone on the left has suffered from weathering far more than the bone on the right.*

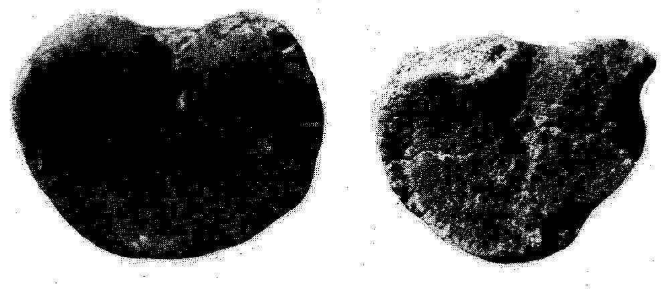

FIGURE 9. *View of the proximal articular surfaces of the same two camel phalanges as in Figure 8, showing extreme differences in weathering 26 years after death.*

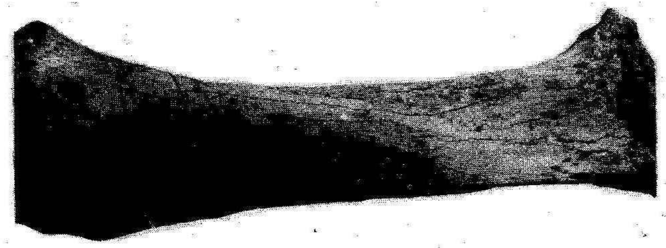

FIGURE 10. *African elephant tibia, posterior surface, showing damage resulting from partial charring in a bushfire two years before the photograph was taken, and one year after death of the animal. The carbonized bone has flaked off or been blown away, leaving a patch of bleached white tissue that appears well weathered*

FIGURE 11. *An isolated patch or burn "scar" on an elephant femur that was part of the same skeleton whose tibia is shown in Figure 10. As is the case with the bone in Figure 10, this scar resulted from burning of an isolated patch of grease or cartilage left on an otherwise degreased and naturally-cleaned bone.*

CONCLUSION

This paper has abstracted some of the patterns emerging in a large body of data derived from sites that are still under study. The site inventories are constantly changing as new bones are added, or old bones are destroyed by trampling, weathering, and scavenging animals. Patterns from sites such as these mass-death and predation loci never truly "stabilize", since bone input, subtraction, and burial continue as long as there are animal populations in the vicinity of the sites. An abstract report ten years from now may look different from this one.

These longitudinal studies of natural bone accumulations are intended to provide baseline data, and probably the most significant result to date is the dynamic nature of bone site assemblage patterns.

ACKNOWLEDGEMENTS

I gratefully acknowledge the crucial assistance of the Zimbabwe Department of National Parks and Wildlife Management, and Parks Canada (which has undergone several name changes over the past few years). I thank D. Cumming; R. Martin; A. Conybeare; M. Jones; the Wardens, Rangers, and Scouts of the Zimbabwe Department of National Parks and Wildlife Management; R. Lewis; R. Redhead; G. Masson and the Wardens and Staff of Wood Buffalo National Park, Canada. Janis Klimowicz prepared the manuscript. Funding was provided mainly by the National Geographic Society, and also by the National Science Foundation. I thank Dr. H. Ullrich for inviting me to the symposium in Zagreb.

REFERENCES

ANDREWS P., COOK J., 1985: Natural modification to bones in a temperate setting. *Man* 4: 675-691.

BEHRENSMEYER A. K., GORDON K., YANAGI G., 1986: Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319: 768-771.

CONYBEARE A., HAYNES G., 1984: Observations on elephant mortality and bones in water holes. *Quaternary Research* 22: 189-200.

FIORILLO A., 1984: An introduction to the identification of trample marks. *Current Research* 1: 47-48.

HAYNES G., 1980: Evidence of carnivore gnawing on Pleistocene and recent mammalian bones. *Paleobiology* 6(3): 341-351.

HAYNES G., 1981: Bone modifications and skeletal disturbances by natural agencies: Studies in North America.. Unpubl. Ph. D. dissertation, Catholic University of America.

HAYNES G., 1982: Utilization and skeletal disturbances of North American prey carcasses. *Arctic* 35(2): 226-281.

HAYNES G., 1983a: A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb-bones. *Paleobiology* 9: 164-172.

HAYNES G., 1983b: Frequencies of spiral and green-bone fractures on ungulate limb-bones in modern surface assemblages. *American Antiquity* 48(1): 102-114.

HAYNES G., 1985: On watering holes, mineral licks, death, and predation. In: *Environments and Extinctions in Late Glacial North America*, D. Meltzer and J. Mead, pp. 53-71. Orono: University of Maine.

HAYNES G., 1987: Where elephants die. *Natural History* 96(6): 28-33.

HAYNES G., 1988: Mass deaths and serial predation: Comparative taphonomic studies of modern large mammal deathsites. *Journal of Archeological Science* 15: 219-235.

HAYNES G., STANFORD D., 1984: On the possible utilization of *Camelops* by early man in North America. *Quaternary Research* 22: 216-230.

Gary Haynes
Associate Professor
Department of Anthropology
University of Nevada-Reno
Reno, Nevada 89557
USA