DANGER CAVE, LAST SUPPER CAVE, AND HANGING ROCK SHELTER: THE FAUNAS

DONALD K. GRAYSON

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THE FAUNAS

DONALD K. GRAYSON
Research Associate, American Museum of Natural History
Professor, Department of Anthropology and Burke Memorial Museum
University of Washington

WITH CONTRIBUTIONS BY

PAUL W. PARMALEE
Director, Frank H. McClung Museum
Professor, Department of Anthropology
University of Tennessee

R. LEE LYMAN
Assistant Professor, Department of Anthropology
University of Missouri–Columbia

JIM I. MEAD
Assistant Professor, Department of Geology and Quaternary Studies Program
Northern Arizona University

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ABSTRACT

This monograph presents the results of the analysis of faunas from three caves and rockshelters in the northern half of the Great Basin: Danger Cave (Tooele County, western Utah), Last Supper Cave (Humboldt County, northwestern Nevada), and Hanging Rock Shelter (Washoe County, northwestern Nevada).

The Danger Cave fauna was excavated by Jesse D. Jennings between 1949 and 1953. A total of 3628 Danger Cave bones and teeth were identified to at least the genus level, of which 3513 are mammalian, 114 are avian, and 1 is reptilian. Stratigraphic analysis of this fauna shows that the major change in the nature of the vertebrate fauna in the western basin of Pleistocene Lake Bonneville occurred at ca. 10,000 B.P. At this time, a series of relatively mesic-adapted taxa seems to have become locally extinct: pygmy rabbits (*Sylvilagus idahoensis*), yellow-bellied marmots (*Marmota flaviventris*), and Sage Grouse (*Centrocercus urophasianus*). This faunal shift indicates a decrease in locally available mesic habitats, and correlates well with the suggested retreat of Lake Bonneville from the Gilbert level at about 10,000 B.P. It does not support suggestions that Lake Bonneville did not exceed historic levels between ca. 14,500 and 3500 B.P. In documenting the local presence of yellow-bellied marmots and bushy-tailed wood rats along the lower elevations of the Silver Island Mountains, the Danger Cave fauna adds significant support to J. H. Brown's account of the history of boreal mammals in the Great Basin. The decline in the abundance of pygmy rabbits at ca. 10,000 B.P. here may be correlated with the terminal Pleistocene extirpation of these animals from the Southwest, and suggests that these leporids underwent two periods of prehistoric decline in the Great Basin: one at the end of the Pleistocene (documented only from Danger Cave), and one at about 7000 B.P. (documented from a number of sites in the northern Great Basin).

Last Supper Cave was excavated by T. N. Layton between 1968 and 1973, and by J. O. Davis in 1974. The faunal collection retrieved by these excavations provided a total of 9095 vertebrate specimens that could be identified to at least the genus level. Of these, 8975 are mammalian, 63 are reptilian, 56 are avian, and 1 is amphibian. Although the Last Supper Cave sediments were deposited over at least 11,000 years, most of the faunal materials from the site came from wood rat middens that lined the walls of the cave. Radiocarbon dates spanning the last 2000 years were obtained for midden in the rear of the site. There is little correlation between depth and age of the dated material in that midden, hence the entire

faunal assemblage from that setting is treated here as a single analytic unit. In addition to the vertebrate specimens, a total of 1412 valves of *Margaritifera falcata* were identified from the Last Supper Cave fauna. Initial reports on Last Supper Cave noted that units deposited between about 9000 and 7000 B.P. contained concentrations of these shells. However, all shells available to us came either from the rear wood rat midden or lacked provenience. Last Supper Cave also provided a small number of wapiti (*Cervus elaphus*) specimens. These animals are unknown historically from northwestern Nevada and adjacent Oregon; the Last Supper Cave specimens join those from Fort Rock Cave, the Connley Caves, and Hanging Rock Shelter in suggesting that wapiti were once widespread, although apparently nowhere very abundant, in the northern Great Basin. With the exception of the tentatively identified Blue Grouse (*Dendragapus obscurus*), all other taxa represented in the Last Supper Cave collection are either present in the area today, or would have been so in early historic times.

A total of 2194 mountain sheep (*Ovis canadensis*) specimens were retrieved from Last Supper Cave, many of which bear marks inflicted by people, rodents, and carnivores. A "reverse utility curve" emerges from arraying Last Supper Cave *Ovis* relative skeletal abundances against MGUI values, a curve virtually identical to that derived by D. H. Thomas and D. Mayer for the Gatecliff Shelter Horizon 2 *Ovis*. Analysis of the relationship between relative skeletal abundance, the MGUI index, and bone density suggests that the Last Supper Cave and Gatecliff Horizon 2 reverse utility curves do not reflect human economic decisions, but instead reflect differential bone destruction, probably due to carnivores. A simple method employing rank order correlation coefficients is presented to help clarify the meaning of such curves, but extreme caution in the use and interpretation of these curves is clearly indicated, even if one is willing to accept the facilitating assumptions on which they are based. A series of marmot mandibles also shows marks from cuts apparently placed to sever the masseter muscle. Identically cut marmot mandibles are known from Alta Toquima Village, central Nevada, and from Hanging Rock Shelter.

Last Supper Cave derives its name from cow bones found on the surface of the site. These bones were thought to represent animals rustled and butchered by Indians early in this century. Detailed taphonomic analysis of these bones, however, fails to support this hypothesis. The surficial bovid fauna from nearby Denton's Cave also

fails to provide any support for the suggestion that those animals had been butchered.

The Hanging Rock Shelter fauna, excavated by T. N. Layton in 1967 and 1968, includes 6478 bones and teeth that were identified to at least the genus level. Of these, 6422 are mammalian, 29 are avian, 26 are reptilian, and 1 is amphibian. Interest in this material was sparked by the possible presence of a late Pleistocene/early Holocene faunal assemblage in the deepest deposits of the site, but the fauna of those deposits proved indistinguishable from that of overlying strata. Hanging Rock Shelter did, however, provide a number of taxa that no longer occupy this portion of northwestern Nevada. Pikas (*Ochotona princeps*) were present here after 8000 B.P., a fact supporting Brown's biogeographic model and chronologically consonant with similar finds elsewhere in the northern Great Basin. Wapiti were present here, as they were in the Last Supper Cave area. The desert spiny lizard (*Sceloporus magister*), now found only far to the south, was present in deposits laid down after 8000 B.P. Less securely identified extralimitals in the Hanging Rock Shelter fauna include chorus frog (*Pseudacris triseriata*), Blue Grouse (*Dendragapus obscurus*), and Sharp-tailed Grouse (*Tympanuchus phasianellus*). Unfortunately, little is known of the stratigraphy and chronology of the Hanging Rock Shelter deposits, precluding more detailed biogeographic and paleoenvironmental analysis of the fauna.

INTRODUCTION

Museum collections, archaeologists and curators often note, represent a remarkably neglected source of information about the past. In this volume, we use a series of such collections in an attempt to shed light on vertebrate history in the northern half of the Great Basin, and on past interactions between people and the nonhuman vertebrates of this region. Our focus is on the faunas from three sites: Danger Cave, located on the western edge of Lake Bonneville in western Utah; Hanging Rock Shelter, northwest of the Calico Mountains in northwestern Nevada; and Last Supper Cave, west of the Pine Forest Range, also in northwestern Nevada. In addition, we examine the mammalian fauna collected from the surface of Denton's Cave, located a few kilometers from Last Supper Cave. The faunas that comprise these collections were excavated as long ago as 1949 (Danger Cave) and as recently as 1975 (Last Supper Cave), but prior to our work, only that from Hanging Rock Shelter had ever been given more than a passing glance (Thomas, 1969, 1971).

During the past decade or so, much has been learned about the late Pleistocene and Holocene history of mammals in the Great Basin (e.g., Grayson, 1987). Our knowledge is weakest for the few thousand years that span the Pleistocene/Holocene border because well-stratified deposits rich in vertebrates that span this time period are poorly known. The initial decision to study the Danger Cave, Last Supper Cave, and Hanging Rock Shelter faunas was made because all three sites were known to contain sediments dating to the latest Pleistocene or the earliest Holocene. Thus, all three held the potential of shedding light on the vertebrate history of this period. As will be seen, only Danger Cave lived up to this potential, but the information it provided repaid the effort expended on all three faunas.

In addition to clarifying our understanding of Great Basin vertebrate history during a particular period of time, it was also hoped that these faunas would clarify our understanding of a particular process that has been advanced to account for the uneven distribution of many montane mammals here. Specifically, it was hoped that analysis of the archaeological faunas would allow a more detailed assessment of aspects of J. H. Brown's (1971, 1978) hypothesis that small mammals currently confined to Great Basin mountaintops colonized this region during the Pleistocene, since which time there have been extinctions but no colonizations. Not only was it hoped that predictions drawn from this hypothesis (Grayson, 1982b, 1987) would be met by these faunas, but it was also hoped that further information on the timing of specific local extinctions of Great Basin mammals would be forthcoming. Danger Cave did not disappoint us in this realm either, while Hanging Rock Shelter also provided new information relevant to this account of the history of Great Basin montane mammals.

Comparisons between chapters 1 and 3 on

the one hand, and 2 and 4 on the other, will show that not all the contributors to this volume are of one mind as regards the certainty with which bone accumulations from cave sediments can be attributed to particular accumulating mechanisms, including people. Nonetheless, because we generally lack secure ways of inferring the processes that introduced bones into sites of this sort, our archaeological expectations of these faunas were initially low. Last Supper Cave, however, proved to contain a large sample of heavily butchered mountain sheep bones. Our objectives in the analysis of this collection are to provide some methodological refinements, or at least some cautions, in approaching the relationship between human activities and the remains of large mammals in archaeological sites. In addition, reanalysis of the cow bones from the surface of both Last Supper and Denton's caves leads us to unexpected conclusions concerning the possible human role in the deposition of those materials.

Accordingly, we believe that the analyses presented in the following chapters contribute to our knowledge of past environments in general, and mammalian history in specific, in the Great Basin. In addition, we attempt to clarify certain aspects of the nature of past interactions between the human and nonhuman occupants of this region, and suggest ways in which that interaction might be profitably studied.

ACKNOWLEDGMENTS

1. DANGER CAVE

The Silver Island Mountains curve in a northeast–southwest direction through the western reaches of the basin of Pleistocene Lake Bonneville, cutting across the Utah–Nevada border in the vicinity of Wendover, Utah. Between 1949 and 1953, Jesse D. Jennings of the University of Utah excavated the contents of a large cave located on the southern edge of this range, approximately 2 km east of Wendover (fig. 1). Reported in detail in 1957, Danger Cave immediately became a celebrated site because of its contents, and because of the excellence with which those contents had been excavated, described, and discussed (Jennings, 1957; see also Jennings, 1953). As the years passed and as more and more archaeological sites in the Great Basin were dug and reported, the importance of Danger Cave was not diminished, but instead grew to the point that today it remains the most famous of Great Basin sites, and one of the most famous in North America.

For Great Basin archaeologists and geologists, Danger Cave's fame and historical importance rest on a few key facts, above and beyond the large collection of artifacts it yielded. First, the deposits in the cave were not only deep (some 3.5 m at their deepest), but they were also well stratified, and these strata were carefully observed during excavation. Second, the cave sits at an elevation of 1314 m, 28 m above the 1286 m elevation of the salt flats that stretch outward beneath it, and some 48 m beneath the Stansbury shoreline (at approximately 1362 m) of Lake Bonneville.[1] As a result, Danger Cave sits in a sensitive location for understanding the later history of this important Pleistocene lake. Third, Jennings took full advantage of the

[1] In September 1986, David B. Madsen began the excavation of undisturbed deposits near the portal of Danger Cave. This project will provide more accurate elevations for the site, which will replace those given here. In addition to excavating Danger Cave, Madsen and Donald R. Currey are also analyzing the development of the spring-fed marshes that once existed to the immediate east of Danger Cave. The stratigraphic, sedimentological, and chronological information provided by this work should clarify the nature of the relationship between the sands of DI and the final retreat of Lake Bonneville.

newly developed radiocarbon dating method, and obtained 12 radiocarbon dates for these stratified deposits (table 1). These dates suggested the presence of a late Pleistocene human occupation in the site and questioned contemporary views of late Pleistocene geological events, including the timing of the retreat of Lake Bonneville and the correlation between events in the Lake Bonneville basin and glacial events in the Great Lakes region. Fourth, and most important for archaeologists, Jennings did not merely describe the contents of Danger Cave. In addition, he used them to develop a coherent view of Great Basin prehistory and of human adaptation in the region. He reached this view by comparing the description of Great Basin aboriginal lifeways presented by Steward (1938) with the artifact content of such widely scattered sites as Fort Rock Cave (Cressman, 1942), Lovelock Cave (Loud and Harrington, 1929), Tularosa Cave (Martin et al., 1952), and Danger Cave. This comparison indicated what seemed to be similarities of such striking depth that Jennings concluded that the lifestyle described by Steward (1938) had existed in the Great Basin from the earliest entry of people into the area. The ethnographic record was thus projected into the past as a means of tying together artifactual similarities in far-flung sites in the arid West. In addition, this hypothesized basic adaptation to arid terrain was argued to have been ancestral to more complex developments in the Southwest, thus providing Great Basin prehistory with greater theoretical importance and putting an end to the practice of treating the Great Basin as merely peripheral to developments in the Southwest (see also Fowler, 1980; Fowler and Jennings, 1982). The name given to this long-lasting adaptation to the arid Great Basin was the "Desert Culture," proposed, as Jennings (1957: 280) observed, "as a convenient label for a long stable lifeway and as a means of calling attention to the age, stability, and similarity of the Basin pattern."

Although Jennings (1973: 4) himself later suggested that the time might have come to put the Desert Culture concept "quietly to rest," its importance to the development of Great Basin prehistory cannot be overem-

Fig. 1.   The location of Danger Cave.

phasized. Before its introduction, the archaeology of the Great Basin was conceived in terms of a small number of scattered sites; once introduced, the archaeology of the Great Basin crystallized around the notion of a lengthy, stable adaptation to a desert environment, the Great Basin became an area to be dealt with as a coherent unit, and later work focused on (and eventually led to the demise of) this concept. In a very real sense, one may say that Danger Cave, as used by Jennings, led to the development of an archaeology of the Great Basin, a fact at least implicitly recognized by all Great Basin archaeologists.

For many reasons, then, Danger Cave is an extremely important site, though it is fair to say that its importance now stems more from the historical role it has played in the development of Great Basin archaeology than from its archaeological content, the latter having been augmented from a number of other sites in the eastern Great Basin. I stress the importance of Danger Cave because I am fully aware of the shadow in which I am working, and because much of what I will now say about the stratigraphy and chronology of Danger Cave is simply taken from Jennings (1957).

THE DANGER CAVE DEPOSITS

Harper and Alder (1972: 13) aptly described the Danger Cave area as "bleakly

arid." The vegetation on the slope immediately surrounding the site is characterized by scattered shadscale (*Atriplex confertifolia*), black greasewood (*Sarcobatus vermiculatus*), horsebrush (*Tetradymia* spp.), Mormon tea (*Ephedra* sp.), alkali seepweed (*Suaeda fruticosa*), and grasses. The floor of Danger Cave today lies at 1314 m but, as Scott et al. (1983) have observed, the actual elevation of the cave at about 11,000 years ago was some 15 m lower than its current elevation, the difference resulting from isostatic rebound. The cave is spacious, some 18 m wide and 37 m long. In the 1930s, prior to archaeological excavations at the site, the cave opening was nearly choked with deposits, the site thus appearing as "no more than a very shallow overhang" (Jennings, 1957: 45). The first professional excavations here were conducted by E. R. Smith in 1940 and 1941; the current name of the cave was adopted during the 1941 work as a result of roof fall that occurred while the excavations were in progress.

Jennings first tested Danger Cave in 1949, diverting a small crew from work at nearby Juke Box Cave. This test demonstrated that the deposits of the cave would repay detailed attention, and Jennings returned in 1950, then again in 1951 and, in more limited fashion, in 1953. The major work at Danger Cave was accomplished in 1950 and 1951, with excavations focusing on deposits in the anterior and immediately in front of the cave, the latter excavated in order to assess the relationship between natural and cultural factors in accumulating materials within the cave itself.

Because of the work done by Smith in 1940 and 1941, and because of the testing done in 1949 by Jennings himself, it was known prior to the beginning of work in 1950 that the deposits of Danger Cave were both deep and stratified. The excavation techniques adopted were directed toward capitalizing on these facts. Details of the excavations can be obtained from Jennings (1957), but here I note that the Danger Cave deposits were peeled horizontally, with care taken not to mix the contents of recognizably distinct major strata. Jennings (1957) notes that the deposits were screened, but, as I discuss below, the nature of the vertebrate faunal sample is not con-

sistent with routine screening, and Jennings (personal commun.) estimates that no more than 80 percent of the deposits, and perhaps much less, were in fact screened, and suggests that screens as large as ⅓ in. (0.85 cm) or ½ in. (1.27 cm) were employed. The fieldnotes, however, mention the use of ¼ in. (0.64 cm) screens as well. Exactly what fraction of the deposits were screened, and the mesh of the screens that were used, are unclear.

Proceeding in this fashion, Jennings defined five major "cultural" strata for the Danger Cave deposits. While he termed these strata "cultural," in fact the lower and upper boundaries of these units were defined geologically, and artifactual criteria played absolutely no role in the assignment of a set of deposits to a given stratum. Thus, while each of the major Danger Cave strata contained recognizably distinct depositional events, each is a natural stratigraphic unit, even though Jennings (1957) routinely referred to these units as cultural strata or layers.

Because these five strata provided the basic stratigraphic organizational scheme for the site, they provide the organizational scheme for the fauna as well, and must be discussed in some detail here, even though much of my discussion is little more than a synthesis of information presented in Jennings (1957).

The basal deposits within Danger Cave consisted of a set of clays and gravels. The stratigraphic relationship between these two was not discovered during Jennings' excavations: the clays existed at the base of the deposits in the rear of the cave, the gravels at the base of the deposits in the front, but the contact between the two was not sought. The gravels themselves are clearly beach gravels, the upper 5 to 10 cm of which were frequently cemented together by the deposition of secondary carbonates. Near the mouth of the cave, the gravels are deeper than 2 m, but their full depth remains unknown. Because these gravels and clays were reached but not excavated, and because they did not appear to contain artifacts, they did not receive a numerical designation in Jennings' stratigraphic scheme. Hunt and Morrison (1957), however, suggested that the gravels were of Provo age.

Resting on the beach gravels and clays were two superimposed sand deposits, which Jen-

nings referred to as DI. The lowest of these, sand 1, was generally 2.5 to 7.5 cm thick, lightly cemented in most areas of the cave, and contained unbroken ostracodes (*Cytherissa lacustris*), suggesting to Jennings a subaqueous origin. Jennings noted that obsidian flakes were found within this sand but were not saved; since human occupation is known to have occurred on the surface of sand 1, these flakes, if cultural, were likely to have been intrusive. At least one radiocarbon date is available for sand 1: a date of 11,151 ± 570 B.P. (C-610) was obtained from uncharred wood in this unit, approximately 1.2 cm above the basal gravels. The exact position of the specimen that provided a second date assigned to sand 1 is much less clear. A date of 10,270 ± 650 B.P. (M-204) was obtained from "slightly charred sheep dung" (Jennings, 1957: 93), and was assigned to sand 1 by Jennings (1957, table 11 and fig. 38). In his discussion of this stratum, however, Jennings (1957) assigns only C-610 to sand 1 unit and does not discuss M-204. It is significant that the presence of charred sheep dung is inconsistent with Jennings' characterization of sand 1 as water-deposited, especially since both Jennings (1957) and Hunt and Morrison (1957) imply that, within DI, such dung was found only in sand 2. Equally important, Crane (1956) notes that the dated material came from Feature 19. The Danger Cave fieldnotes clearly equate this feature with aeolian deposition: on 20 July 1951, for instance, the notes state that Feature 19 contains "specks of pickle-weed. This could have easily been blown in at the same time the sand was," while the notes for 29 July 1951 equate this feature with "a wind blown sand dune." Thus, it seems reasonable to conclude that M-204 pertains not to sand 1 but to sand 2.

Six small hearths were built on the surface of sand 1, the earliest in situ evidence of human use at Danger Cave. A single date of 10,270 ± 650 B.P. (M-202) is available for one of these hearths.

Sand 2 covers these hearths, and contained broken ostracodes, artiodactyl dung, occasional pieces of lithic debitage, and plant macrofossils. The artiodactyl dung was identified as "sheep droppings" by Sperry (1957b: 302), an identification which is certainly bio-

geographically reasonable. Jennings interprets this sand as wind-deposited, notes that there is no firm evidence for human use of the cave during the time it was deposited, and suggests that the cave was used by mountain sheep either during, or most likely after, the accumulation of this deposit. In addition to M-204, discussed above, Jennings obtained three radiocarbon dates for this stratum: 11,453 ± 600 B.P. (C-609) on uncharred sheep dung, 11,000 ± 700 B.P. (M-118) also on uncharred sheep dung, and 10,400 ± 700 B.P. (M-119) on uncharred twigs and leaves.

One reason for the importance of the Danger Cave deposits stems, as I have noted, from the fact that this site sits some 27 m above the now-dry floor of Lake Bonneville, and roughly 49 m beneath the Stansbury shoreline, making these deposits sensitive indicators of the late history of Lake Bonneville. Indeed, when the radiocarbon dates for the two sands that comprise DI were published, Crane (1956: 669) noted that as a result of these dates, "all the previous interpretations of Pleistocene lake history, depth, and position in geologic time must be reassessed." In particular, these dates showed that Lake Bonneville could not have been at either the Stansbury (1362 m) or the Provo (1469 m) levels 11,500 years ago. Three decades later, the radiocarbon dates for DI are no longer so controversial, although particular details of Lake Bonneville history remain somewhat obscure (see the discussion in Smith and Street-Perrott, 1983). The data amassed by Scott et al. (1983) imply that by 11,000 years ago, Lake Bonneville had retreated to a level close to that of the present Great Salt Lake (1280 m), and strongly suggest that the lake had fallen beneath the Provo level by 13,000 B.P. They suggest as well that since 11,000 B.P., the lake has not risen more than 12 m above its modern level—that is, during the last 11,000 years, the lake has reached, but not exceeded, the Gilbert shoreline (see Currey, 1980). Scott and his colleagues thus call for rapid lake recession between 13,000 and 11,000 B.P., on the order of 6 m per 100 years (see Scott et al., 1983: fig. 5).

Although the picture they paint has been well-received and is in line with the recent work done by Thompson (1984) and by

TABLE 1
Danger Cave Radiocarbon Dates

Stratum	Years B.P.	Lab no.	Reference
DV	1930 ± 240	C-635	Jennings, 1957
	4000 ± 300	M-203	Jennings, 1957
	4900 ± 350[a]	M-205	Jennings, 1957
DIV	3819 ± 160	C-636	Jennings, 1957
	5050 ± 120	GaK-1902	Marwitt and Fry, 1973
	6825 ± 160	Gx-1465	Marwitt and Fry, 1973
DIII	6560 ± 120	GaK-1898	Marwitt and Fry, 1973
	6570 ± 110	GaK-1901	Marwitt and Fry, 1973
	7100 ± 150	GaK-1897	Marwitt and Fry, 1973
DII	6960 ± 210	GaK-1895	Marwitt and Fry, 1973
	8960 ± 340	C-640	Jennings, 1957
	9590 ± 160	GaK-1896	Marwitt and Fry, 1973
	9789 ± 630	C-611	Jennings, 1957
	9900 ± 200	GaK-1900	Marwitt and Fry, 1973
	10,130 ± 250	GaK-1899	Marwitt and Fry, 1973
DI			
Sand 2	10,400 ± 700	M-119	Jennings, 1957
	11,000 ± 700[b]	M-118	Jennings, 1957
	11,453 ± 600[c]	C-609	Jennings, 1957
On Sand 1	10,270 ± 650	M-202	Jennings, 1957
Sand 1	10,270 ± 650	M-204	Jennings, 1957
	11,151 ± 570	C-610	Jennings, 1957

[a] Jennings (1957) gives this date as 4900 ± 500 B.P.: see Crane, 1956.
[b] Scott et al. (1983) incorrectly list this date as 11,454 ± 600 B.P.
[c] Scott et al. (1983) incorrectly list the lab number for this date as M-700.

Thompson et al. (1986) on the history of Lake Lahontan, it is in conflict with the interpretation of Lake Bonneville history presented by Spencer et al. (1984), as I will discuss below. It is also in conflict with the arguments of Jennings (1957) and Hunt and Morrison (1957) that sand 1 is subaqueous in origin *as long as* one or both of the sand 1 dates are accepted. I have already noted that M-204 clearly seems to pertain to sand 2. If, however, C-610 really does date the time of deposition of sand 1, then the interpretation of Scott et al. (1983) cannot be correct. Accordingly, it is of interest to note that of the six dates available for DI, Scott et al. (1983) accept only the sand 2 dates of M-118 (11,000 ± 700 B.P.) and C-609 (11,453 ± 600 B.P.), and reject both C-610 (11,151 ± 570 B.P.) for sand 1, and the three sub-11,000 B.P. dates (M-202, M-204, and M-119). Unfortunately, they do not discuss the reasons for this rejection. This is not an issue that can be resolved here; I merely note the conflict. Having no reason to differentially accept or reject

any of the DI dates, I accept them all and, given the suite of dates now available for DII (see table 1), consider the fauna of DI to have accumulated between 11,000 and 10,000 B.P. Since Jennings (1957) and Hunt and Morrison (1957) note that sand 1 contained no bones, the DI vertebrate fauna can be assigned to the surface of sand 1 and to sand 2 with confidence.

The remaining Danger Cave strata may be more briefly discussed. Sand 2 was covered by a layer of bat guano admixed with sand and roof spall, approximately 10 cm thick. Human occupation occurred on this surface, as evidenced by hearths and artifacts; the base of DII was defined by Jennings as the base of this sand and roof spall unit. The rest of DII consisted primarily of roof spall, organic debris, and, especially, ash. Jennings interpreted this ash layer, which averaged some 7 cm in thickness in the central portion of the site, as resulting from the in situ combustion of floor litter. The analysis conducted by Harper and Alder (1972) of the plant macrofos-

sils in samples taken from the rear of the cave suggests that the organic component of this stratum is primarily pickleweed (*Allenrolfea occidentalis*), shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus baileyi*), and black sagebrush (*Artemisia arbuscula*). Jennings (1957) suggested that the presence of bat guano throughout DII implies shallow water nearby, and a climate moister than that which currently characterizes the area. He also obtained two radiocarbon dates for the deposits of DII; six additional dates are now available, the sum of which suggests that DII accumulated between about 10,000 and 9000 B.P. (table 1).

A layer of roof spall covered much of DII; Jennings suggested that this material may have accumulated over a lengthy period of time, and noted as well that the lack of guano intermixed with these spalls "probably testifies to a period of regional desiccation" (1957: 64). DIII lay on this spall layer, varied between 5 and 10 cm in thickness, and consisted largely of alternating layers of fine inorganic sediments ("dust") and organic material. In 1957, Jennings felt that much or all of the plant material in the excavated sediments of DIII was pickleweed debris, including chaff remaining from winnowing. Harper and Alder (1972), however, found that shadscale and greasewood were also major components of the organic fraction of the DIII sediments. Much of the fill of this stratum had burned, producing massive ash deposits; there is also evidence that the human occupants of the site cleared ash from central parts of DIII floors, redepositing it in peripheral areas of the cave. Jennings did not obtain any dates from DIII. Fortunately, later work has provided three (Marwitt and Fry, 1973), all of which fall between 6560 and 7100 B.P. (table 1). As Harper and Alder (1972) note, however, these dates pertain to the mid- and upper sections of DIII; the lower reaches of these deposits remain undated. I will treat DIII as having accumulated between 7500 and 6500 B.P., but it should be clear that there is little control over the age of the earliest DIII material. If the youngest DII date (6960 ± 210 B.P.) is discounted because it is more than three standard deviations younger than the next youngest date available for that stratum (8960 ± 340 B.P.), then Jennings' initial

belief that a lengthy depositional hiatus might have occurred between DII and DIII times remains fully reasonable.

DIII was discontinuously covered by a layer of roof spall; DIV accumulated on top of this layer. The nature of the DIV deposits was similar to that of DIII: fine inorganic sediments alternating with organic debris, much of which had burned. In Harper and Alder's (1972) samples, pickleweed was almost absent, while shadscale and greasewood comprised the bulk of the assemblage. Three dates are available for this stratum: 3819 ± 160 B.P. (C-636), 5050 ± 120 B.P. (GaK-1902), and 6825 ± 160 B.P. (Gx-1465). Marwitt and Fry (1973) suggest that Gx-1465 may actually pertain to DIII, since it falls between the youngest date obtained for DII and the oldest obtained for DIII. GaK-1902 came from the middle section of DIV, leaving the age of the bottom of this stratum uncontrolled. I have assigned DIV an age of 5500–4000 B.P., but further dates for this stratum are clearly needed.

Roof spall also covered DIV; a final layer of inorganic material and plant debris, DV, covered this spall layer. Unlike DII, DIII, and DIV, which contained little to no *Scirpus*, Jennings (1957) notes that *Scirpus americanus* became increasingly common as the deposition of DV continued. This unit was not represented in the samples analyzed by Harper and Alder (1972). Three radiocarbon dates are available for DV: 1930 ± 240 B.P. (C-635), 4000 ± 300 B.P. (M-203), and 4900 ± 350 B.P. (M-205). M-205 is statistically indistinguishable from the oldest date available for DIV (Gak-1902). If M-205 is rejected (but see Schiffer [1986] on this approach to date selection), the radiocarbon evidence would suggest that DV accumulated between 4000 and 2000 B.P. Archaeological evidence, however, suggests that deposition in the front of Danger Cave continued well beyond 2000 years ago. The reanalysis of Danger Cave projectile points conducted by Aikens (1970) demonstrated that the DV deposits contain significant numbers of Desert side-notched, Rosegate (sensu Thomas, 1981), and Cottonwood triangular points. At nearby Hogup Cave, such points become common only in Aikens' Settlement Units III and IV, dated to A.D. 400 – A.D. 1850 (Ai-

TABLE 2
Numbers of Identified Mammalian Specimens per Taxon by Stratum at Danger Cave
(S = surface; NP = no provenience)

Taxon	Stratum					S	NP	Totals
	I	II	III	IV	V			
Sylvilagus sp.	19	1	—	—	—	—	9	29
Sylvilagus sp. (large)	76	20	5	2	18	—	36	157
S. idahoensis	35	1	—	—	1	—	13	50
S. nuttallii	5	—	—	1	3	—	7	16
Lepus sp.	135	568	567	182	525	4	381	2362
L. californicus	—	—	2	—	6	—	1	9
Marmota flaviventris	17	—	—	—	—	—	—	17
Thomomys sp.	—	—	—	—	1	—	—	1
Dipodomys sp.	22	4	1	—	4	—	—	31
D. cf. *ordii*	1	—	—	—	—	—	—	1
D. microps	—	3	—	—	—	—	—	3
Neotoma sp.	16	—	—	—	3	—	—	19
N. cf. *lepida*	5	—	—	1	6	—	1	13
N. lepida	3	6	1	2	21	—	4	37
N. cf. *cinerea*	69	8	1	—	2	—	26	106
N. cinerea	41	7	2	—	1	—	14	65
Microtus sp.	1	—	—	—	—	—	—	1
Erethizon dorsatum	—	—	—	—	1	—	—	1
Canis sp.	—	1	—	1	5	—	—	7
Canis cf. *latrans*	—	—	—	—	3	—	—	3
Canis latrans	2	9	5	11	48	—	8	83
Canis lupus	—	2	9	1	5	—	1	18
Canis familiaris	—	2	—	—	—	1	—	3
Vulpes cf. *vulpes*	—	—	—	—	1	—	—	1
V. vulpes	—	1	—	—	4	—	2	7
V. macrotis	—	4	—	—	3	—	—	7
Mustela frenata	2	—	—	—	—	—	—	2
Taxidea taxus	—	—	1	—	5	—	3	9
Lynx cf. *rufus*	—	2	—	—	3	—	—	5
Lynx rufus	—	1	2	—	—	—	1	4
Odocoileus cf. *hemionus*	—	2	4	10	15	—	—	31
Antilocapra americana	—	5	3	6	14	—	3	31
Bison bison	—	2	1	—	8	—	—	11
Ovis canadensis	—	65	64	49	176	—	19	373
Totals	449	714	668	266	882	5	529	3513

kens, 1970). Accordingly, Aikens postulates that "a sixth level, DVI, existed at Danger Cave but was not discovered and that artifacts from it were combined with artifacts from DV" (1970: 197–198). Aikens' arguments are compelling, and have been accepted by Jennings (1974). DV thus appears to span the last 4000 years.

DESCRIPTIVE SUMMARY

Table 2 presents the number of identified specimens per mammalian taxon by stratum at Danger Cave. In this section, I provide a discussion of the criteria used to identify these elements, and comment on selected aspects of the taxa represented within the Danger Cave vertebrate fauna. In some cases, I have provided catalog numbers for particular specimens. When the Danger Cave material was initially cataloged under Jennings' direction, some of the faunal material was given University of Utah (UU) numbers. Because it would have been both unwise and inefficient to work with uncataloged material, all faunal material was renumbered using a second system. Each of the numbers in this sec-

ond system begins with the prefix DC; the catalog itself has been deposited, with the faunal material, in the Utah Museum of Natural History. Where needed, both the original (if assigned) and new catalog numbers are given below.

Order Lagomorpha—Rabbits, Hares, and Pikas
Family Leporidae—Rabbits and Hares
Sylvilagus sp.—Rabbits

Material: 2 skull fragments, 7 mandibles, 4 isolated teeth, 3 radii, 1 ulna, 5 vertebrae, 1 sacrum, 5 femora, 1 tibia: 29 specimens.

Sylvilagus sp. (large)—Rabbits

Material: 7 skull fragments, 18 mandibles, 7 isolated teeth, 10 scapulae, 13 humeri, 2 radii, 6 ulnae, 18 vertebrae, 1 sacrum, 28 innominates, 17 femora, 23 tibiae, 7 metatarsals: 157 specimens.

Sylvilagus idahoensis—Pygmy Rabbit

Material: 3 skull fragments, 8 mandibles, 7 isolated teeth, 3 scapulae, 4 humeri, 3 radii, 1 ulna, 1 metacarpal, 2 sacra, 2 innominates, 6 femora, 5 tibiae, 2 calcanea, 3 metatarsals: 50 specimens.

Sylvilagus nuttallii—Nuttall's Cottontail

Material: 5 skull fragments, 4 mandibles, 7 isolated teeth: 16 specimens.

Remarks: Three species of *Sylvilagus* are currently found in the Bonneville Basin (Durrant, 1952; Shippee and Egoscue, 1958; Egoscue, 1961, 1965): *S. idahoensis,* the pygmy rabbit, *S. nuttallii,* Nuttall's cottontail, and *S. audubonii,* the desert cottontail. Of these, only the pygmy rabbit has been reported from the Danger Cave area. *S. audubonii* has been taken only in the more central and southern parts of the Bonneville Basin. Pygmy rabbits, however, are generally associated with fairly dense stands of tall sagebrush (*Artemisia tridentata*: Weiss and Verts, 1984). Such habitat is not present in the vicinity of Danger Cave today, and pygmy rabbits could not exist here now, although they may have during earlier historic times.

I have discussed the identification of pygmy rabbit bones and teeth elsewhere (Grayson, 1983, 1985), and do not repeat that discussion here. In previous work (Grayson, 1983, 1985), I have relied on three sets of characters to identify *S. nuttallii* and *S. audubonii* elements: skull morphology (e.g., Durrant, 1952; Hoffmeister and Lee, 1963), the morphology of the occlusal surfaces of p3-m2 (Orr, 1940; Findley et al., 1975), and the ratio of the alveolar length of the lower cheekteeth, or the p3-m1 alveolar length, to the height of the mandible at the lateral anterior notch of p4 (Findley et al., 1975). In the analysis of the Danger Cave *Sylvilagus,* only the first two of these characters were used.

Findley et al. (1975: 84) note that "in most cases the depth of the lower jaw relative to the alveolar length of the cheektooth-row (p3-m3) will separate *S. audubonii*" from both *S. nuttallii* and *S. floridanus,* the eastern cottontail. They note that the p3-m1 alveolar length also allows this separation when the alveolar length of the complete cheektooth-row cannot be measured. To demonstrate the use of this criterion, they presented a scattergram of mandibular alveolar lengths (p3-m3) against the mandibular depth at p4 (Findley et al., 1975: 85; note that the Y axis of their figure is mislabeled), in which they employed a sample of 14 *S. audubonii,* 13 *S. nuttallii,* and 5 *S. floridanus.* Their scattergram showed clear separation between *S. audubonii* and *S. nuttallii.* Scattergrams that I constructed based on equally small samples of *S. audubonii* and *S. nuttallii* also suggested that this criterion was valid, and I accordingly used it to identify *S. nuttallii* in a number of faunas (e.g., Grayson, 1983, 1985). Neusius and Flint (1985), however, suggest that the approach used by Findley et al. (1975) is flawed. They identified a series of *Sylvilagus* mandibles from Anasazi sites from southwestern Colorado using both p3-m3 and p3-m1 lengths, and then reidentified those mandibles using discriminant function analysis. The results of the latter analysis were discordant with the results of the former, and they concluded that the approach taken by Findley et al. (1975) is inappropriate. Surprisingly, however, they did not attempt to document that modern mandibles from known species of cottontails are misidentified
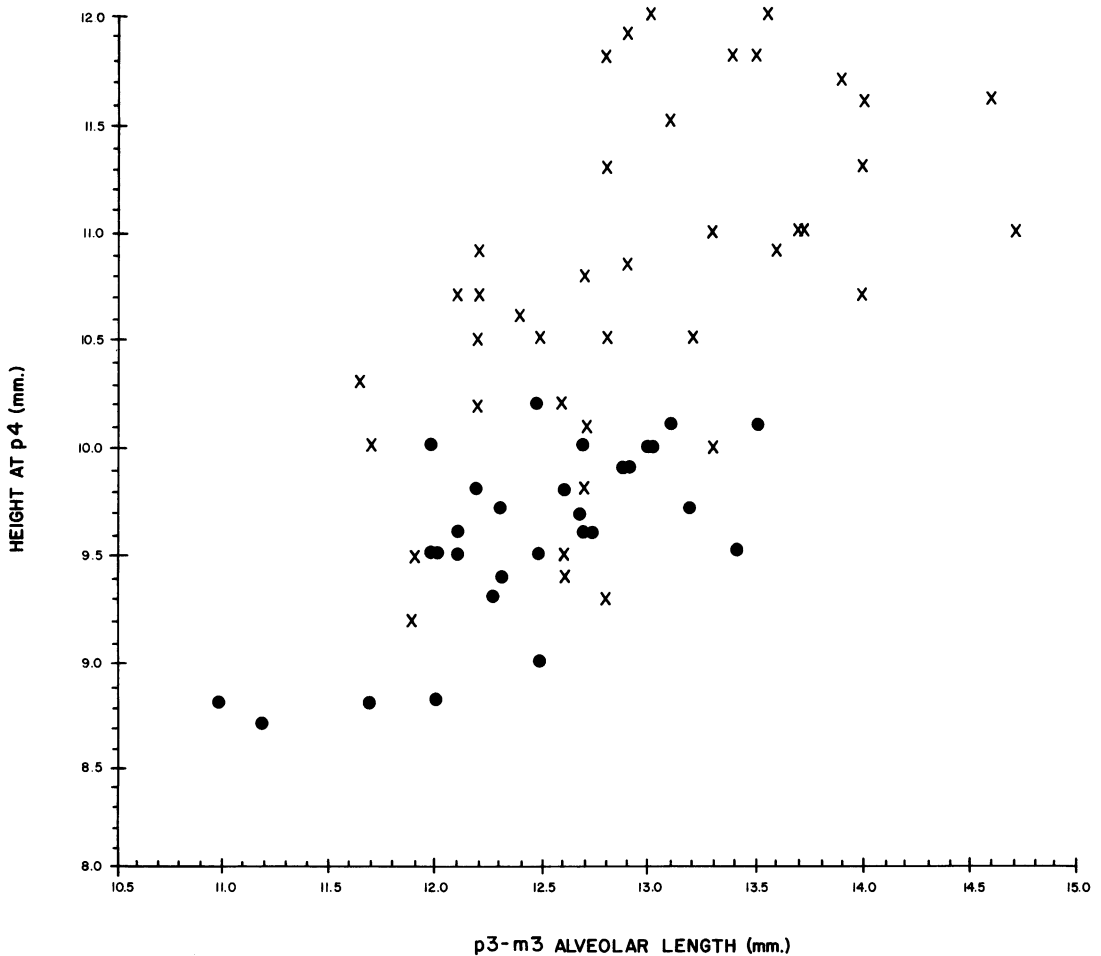
Fig. 2.   Relationship between mandibular height at p4 and alveolar length (p3-m3): *Sylvilagus nuttallii* (solid circles) and *S. audubonii* (x).

by Findley et al.'s (1975) method. That this is the case is easy to show. Using a much larger sample of *S. nuttallii* and *S. audubonii* than has been available to me in the past, I find that neither p3-m3 nor p3-m1 alveolar lengths securely allow their discrimination.

Figure 2 shows the height of the mandible at the lateral notch of p4 plotted against p3-m3 alveolar length for a sample of 30 *S. nuttallii* (subspecies *S. grangeri* [3], *S. n. nuttallii* [22], and *S. n. pinetus* [5]), and 40 *S. audubonii* (*S. a. audubonii* [1], *S. a. arizonae* [15], *S. a. baileyi* [12], *S. a. minor* [6], and *S. a. cedrophilus* [6]). In this sample, there is tremendous overlap between these two species at p4 mandibular heights of less than 10.5 mm. Figure 3 presents a similar scattergram

utilizing p3-m1 alveolar lengths; again, there is great overlap between *S. nuttallii* and *S. audubonii* beneath mandibular heights of 10.5 mm. None of the Danger Cave large *Sylvilagus* mandibles can be identified using this approach (table 3).

As a result, I concur with the conclusion reached by Neusius and Flint (1985). While these measurements allowed *S. nuttallii* and *S. audubonii* to be separated in the smaller samples used by Findley et al. (1975) and by myself in earlier studies, they do not allow secure identification of prehistoric material.

Lepus sp.—Hares

Material: 198 skull fragments, 360 mandibles, 196 isolated teeth, 208 scapulae, 157
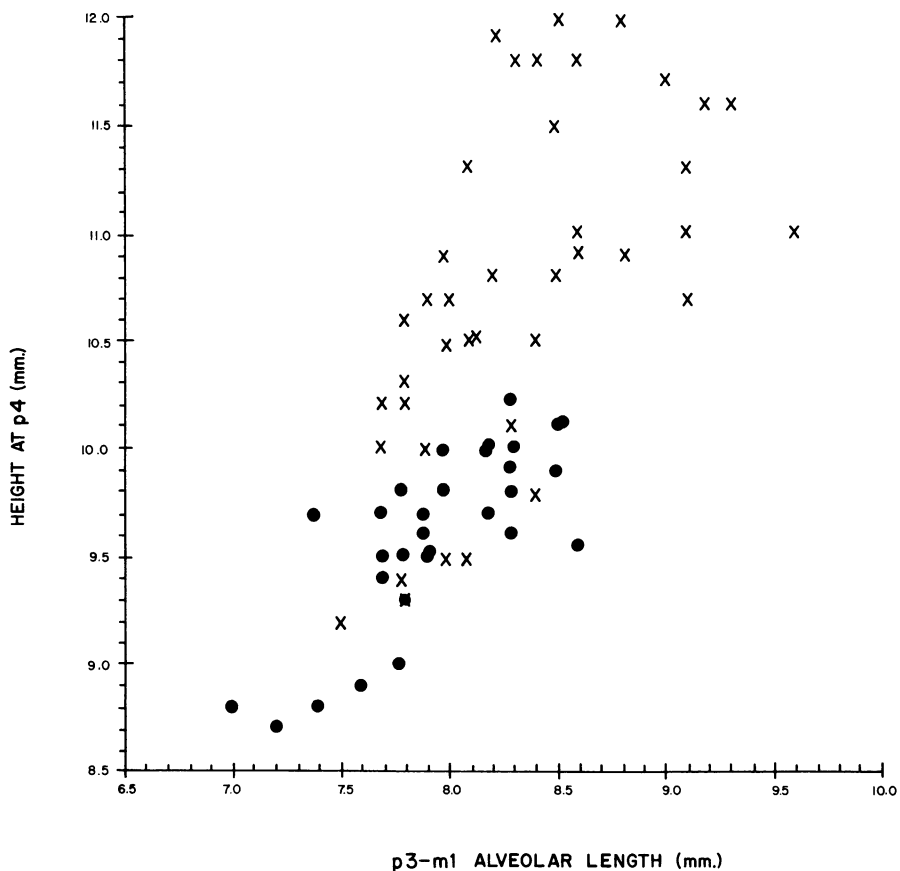
Fig. 3.   Relationship between mandibular height at p4 and alveolar length (p3-m1): *Sylvilagus nuttallii* (solid circles) and *S. audubonii* (x).

humeri, 205 radii, 52 ulnae, 3 metacarpals, 3 sternabrae, 32 vertebrae, 96 innominates, 211 femora, 591 tibiae, 27 calcanea, 1 astragalus, 1 cuneiform, 17 metatarsals, 4 phalanges: 2362 specimens.

Lepus californicus — Black-tailed Jackrabbit

Material: 9 skull fragments: 9 specimens.

Remarks: The black-tailed jackrabbit is the only member of the genus currently found in the Danger Cave area. Both *L. americanus* and *L. townsendii* can be expected, however, in late Pleistocene and perhaps early Holocene low elevation Great Basin faunas (Grayson, 1987).

Order Rodentia — Rodents
Family Sciuridae — Squirrels
Marmota flaviventris — Yellow-bellied Marmot

Material: 4 skull fragments, 1 mandible, 1 isolated tooth, 1 clavicle, 2 metacarpals, 1 vertebra, 1 calcaneus, 6 metatarsals: 17 specimens.

TABLE 3
Mandibular Measurements (in millimeters), Danger Cave Large *Sylvilagus*
(Edentulous mandibles only: AL = alveolar length; H = height)

Specimen number	Stratum	AL		H p4
		p3-m3	p3-m1	
95 (4)	V		8.0	9.8
101 (1)	V	12.0		10.0
101 (2)	V	12.3		9.9
101 (7)	V	12.1		9.6
23083/25 (5)	IV	12.5		9.7
65 (8)	III	12.8		9.6
29 (6)	I	12.8		10.4
30 (3)	I	12.6		9.8

Remarks: There are no modern records for marmots in the Wendover area. The closest known populations are all slightly over 100 km distant: 110 km to the west in the Ruby Mountains (Hall, 1946, 1981), 135 km to the north in the Raft River Mountains (Durrant, 1952), 130 km to the southeast on Deseret Peak (Durrant et al., 1955), and 120 km to the south in the Deep Creek Mountains (Shippee and Egoscue, 1958). Although intervening populations may exist, the Silver Island Mountains are certainly too xeric for these animals today.

Because all of the Danger Cave marmot specimens came from DI, and because marmots do not currently exist in this area, these specimens may provide significant information concerning the timing of the local extinction of marmots. It is, however, possible that the marmot specimens were transported here by people. Not only does DI contain archaeological material, but, assuming that the marmot assemblage has not been biased by collection procedures, whatever deposited these specimens was skeletally selective. Fifteen of these specimens are cranial and distal limb elements, the remaining two a clavicle and a thoracic vertebra.

Although both sand 1 and sand 2 contained occasional pieces of debitage, Jennings considered these intrusive, arguing that there was no evidence for human occupation of the cave during DI times except for that which was found on the surface of sand 1, including the six hearths discussed above. Thus, it is important to realize that of the 17 marmot specimens, 16 (UU-23715; DC-22) came from Feature 114, while the remaining specimen, the clavicle (UU-23716; DC-31), came from Feature 113 (in Jennings' usage, "features" were "individual accretional strata" [Jennings, 1957: 52] that may or may not have contained cultural material). Both Features 113 and 114 were within sand 2. Feature 113 overlaid the hearths, was not screened, and provided a small amount of debitage; Feature 114 overlaid Feature 113, was passed through ¼ in. (0.64 cm) mesh screen, and provided no artifacts (Danger Cave fieldnotes for 17 June, 7 July, and 16 July, 1953). Because the marmot specimens occurred within sand 2, and because 16 of the 17 specimens came from Feature 114, which provided no evi-

dence of human occupation whatsoever, it seems unlikely that the Danger Cave marmots were transported to the cave by people.

Family Geomyidae — Pocket Gophers
Thomomys sp. — Smooth-toothed Pocket Gopher

Material: 1 mandible: 1 specimen.
Remarks: *Thomomys bottae* is the only pocket gopher known from the Wendover area today. The single Danger Cave specimen is an edentulous mandible with a p4-m2 alveolar length of 5.6 mm. The only other member of the genus currently present west of the Sierra Nevada–Cascades that this mandible could represent is *T. talpoides,* the northern pocket gopher. An alveolar length of 5.6 mm is consistent with an identification of either *T. talpoides* or *T. bottae* (see Grayson, 1983, table 11; see also chap. 3, this volume).

Family Heteromyidae — Pocket Mice, Kangaroo Mice, Kangaroo Rats
Dipodomys sp. — Kangaroo Rats

Material: 2 skull fragments, 1 humerus, 1 vertebra, 1 sacrum, 3 innominates, 10 femora, 13 tibiae: 31 specimens.

Dipodomys cf. *ordii* — Ord's Kangaroo Rat

Material: 1 mandible: 1 specimen.

Dipodomys microps — Chisel-toothed Kangaroo Rat

Material: 2 skull fragments, 1 isolated tooth: 3 specimens.
Remarks: Both *D. ordii* and *D. microps* currently inhabit the Wendover area (Durrant, 1952).

Family Muridae — Murids
Neotoma sp. — Wood Rats

Material: 7 skull fragments, 1 mandible, 4 isolated teeth, 1 scapula, 1 humerus, 3 vertebrae, 2 metatarsals: 19 specimens.

Neotoma cf. *lepida* — Desert Wood Rat

Material: 4 skull fragments, 1 mandible, 2 innominates, 3 femora, 3 tibiae: 13 specimens.

TABLE 4
Alveolar Lengths (in millimeters) of Modern *Neotoma lepida* and *Neotoma cinerea* Mandibles and Maxillae

	N	Range	$\bar{x}$	s
Mandible				
Neotoma lepida	28	7.6–8.6	8.18	0.37
Neotoma cinerea	125	9.3–11.5	10.07	0.39
Maxilla				
Neotoma lepida	23	7.8–8.6	8.40	0.26
Neotoma cinerea	34	9.4–11.4	10.23	0.42

Neotoma lepida — Desert Wood Rat

Material: 12 skull fragments, 19 mandibles, 6 isolated teeth: 37 specimens.

Neotoma cf. *cinerea* — Bushy-tailed Wood Rat

Material: 9 skull fragments, 1 mandible, 5 isolated teeth, 17 humeri, 1 radius, 4 ulnae, 11 innominates, 32 femora, 25 tibiae, 1 calcaneus: 106 specimens.

Neotoma cinerea — Bushy-tailed Wood Rat

Material: 17 skull fragments, 33 mandibles, 15 isolated teeth: 65 specimens.

Remarks: Desert wood rats are known from the Wendover area (Hall, 1946), but there are no records for bushy-tailed wood rats here, the closest known modern populations being in the Cedar Mountains some 100 km to the east and in the Deep Creek Mountains approximately 110 km to the south. As Shippee and Egoscue (1958: 277) note, however, the Cedar Mountains are a low (highest elevation ca. 2360 m), poorly watered range and it is possible that other ranges within the Bonneville Basin, including the Pilot Range to the immediate northwest of the Silver Island Mountains, support populations of these animals.

In identifying the Danger Cave *Neotoma* specimens, I have assumed that only *N. lepida* and *N. cinerea* are present. I have used the morphology of M1 to separate these two taxa: the reentrant angle of the anterior prism of this tooth is deep in *N. cinerea*, shallow in

TABLE 5
Occlusal Lengths (in millimeters) of Modern *Neotoma lepida* and *N. cinerea* Molars

	N	Range	$\bar{x}$	s
Neotoma lepida				
M1	26	2.90–3.46	3.09	0.16
M2	26	2.22–2.57	2.38	0.09
M3	26	1.43–2.22	1.70	0.20
m1	26	2.73–3.33	3.00	0.16
m2	26	2.37–2.82	2.63	0.11
m3	26	1.33–2.01	1.67	0.18
Neotoma cinerea				
M1	37	3.19–4.27	3.59	0.19
M2	37	2.48–3.09	2.85	0.15
M3	37	1.75–2.73	2.30	0.27
m1	37	3.01–4.04	3.51	0.23
m2	37	2.75–3.28	3.02	0.13
m3	37	1.52–2.57	2.15	0.22

N. lepida. Alveolar lengths were used to identify mandibles and maxillae that lacked M1. Table 4 presents mandibular and maxillary alveolar lengths for modern samples of *N. cinerea* and *N. lepida* (see Grayson, 1985, for the subspecies involved). The distributions of the measurable Danger Cave *Neotoma* maxillary and mandibular alveolar lengths are shown in figure 4. Specimens with alveolar lengths of less than 8.7 mm were assigned to *N. lepida*; those with alveolar lengths of greater than 9.3 mm were assigned to *N. cinerea.* A similar approach was taken for isolated *Neotoma* molars, using occlusal lengths of those teeth. Because occlusal lengths are heavily affected by wear, however, there is considerable overlap between *N. cinerea* and *N. lepida* in the ranges of this measurement for any given molar (see table 5), and *t*-tests were used to identify the 19 isolated *Neotoma* molars in the Danger Cave fauna (table 6; see also Grayson, 1983, 1985). Postcranial material was assigned to *N.* cf. *cinerea* and *N.* cf. *lepida* on the basis of size.

Microtus sp. — Meadow Voles

Material: 1 mandible: 1 specimen.

Remarks: Both *M. longicaudus,* the long-tailed vole, and *M. montanus,* the montane vole, are to be expected in the Wendover area.

TABLE 6

**Occlusal Lengths (in millimeters) of Isolated *Neo-
toma* Molars Assigned to *N. lepida* and *N. cinerea***

Tooth	Specimen number	Occlu-sal length	Identification	Stra-tum
M1	DC-28	3.29	*N.* cf. *cinerea*	DI
	DC-30	3.31	*N. cinerea*	DI
	DC-22	3.66	*N. cinerea*	DI
	DC-152	3.75	*N. cinerea*	DII
M2	DC-22	2.73	*N. cinerea*	DI
	DC-28	2.73	*N. cinerea*	DI
	DC-152	2.74	*N. cinerea*	DII
	DC-28	2.93	*N. cinerea*	DI
	DC-30	2.94	*N. cinerea*	DI
	DC-152	3.04	*N. cinerea*	DII
M3	DC-28	2.63	*N. cinerea*	DI
m1	DC-37	3.65	*N. cinerea*	DIII
	DC-22	3.94	*N. cinerea*	DI
	DC-22	3.95	*N. cinerea*	DI
m2	DC-236	2.53	*N. lepida*	NP
	DC-116	2.76	*N. lepida*	DV
	DC-31	2.79	*N. lepida*	DI
	DC-116	3.04	*N. cinerea*	DI
	DC-116	3.07	*N. cinerea*	DV
m3	DC-236	1.65	*N. lepida*	NP

Family Erethizontidae—New World Porcupines
Erethizon dorsatum—Porcupine

Material: 1 mandible: 1 specimen.
Remarks: Porcupines are found throughout Utah and the adjacent parts of Nevada.

Order Carnivora—Carnivores
Family Canidae—Coyote, Wolves, Foxes, and Dogs
Canis sp.—Coyote, Wolves, and Dogs

Material: 1 skull fragment, 2 scapulae, 1 ulna, 1 metacarpal, 1 femur, 1 tibia: 7 specimens.

Canis cf. *latrans*—Coyote

Material: 1 skull fragment, 1 humerus, 1 navicular: 3 specimens.

Canis latrans—Coyote

Material: 14 skull fragments, 15 mandibles, 3 isolated teeth, 1 scapula, 8 humeri, 4 radii, 3 ulnae, 1 nearly complete carpus, 4 metacarpals, 6 vertebrae, 1 sacrum, 2 innominates, 3 femora, 4 tibiae, 1 nearly complete tarsus, 6 calcanea, 3 astragali, 4 phalanges: 83 specimens.
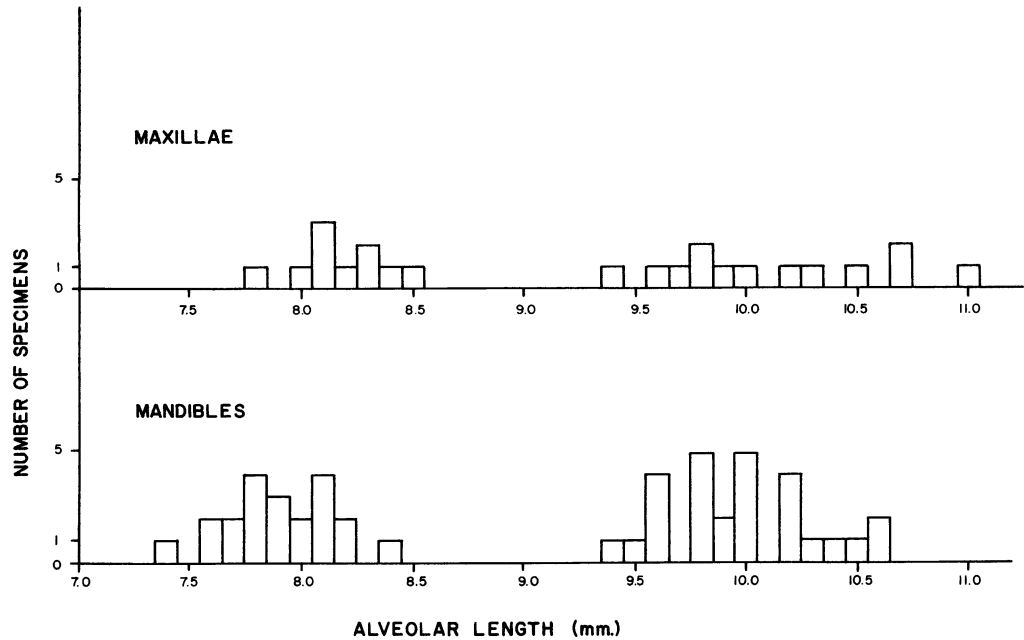
Fig. 4.   The distribution of maxillary and mandibular alveolar lengths, Danger Cave *Neotoma*.

Canis lupus—Wolf

Material: 4 skull fragments, 2 mandibles, 8 isolated teeth, 1 ulna, 1 vertebra, 1 tibia, 1 phalanx: 18 specimens.

Canis familiaris—Domestic Dog

Material: 1 skull fragment, 2 mandibles: 3 specimens.

Vulpes cf. vulpes—Red Fox

Material: 1 vertebra: 1 specimen.

Vulpes vulpes—Red Fox

Material: 6 skull fragments, 1 mandible: 7 specimens.

Vulpes macrotis—Kit Fox

Material: 2 skull fragments, 2 mandibles, 3 isolated teeth: 7 specimens.

Remarks: None of the Danger Cave canids are unexpected. While there are no records for *Vulpes vulpes* in the western Bonneville Basin, there are scattered records throughout the adjacent state of Nevada, and their presence in the Wendover area is not surprising.

The two *Canis familiaris* mandible fragments (UU-23684; DC-87) came from a single element and were readily reassembled. The resultant edentulous left mandible includes the anterior part of the ascending ramus and the body caudal to the posterior portion of the alveolus for the canine (fig. 5). The p2 alveolus has been almost completely resorbed, while the bone buccal to p3 and the anterior root of p4 appears to have been remodeled. The specimen, which has a p1-m3 alveolar length of 61.0 mm, was identified as domestic dog because the cheekteeth are crowded and because the body is convex in lateral view, twisted when viewed from above, and markedly robust for its short length. Unfortunately, the measurements used by Lawrence (1968) in her analysis of early North American domestic dogs could not be taken on this specimen, although the same lateromedial thickening discussed by her is evident. The buccal wall posterior to the anterior root of p4 is darkened with what appears to be *Neotoma* urine.

This mandible came from DII (Feature 30), and thus dates to between 10,000 and 9000 B.P. Although this is not the earliest domestic

Fig. 5.   Danger Cave *Canis familiaris* mandible UU 23684 from stratum DII.

dog material known from North America—the Jaguar Cave, Lemhi County, Idaho specimens date to between ca. 10,400 and 11,600 B.P. (Lawrence, 1968; Kurtén and Anderson, 1972)—it is certainly the earliest specimen reported from the Great Basin, and among the earliest known from the New World (see the review in Olsen, 1985). The presence of domestic dogs in the Great Basin during the earliest Holocene can occasion no surprise, especially given their presence not far to the north at an even earlier time.

The fragmentary skull includes portions of the right frontal, nasal, premaxilla, and maxilla (DC-274), and was one of the few identified specimens in the collection retrieved from the surface of the site.

Family Mustelidae—Weasels, Skunks, and Allies
Mustela frenata—Long-tailed Weasel

Material: 1 humerus, 1 ulna: 2 specimens.

Taxidea taxus — Badger

Material: 2 skull fragments, 4 mandibles, 1 humerus, 1 ulna, 1 vertebra: 9 specimens.

Remarks: Both long-tailed weasels and badgers range throughout Utah.

Family Felidae — Cats and Allies
Lynx cf. *rufus* — Bobcat

Material: 2 mandibles, 1 scapula, 2 femora: 5 specimens.

Lynx rufus — Bobcat

Material: 1 skull fragment, 3 mandibles: 4 specimens.

Remarks: Bobcats are known historically from throughout the Bonneville Basin.

Order Artiodactyla — Artiodactyls
Family Cervidae — Cervids
Odocoileus cf. *hemionus* — Mule Deer

Material: 7 skull fragments, 4 mandibles, 2 isolated teeth, 1 radioulna, 2 innominates, 1 tibia, 4 metatarsals, 1 astragalus, 1 calcaneus, 1 metapodial, 7 phalanges: 31 specimens.

Family Antilocapridae — Pronghorn
Antilocapra americana — Pronghorn

Material: 3 skull fragments, 4 mandibles, 5 isolated teeth, 4 humeri, 1 metacarpal, 1 tibia, 3 metatarsals, 2 astragali, 8 phalanges: 31 specimens.

Family Bovidae
Bison bison — Bison

Material: 2 isolated teeth, 2 carpals, 1 innominate, 1 metatarsal, 1 metapodial, 4 phalanges: 11 specimens.

Ovis canadensis — Mountain Sheep

Material: 24 skull fragments, 13 horn sheath fragments, 50 mandibles, 76 isolated teeth, 6 scapulae, 17 humeri, 30 radioulnae, 12 metatarsals, 12 carpals, 7 first cervical vertebrae, 4 second cervical vertebrae, 8 innominates, 2 femora, 1 patella, 27 tibiae, 1 fibula, 37 metatarsals, 3 astragali, 5 calcanea, 2 miscellaneous tarsals, 11 metapodials, 25 phalanges: 373 specimens.

Remarks: All four of these artiodactyls were widespread in the Great Basin during late prehistoric times. Durrant (1952) discusses the fact that the current abundance of deer in Utah is a very recent phenomenon; both 18th and 19th century accounts stress the scarcity of large mammals, including deer, in the state. Danger Cave is but one of many Great Basin archaeological sites that suggest that deer were relatively uncommon in much of the Great Basin during much or all of the Holocene (see Thomas, 1970a; Grayson, 1982b). Archaeological and paleontological records show that bison were widely scattered, though apparently nowhere very abundant, throughout the Great Basin during the Holocene (Grayson, 1982b).

SOME TAPHONOMIC CONSIDERATIONS

The evidence for human and carnivore modification of the Danger Cave artiodactyls is to be the subject of a separate analysis by S. R. James. Here, I discuss only the fact that many of the Danger Cave bones are burned and etched.

BURNING: DISTRIBUTION BY STRATUM AND BY TAXON

As I have noted, Jennings reported that substantial portions of the organic deposits of DII through DV had burned, and that massive amounts of ash characterized each of these strata. Even in DI, both fires made on sand 1 and those made after the deposition of sand 2 caused some burning of intermixed organic materials.

The mammal bones show the results of this history. Many are blackened, many are calcined, and many are ash-gray, either as a direct result of burning or because they have become stained by contact with ash. Since large numbers of ash-gray bones are calcined, I have treated either attribute as indicative of burning. The distribution of burned bones by taxon and stratum is presented in table 7.

The fact that all strata contained substantial amounts of burned bones is certainly in line with Jennings' description of the burning that characterized the Danger Cave deposits. That simple observation, however, obscures the fact that burning is not randomly distrib-

TABLE 7
The Distribution of Burned Specimens by Taxon and Stratum in Danger Cave

	Stratum					
	I	II	III	IV	V	Totals
Lepus sp.	15	46	76	15	56	208
Sylvilagus sp. (large)	0	0	1	0	1	2
Dipodomys sp.	1	0	0	0	0	1
Neotoma cinerea	7	1	0	0	0	8
Canis sp.	0	0	0	0	2	2
Canis latrans	2	1	2	0	21	26
Canis lupus	0	0	0	0	1	1
Vulpes vulpes	0	0	0	0	5	5
Taxidea taxus	0	0	1	0	0	1
Lynx rufus	0	1	0	0	1	2
Odocoileus cf. *hemionus*	0	0	0	0	4	4
Antilocapra americana	0	1	0	1	6	8
Bison bison	0	0	0	0	6	6
Ovis canadensis	0	15	21	3	58	97
Total burned	25	65	101	19	161	371
Total NISP	449	714	668	266	887	2984
% Burned	06	09	15	07	18	12

uted across strata, across mammalian taxa, or across elements within taxa.

Table 8 presents the matrix of chi-square values that results from comparing each Danger Cave stratum with every other Danger Cave stratum in terms of the number of burned and unburned bones that it contains. As this table shows, DI has significantly fewer burned bones than all other strata, with the exception of DIV. That the fauna of DI would be less modified by burning than that of other strata follows from the lower organic content of this stratum, composed primarily of sand. Although Jennings (1957) does not suggest that strata II through V were differentially burned, table 8 shows that significantly fewer bones and teeth have been burned in DII and DIV than in DIII and DV.

The distribution of burned specimens across taxa and across elements within taxa seems analytically intractable. I have explored the distribution of burned specimens across only *Lepus* and *Ovis,* because these taxa comprise 78.5 percent of the total provenienced, identified mammalian collection. Table 9 presents the chi-square values that result when *Lepus* is compared with *Ovis,* when *Lepus* is compared with all other mammals, and when *Ovis* is compared with all other mammals, on the basis of the number of specimens in each of these classes that are, or are not, burned (there are no values for *Ovis* in DI because there are no *Ovis* specimens in this stratum). As table 9 shows, the bones of mountain sheep are burned more often than can be accounted for by chance in

TABLE 8
Matrix of Chi-square Values: Burned Versus Unburned Bones by Danger Cave Stratum
(Underrepresented strata in parentheses)

Stratum D:	I	II	III	IV	V
I	—				
II	*4.82 (I)	—			
III	***24.48 (I)	***11.91 (II)	—		
IV	0.73	0.95	**10.81 (IV)	—	
V	***39.38 (I)	***26.71 (II)	2.50	***18.83 (IV)	—

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

TABLE 9

Chi-square Values: Burned Versus Unburned Specimens, *Lepus* and *Ovis* Compared with Each Other and With All Other Mammals, by Danger Cave Stratum

Overrepresented taxa indicated in parentheses (O = *Ovis*; L = *Lepus*; AOM = all other mammals)

Stratum	Comparison		
	Lepus—AOM	*Ovis*—AOM	*Ovis*—*Lepus*
I	***11.28 (L)	—	—
II	3.39	***16.88 (O)	***15.03 (O)
III	***9.09 (AOM)	***17.26 (O)	***16.78 (O)
IV	1.05	0.11	1.92
V	***53.58 (AOM)	***32.39 (O)	***49.74 (O)
I–V	21.37 (AOM)	***82.66 (O)	***76.19 (O)

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

all strata except DIV. *Lepus* bones are burned less often than can be accounted for by chance in DII and DIV when compared to all other mammals, but this is because such a high proportion of *Ovis* bones have been burned in those strata; in DI, in which *Ovis* is lacking, *Lepus* bones are burned more often than chance can explain.

In DI, then, a significantly high fraction of *Lepus* bones has been burned; in all other strata, more *Ovis* bones have been burned than can be accounted for by chance. Because information on the distribution of *Ovis* and *Lepus* bones within each stratum is lacking, it is not possible to account for such differential burning. It is simply not possible to know whether this burning reflects differential use of these taxa by people, differential distribution of the specimens within the site at the time the burning occurred, or even, as Jennings (1957) suggests, whether the burning occurred as a result of accidental conflagrations within the cave, or as a result of human faunal-processing activities.

TABLE 10

Numbers of Burned, Cut, and Burned and Cut *Ovis* Bones, Danger Cave

Stratum	Total *Ovis* NISP	Burned	Cut	Burned and cut
I	0	0	0	0
II	65	15	15	10
III	64	21	5	4
IV	49	3	7	2
V	176	58	23	9
I–V	354	97	50	25

If burning were the result of processing activities, it might be argued that butchering and burning should co-occur more often than could be accounted for by chance across the *Ovis* and *Lepus* specimens. However, of 2371 *Lepus* specimens, only six show cut marks. In the collection as a whole, there is a significant tendency for those *Ovis* bones that are burned to be cut as well ($\chi^2 = 14.95$, $p < 0.001$), but this value results from the situation that pertains in DII, in which burned bones tend very strongly to be cut ($\chi^2 = 17.80$, $p < 0.001$). In DIII ($\chi^2 = 3.40$, $p > 0.05$), DIV ($\chi^2 = 3.33$, $p > 0.05$), and DV ($\chi^2 = 0.45$, $p > 0.50$), burning and cut marks are independently distributed across *Ovis* specimens (table 10; because of small sample sizes, chi-square values for DII, DIII, and DIV have been corrected for continuity).

In sum, significantly more mammalian bones and teeth have been burned in DIII and DIV than in other Danger Cave strata, while *Ovis* specimens are more frequently burned than can be accounted for by chance in all strata but DIV. The heavy burning of all mammalian specimens in DIII and DIV may simply reflect the fact that these strata were more thoroughly burned than DI, DII, and DV, although such differential burning is not indicated by Jennings (1957). The differential burning of *Ovis* specimens in all strata but DIV cannot be explained without more information than is available to us on the horizontal distribution of specimens, since this phenomenon may simply reflect the differential initial deposition of *Ovis* specimens in areas of the cave that were subsequently burned. No compelling case can be made to

TABLE 11
The Distribution of Burning by Element and Stratum, Danger Cave Provenienced *Lepus* Specimens
(B = burned, UB = unburned)

| | Stratum | | | | | | | | | | | |
| | DI | | DII | | DIII | | DIV | | DV | | Totals | |
Element	B	UB	B	UB	B	UB	B	UB	B	UB	B	UB
Skull (SK)	2	13	4	31	3	37	0	16	1	66	10	163
Mandible (MD)	0	5	10	58	16	100	1	35	9	71	36	269
Teeth (TH)	4	15	0	39	3	52	0	4	0	11	7	121
Scapula (SC)	0	5	1	42	5	34	3	28	4	55	13	164
Humerus (HU)	3	14	2	44	5	33	0	8	4	22	14	121
Radius (RD)	1	4	1	79	10	50	1	10	3	22	16	165
Ulna (UL)	0	5	0	11	0	6	0	4	0	15	0	41
Metacarpals (MC)	0	2	0	0	0	0	0	0	0	1	0	3
Sternabrae (ST)	0	3	0	0	0	0	0	0	0	0	0	3
Vertebrae (VT)	4	13	0	4	0	1	0	0	0	7	4	25
Innominate (IN)	0	1	1	28	1	14	0	12	4	19	6	74
Femur (FM)	1	12	8	53	10	48	1	7	2	35	22	155
Tibia (TB)	0	14	17	125	21	110	8	40	27	147	73	436
Tarsals (TR)	0	7	2	6	2	5	1	1	2	3	7	22
Metatarsals (MT)	0	3	0	2	0	3	0	2	0	5	0	15
Phalanges (PH)	0	4	0	0	0	0	0	0	0	0	0	4
Totals	15	120	46	522	76	493	15	167	56	479	208	1781

associate differential burning of specimens across the Danger Cave strata, or of *Ovis* when compared to other taxa, with human processing activities.

BURNING: DISTRIBUTION BY ELEMENT (*Lepus* and *Ovis*)

Other intriguing perplexities are presented by the burned and unburned Danger Cave specimens, all of which pose questions that cannot be answered without more detailed contextual information than is currently at hand. If, for instance, either entire animals or parts of animals were roasted, differential burning of bone might be predicted to occur, with those elements less deeply embedded in muscle masses more heavily affected by the burning process. Fewer femora than tibiae, fewer humeri than ulnae, for instance, should be burned, or at least burned less heavily, were this the case. If, on the other hand, burning occurred after complete skeletal disarticulation, some support would be available for the argument that burning occurred long after these bones had been deposited (Jennings, 1957).

Table 11 shows the distribution of burning

across the provenienced Danger Cave *Lepus* specimens. Chi-square analysis shows that for the collection as a whole (DI–DV), elements have not been randomly burned ($\chi^2 = 27.54$, $p < 0.01$; in order to increase expected values, this analysis merged metatarsals with tarsals, metacarpals with vertebrae, and sternabrae with phalanges). Sample sizes in DI and DIV are too small to support such an element-by-element examination, but this is not the case for DII, DIII, and DV. Burning is differentially distributed across elements in both DII ($\chi^2 = 24.76$, $p < 0.01$; metatarsals merged with tarsals, and radius with ulna) and DV ($\chi^2 = 17.83$, $0.10 > p > 0.05$; tarsals and metatarsals, vertebrae and metacarpals, and radius and ulna merged), but not in DIII ($\chi^2 = 7.06$, $p > 0.50$; element classes merged as for DII).

These chi-square values show that in the provenienced *Lepus* collection as a whole, certain elements have been differentially burned. They show as well that the source of the overall significant chi-square value lies largely in DII and DV. They do not, however, shed any light on which elements have been burned more (or less) often than can be accounted for by chance. The analysis of single-

TABLE 12
Adjusted Residuals for Burned and Unburned Specimens by Element and Element Group: Provenienced Danger Cave *Lepus* Specimens
(See table 11 for key to element abbreviations)

A. Strata DI–DV Combined

	SK	MD	TH	SC	HU	RD	UL	MC/UT	IN	FM	TB	TR/MT	ST/PH
Burned	-2.10^a	0.84	-1.90	-1.41	-0.03	-0.74	-2.21^a	0.39	-0.88	-0.90	3.33^c	1.07	-0.91
Unburned	2.10^a	-0.84	1.90	1.41	0.03	0.74	2.21^a	-0.39	0.88	0.90	-3.33^c	-1.07	0.91

Element

	SK	MD	TH	SC	HU	RD/UL	MC/UT	IN	FM	TB	TR/MT
						B. Stratum DII					
Burned	0.75	2.13^a	-1.92	-1.42	-1.01	-2.66^b	-0.60	-0.93	1.53	1.95	1.39
Unburned	-0.74	-2.14^a	1.92	1.42	1.01	2.66^b	0.60	0.93	-1.54	-1.95	-1.38
						C. Stratum DIII					
Burned	-1.13	0.16	-1.81	-0.10	-0.04	0.45	-0.39	-0.77	0.92	1.03	0.62
Unburned	1.13	-0.16	1.81	0.10	0.04	-0.45	0.39	0.77	-0.92	-1.03	-0.62
						D. Stratum DV					
Burned	-2.58^b	0.24	-1.14	-0.99	0.85	-0.63	-0.98	1.10	-1.04	2.67^b	0.99
Unburned	2.59^b	-0.24	1.17	1.00	-0.85	0.63	0.98	-1.10	1.04	-2.67^b	-1.00

[a], $p < 0.05$; [b], $p < 0.01$; [c], $p < 0.001$.

cell adjusted residuals, however, provides precisely this information (see Everitt, 1977, for a discussion of single-cell adjusted residuals; the values of these residuals are read as standard normal deviates). The adjusted residuals for DI–V, DII, DIII, and DV are shown in table 12. In the collection as a whole, specimens of skull and ulna are burned less often, and those of tibia more often, than can be accounted for by chance. In DII, however, it is the combined radius/ulna category whose members are burned significantly less often than other element classes, and the mandible that is burned more often. Burning is randomly distributed across all elements in DIII, while in DV the tibia is burned more often, and the skull less often, than chance can explain.

These results are clearly not related to anatomical position. In DV, for example, the skull is burned less often than can be accounted for by chance but the mandible and isolated teeth are burned as chance would dictate. In the collection as a whole, only the skull, ulna, and tibia are burned more often than chance allows; even though the ulna is burned less often than chance allows, the radius is not. Although there is an obvious clustering effect here (one would not infer lack of differential burning in DIII from the results of the DV analysis, for example), there is no replication of differential burning of elements across Danger Cave strata. The lack of consistent patterning supports Jennings' interpretation that sheet-burning can readily account for the pattern of burning of *Lepus* elements within the site. As with the preferential burning of *Ovis* bones, more detailed contextual information—and in particular, horizontal provenience data—would seem to be required to probe the precise meaning of these patterns more fully.

Similar difficulties impede analysis of the differential burning of *Ovis* specimens, although here the problem is even more severe because of small sample sizes. Table 13 presents the distribution of burning by element for all provenienced *Ovis* bones and teeth. Merging specimens by hindlimb (femur through tarsals) and forelimb (humerus through carpals) and examining the resultant figures with either chi-square or Fisher's exact shows that fore- and hindlimbs are not differentially burned in any stratum, nor in the collection treated as a whole. Dividing those limbs into upper (humerus and femur), middle (radius, ulna, and tibia), and lower (all metapodials, tarsals, carpals, and phalanges) segments and examining those figures for the entire collection and for DV alone, the only stratum with a sufficiently large sample for analysis, shows that limb segments are not differentially burned (DI–V: $\chi^2 = 4.55$, $p > 0.10$; DV: $\chi^2 = 4.15$, $p > 0.10$). Comparing elements of the head (skull, mandible, teeth) with all other elements shows that in the collection as a whole ($\chi^2 = 8.68$, $p < 0.01$) and in DV ($\chi^2 = 5.62$, $p < 0.02$), head elements have been burned significantly less often than all other elements combined. As with the *Lepus* specimens, however, it is not possible to say why this has occurred. With this single exception, burning seems randomly distributed across body segments of *Ovis*, a pattern that is again consistent with Jennings' suggestion that sheet-burning best explains the massive ash deposits that comprise so much of the Danger Cave deposits.

Thus, approximately 12 percent of the provenienced Danger Cave mammalian bones and teeth have been burned. Although it can be demonstrated that *Ovis* bones were burned significantly more often than the bones of other taxa, that some *Lepus* elements in some strata were burned significantly more often than can be accounted for by chance, and that *Ovis* head elements were burned significantly less often than can be accounted for in this fashion, the detailed provenience information that might help address the causes of these differences is not available. Burning patterns across *Lepus* elements make sense only if burning occurred after disarticulation, and the same is largely true for *Ovis*. All these conclusions are consistent with Jennings' argument that the deposits of Danger Cave burned en masse after having accumulated to substantial depth.

ETCHING

The surfaces of approximately 5 percent (174) of the identified mammal bones from Danger Cave show patches of linear-to-wavy depressions that at times closely resemble the etching produced on bone surfaces by roots (fig. 6). The appearance of these modified sur-

TABLE 13
The Distribution of Burning by Element and Stratum: Danger Cave *Ovis*
(See table 11 for element abbreviations; B = burned; UB = unburned)

	Stratum NISP									
	II		III		IV		V		Totals	
	B	UB	B	UB	B	UB	B	UB	B	UB
SK	0	3	0	1	0	0	4	15	4	19
SHEATH	0	1	0	1	0	2	1	8	1	12
MD	1	10	1	12	0	4	6	14	8	40
TH	3	12	7	12	0	8	8	24	18	56
SC	0	0	0	1	0	1	0	4	0	6
HU	0	2	1	1	0	3	1	7	2	13
RU	1	3	0	3	0	7	8	7	9	20
MC	0	4	0	0	1	2	1	2	2	8
C	0	1	1	3	0	4	0	3	1	11
VT	0	1	0	0	0	1	4	4	4	6
IN	0	1	2	1	0	1	1	1	3	4
FE	0	0	0	1	0	1	0	0	0	2
PATELLA	0	0	0	0	0	0	0	1	0	1
TB	1	1	1	0	0	1	10	10	12	12
FIBULA	0	0	0	0	0	0	0	1	0	1
MT	5	9	4	3	1	5	4	5	14	22
T	0	0	1	1	0	1	3	4	4	6
MP	1	0	0	1	1	1	3	1	5	3
PH	3	2	3	2	0	4	4	7	10	15
Totals	15	50	21	43	3	46	58	118	97	257

faces suggests that the depressions were produced as a result of contact between the bones and plant material. This explanation gains some support from the fact that only DI failed to provide such specimens (table 14), and that DI is the only stratum in the cave characterized by an extremely low organic content. Given that the poorly lighted, dry floor of Danger Cave was not likely to have supported much rooted vegetation, what precise mechanism could have caused these apparent etchings?

It seems most likely that the Danger Cave bones were etched as they came in contact with acids associated with decomposing plants. K. T. Harper (personal commun.) has suggested to me that such acids may have been produced by fungi. Fungi can not only decompose organic matter under relatively dry conditions, but can also produce a wide variety of organic acids during the process (Griffin, 1972; Russell, 1973). A diverse set of fungal species exists in the arid western United States (States, 1978) and could have been involved in the decomposition of the Danger Cave plant material. The possibility that the etched Danger Cave bones were produced as a result of fungal activity suggests that the Danger Cave sediments be analyzed for their fungal content. Such an analysis might not only help evaluate this proposed explanation, but might also help explain the differential stratigraphic distribution of etched specimens above DI (table 14). If this distribution is related to differential fungal activity through time, the distribution itself might have paleoenvironmental significance.

DANGER CAVE, THE BIOGEOGRAPHY OF GREAT BASIN MAMMALS, AND THE LATE PLEISTOCENE HISTORY OF LAKE BONNEVILLE

Table 15 displays the absolute and relative abundances of six taxa of mammals across the five Danger Cave strata. Although the samples are small, and the bias against the collection of small mammals as a result of the screening procedures employed is evident, these numbers provide significant in-

Fig. 6.   Etched bones from Danger Cave (**a,** DC-98; **b,** DC-98; **c,** UU 22961/3).

formation on the history of small mammals in this part of the Great Basin. In addition, they appear to shed light on the late Pleistocene history of Lake Bonneville.

THE DI/DII FAUNAL SHIFT

DI contains the only mammalian assemblage in the site with significant numbers of mesic-adapted mammals. Marmots do not currently exist in the Wendover area, yet marmot bones and teeth comprise 4 percent of the DI mammalian collection (17 specimens); the Holocene assemblages lack marmots. A full 25 percent (110 specimens) of the DI mammalian fauna was contributed by bushy-tailed wood rats, after which time their

TABLE 14
The Number of Etched Bones by Taxon and Stratum at Danger Cave

Taxon	Stratum						Totals
	I	II	III	IV	V	NP	
Lepus sp.	0	109	6	4	11	28	158
Canis latrans	0	0	0	0	1	0	1
Lynx cf. *rufus*	0	2	0	0	0	0	2
Odocoileus cf. *hemionus*	0	0	0	0	1	0	1
Antilocapra americana	0	1	0	0	0	0	1
Ovis canadensis	0	10	0	1	0	0	11
Totals	0	122	6	5	13	28	174
Total mammal NISP	449	714	668	266	887	529	3513
% etched	00	17	01	02	02	05	05

TABLE 15
Abundances of Selected Mammalian Taxa by Stratum at Danger Cave
(*Lepus* sp. includes *L. californicus*)

Taxon	Stratum (NISP, %)									
	I		II		III		IV		V	
Sylvilagus sp. (large)	81	18	20	03	5	01	3	01	21	02
S. idahoensis	35	08	1	00	0	00	0	00	1	00
Lepus sp.	135	30	568	80	569	85	182	68	535	60
Marmota flaviventris	17	04	0	00	0	00	0	00	0	00
Neotoma lepida	8	02	6	01	1	00	3	01	27	03
Neotoma cinerea	110	25	15	02	3	01	0	00	3	00
All others	63	14	104	15	90	14	78	29	300	34
Totals	449	101%	714	101%	668	101%	266	99%	887	99%

numbers dropped rapidly. Bushy-tailed wood rats do not appear to exist in the Silver Island Mountains; the closest populations may be in the Pilot Range to the immediate northwest. Although relatively little is known about the ecology of pygmy rabbits, what is known documents that they prefer dense stands of tall sagebrush (Weiss and Verts, 1984), a habitat that does not exist in the vicinity of Danger Cave today. In DI, however, 8 percent (35 specimens) of the mammalian assemblage was contributed by pygmy rabbits; during the subsequent 10,000 years represented in these deposits, only two pygmy rabbit specimens were added to the sample. Although I have little knowledge of the mechanisms that accumulated the Danger Cave fauna, there seems little reason to doubt that during the time the fauna of DI was being deposited, populations of yellow-bellied marmots, bushy-tailed wood rats, and pygmy rabbits lived nearby, and that the size of these populations was greatly diminished by the time the deposition of DII began.

In short, the DI mammalian fauna suggests that relatively mesic environments occurred in the vicinity of the site between 11,000 and 10,000 B.P., environments that seem to have been replaced by relatively xeric ones by DII times. Unfortunately, with the possible exception of the Sage Grouse material, the very small avian sample from Danger Cave does not seem to shed much light on this period of time (see chap. 2). Although the relatively large numbers of waterfowl in DI and DII (26 of 87, and 28 of 30 specimens, respectively) suggest locally available mesic habitats, in fact most of these birds are *Anas* and may

indicate no more than ephemeral ponding. The relatively high numbers of Sage Grouse in DI are of interest. Of the 37 specimens of both *Centrocercus urophasianus* and cf. *C. urophasianus* from DI, 30 came from Feature 114, 4 from Feature 113, and 1 from Feature 108; the remaining 2 cannot be given more precise provenience. As I have noted in my discussion of the marmot material, Features 113 and 114 are within sand 2, and bones within these features are not likely to represent human transport. The same cannot be said for Feature 108, which is one of the six hearths built on the surface of sand 2; the fragmentary sacrum of cf. *Centrocercus urophasianus* (UU-23345; DC-24) that came from this feature may well reflect human activities. Clearly, though, the bulk of the DI Sage Grouse specimens represents local populations of these birds. Although the very small avian sample does not inspire confidence, the decline in abundance of Sage Grouse from DI (in which they comprise 38% of the avian assemblage) to DII (7% of the assemblage) correlates well with the decline of pygmy rabbits at this time. Together, these decreases suggest a substantial loss of sagebrush habitat in the area at about 10,000 B.P.

I have noted that Scott et al. (1983) argue that Lake Bonneville began to retreat from the Provo level sometime before, but not long before, 13,000 B.P., and had retreated to essentially modern levels by 11,000 years ago. They concur with Currey (1980) that during the past 11,000 years, Lake Bonneville has reached no higher than the Gilbert shoreline. At Danger Cave, this shoreline is at 1294 m, or 20 m beneath the cave itself (Eardley et

al., 1957: 1169). Currey and his colleagues (Currey, 1980; Currey et al., 1884; Currey and Oviatt, 1985) argue that the Gilbert shoreline was occupied between 11,000 and 10,000 B.P., but not after that time, a view which is opposed to that taken by Spencer et al. (1984).

Spencer et al. (1984) argue that Lake Bonneville had reached the extremely low level of ca. 1275 m, 5 m beneath its historic average, by 14,500 B.P., and that it has exceeded its historic level for only two brief intervals since this time: at ca. 3500 and 2300 B.P., when it rose to between 1290 m and 1295 m. In short, Spencer et al. (1984) maintain that Lake Bonneville was at or beneath historic levels during DI times.

While the Danger Cave mammals tell us nothing directly about Lake Bonneville levels, they certainly do suggest that the period of time between about 11,000 and 10,000 years ago was significantly more mesic here than any time after. Insofar as such conditions were caused by altered precipitation/evaporation ratios and are thus related to lake levels, the Danger Cave mammal data are consistent only with the Currey (1980), Scott et al. (1983), Currey et al. (1984), and Currey and Oviatt (1985) sequences, which allow occupation of the Gilbert shoreline after 11,000 B.P. They are inconsistent with the sequence forwarded by Spencer et al. (1984), which does not allow the Gilbert level to be occupied between 14,500 and 8000 B.P.

BIOGEOGRAPHIC COMMENTS

The DII through DIV mammalian assemblages are less instructive, and I note here only the domination of the DII and DIII assemblages by Lepus sp. Lepus californicus, the only jackrabbit demonstrably present in the collection, prefers open vegetation and is well-adapted to xeric habitats. It is thus not surprising that this species is the most widespread lagomorph in Utah (Durrant, 1952). It is reasonable to infer from the decrease in Sylvilagus idahoensis and the increase in Lepus sp. from DI to DII that a corresponding shift from closed to open vegetation occurred at this time. It is, however, slightly more difficult to account for the extremely high abundance of Lepus in the early Holocene (DII and DIII) deposits of Danger Cave.

At both the Connley Caves (Fort Rock Basin, southcentral Oregon) and Gatecliff Shelter (Toquima Range, central Nevada), early and middle Holocene deposits were characterized by higher relative abundances of Lepus than were later deposits (Grayson, 1979, 1983), just as occurs at Danger Cave. No such shift occurs at O'Malley Shelter in southeastern Nevada (Fowler et al., 1973), nor is it seen at Hogup Cave, located in the central Bonneville Basin, some 65 km east of Danger Cave (Aikens, 1970). Although Hidden Cave (southern Carson Desert, western Nevada) provided a deep, stratified sequence of small mammals, correlations between relative abundances of Lepus and sample size obscure the interpretation of those abundances (Grayson, 1985). It seems unlikely that correlated changes in the abundance of Lepus in the Connley Caves, Gatecliff Shelter, and Danger Cave, all located in, or on the fringes of, the sagebrush vegetation zone (Cronquist et al., 1972), are accidental, although a satisfactory explanation for this phenomenon has yet to be advanced (see Grayson, 1987).

Even though Danger Cave does not stand alone in showing higher frequencies of Lepus during the first half of the Holocene than during later times, it does stand alone in having earlier Holocene mammalian assemblages that are almost nothing but Lepus. Table 16, taken from Harper and Alder (1970), and Durrant (1970), presents relative abundances of Lepus sp. through time at Hogup Cave, employing the five stratigraphic groups used by Harper and Alder (1970) in their analysis. Since I have observed elsewhere that certain aspects of the Harper and Alder (1970) analysis are clouded by sample-size problems (Grayson, 1984), I note here that the relationship between the relative abundance of Lepus and the total number of mammalian individuals per stratigraphic group at Hogup Cave is not significant (Spearman's rho = 0.10, $p > 0.50$). Unlike the situation at Danger Cave, in which Holocene relative abundances of Lepus range from 60 to 85 percent, relative abundances of Lepus at Hogup Cave range from 34 to 67 percent. Although these abundances are not strictly comparable because my analysis has used numbers of identified specimens (NISP) while the Hogup analysis used minimum numbers of individ-

TABLE 16
Hogup Cave *Lepus*
(From Harper and Alder, 1970; Durrant, 1970)

Stratum	Beginning date (B.P.)	*Lepus* MNI	%
15–16	600	37	44
12–14	1550	202	67
9–11	3200	129	43
4–8	7800	1251	56
1–3	8350	150	34

TABLE 17
Hogup Cave Mammals, Species Smaller than
Neotoma Removed

Stratum	Total MNI	Total *Lepus* (MNI)	% *Lepus*
15–16	66	37	56
12–14	268	202	75
9–11	260	129	50
4–8	1735	1251	72
1–3	296	150	51
Totals	2625	1769	67

uals (MNI), the difference clearly reflects differences in assemblage composition. At Hogup, for instance, there is a total of at least 3376 individual mammals of known provenience in the deposits, of which 1769, or 52 percent, are *Lepus*. At Danger Cave, of 2984 provenienced identified specimens, 1989, or 67 percent, are *Lepus*.

The difference between the two collections in terms of the abundance of *Lepus*, then, is real, but rather than reflecting either the mechanisms that accumulated the faunas or the environments in which the sites are located, it would appear that much of the difference reflects collection techniques. A glance at table 2 shows that there are almost no very small mammals in the Danger Cave collection. There is only one specimen of *Microtus*, for instance, and both *Peromyscus* and *Spermophilus* are unrepresented. However, the analysis conducted by Harper and Alder (1972) demonstrates that small mammals were not lacking in these sediments: their faunal list includes the deer mouse *Peromyscus maniculatus*, the antelope ground squirrel *Ammospermophilus leucurus*, and a diverse set of other small mammals. The Danger Cave deposits contained small mammals in abundance, but the 1949–1953 collections from the site do not. In addition, the Hogup Cave fauna, collected with ¼ in. (0.64 cm) screen, includes large numbers of specimens from very small mammals (see Durrant, 1970). These differences are surely due to differences in collection techniques.

If the Hogup and Danger Cave *Lepus* abundances are to be compared, then, it would seem that such a comparison must somehow take into account the apparent collection bias evident in the Danger Cave assemblage. This I have done by eliminating from consider-

ation all mammals smaller than *Neotoma* that are in the Hogup collection. Table 17 shows the increase in the relative abundances of *Lepus* that result from this elimination, but more important is the fact that *Lepus* now forms 67 percent of the Hogup collection taken as a whole, the same proportion it forms at Danger Cave. It would appear that the very high relative abundances of *Lepus* at Danger Cave are largely a result of collection bias against very small mammals.

In sum, the general pattern presented by the relative abundances of *Lepus* through time at Danger Cave, with higher abundances during early and middle Holocene times than late in the Holocene, is matched by the record provided by the Connley Caves and Gatecliff Shelter. However, the extreme abundances of *Lepus* throughout the Holocene sequence presented by this site seem to be in large part a function of collection bias. If jackrabbits were, indeed, generally more abundant during the earlier millennia of the Holocene than during later ones in and near the sagebrush vegetation zone of the Great Basin, as appears very likely, the phenomenon remains unexplained.

The history of pygmy rabbits has become better understood during the past decade. During the Pleistocene, these rabbits occurred as far south as central New Mexico (Harris, 1985). Today, they are confined to the northern two-thirds of the Great Basin and the southern reaches of the Columbia Plateau, although an isolated set of populations exists in southcentral Washington state. Elsewhere, I have suggested that pygmy rabbits may have retreated from the southwest during late Pleistocene or early Holocene

times (Grayson, 1983, 1987). I have also not-
ed that the original observation made by But-
ler (1972) of higher abundances of *Sylvilagus
idahoensis* during the first few thousand years
of the Holocene than during later times has
been confirmed at both Gatecliff Shelter and
the Connley Caves. In this context, it is of
importance to recall the sharp decrease in *S.
idahoensis* specimens from DI to DII in Dan-
ger Cave. This decrease strongly suggests
higher late Pleistocene than Holocene abun-
dances of pygmy rabbits in this area. Since
these are the first demonstrable Pleistocene-
age pygmy rabbits from the Great Basin of
which I am aware (the earliest specimens from
the Connley Caves may be Holocene in age),
there is no opportunity to compare this de-
crease to that which may have occurred in
other areas. However, this shift does raise the
strong possibility that pygmy rabbits have
undergone two decreases in abundance in the
arid west during the past 12,000 years or so:
one at the Pleistocene/Holocene boundary,
ca. 10,000 B.P., and a second, originally ob-
served by Butler (1972), during the middle
Holocene. The correlated decline of Sage
Grouse at both Danger Cave and the Connley
Caves (Grayson, 1979) suggests that these de-
creases in abundance may have been tightly
linked to decreases in available sagebrush
(*Artemisia tridentata*) habitat. Implications
for the management of modern populations
of pygmy rabbits seem clear.

Finally, I observe that the presence of both
marmots and bushy-tailed wood rats in the
sediments of Danger Cave is in line with one
of the predictions of J. H. Brown's hypothesis
that boreal mammals reached Great Basin
mountains during the Pleistocene, only to be-
come isolated on these mountains and then
differentially extinct across them (Brown,
1971, 1978; see Grayson, 1987, for a review
of the paleontological evidence that now sup-
ports this hypothesis). Brown's model pre-
dicts that the boreal mammals involved, in-
cluding marmots and bushy-tailed wood rats,
must once have been present in the inter-
vening lowlands, since those lowlands pro-
vided access to the mountains during the
Pleistocene. Several years ago (Grayson,
1982b), I noted that the only known extra-
limital record for marmots within their gen-
eral distributional range was provided by

Hidden Cave (Grayson, 1985), which docu-
ments local marmot populations on Eetza
Mountain in the southern Carson Sink until
very late Holocene times, after which they
became locally extinct. I also observed that
"if Brown's hypothesis is correct, further low
elevation records for marmots in areas in
which they no longer occur, but within the
boundaries of their modern general distri-
bution, should be forthcoming" (Grayson,
1982b: 90–91). Danger Cave provides just
such a record, documenting marmots in the
vicinity of Danger Cave during late Pleisto-
cene times, and suggesting that their extir-
pation from this region may have occurred
at about 10,000 B.P. Hogup Cave (Durrant,
1970) also provided records for marmots.
Here, strata 1–5, 6–7, and 10 (ca. 8400–2600
B.P.) contain small numbers of marmots. This
sample is sufficiently small (a total minimum
number of 15 individuals across all eight
strata), and the deposits of Hogup sufficiently
complex, that it would not appear to shed
very detailed light on the history of marmots
in the Hogup Mountain area. However, mar-
mots do not exist here today; indeed, they
are unknown from any isolated mountain
range within the Bonneville Basin. Unless
they represent transport by people, the Ho-
gup Cave marmots also provide a low ele-
vation record for marmots in an area in which
they no longer exist. The Hogup Cave data
suggest that, if transport by people is not in-
volved, marmots survived in the Hogup
Mountains well into the Holocene.

CONCLUSIONS

Although the faunal assemblage reported
here was excavated over 30 years ago, the
care with which those excavations were done
and the excellent curation which the material
has received since that time have allowed the
extraction of information that sheds signifi-
cant light on several aspects of environmental
history in the Great Basin. The Danger Cave
fauna supports the argument that Lake
Bonneville occupied the Gilbert shoreline be-
tween 11,000 and 10,000 years ago (e.g., Cur-
rey, 1980; Currey et al., 1984; Currey and
Oviatt, 1985), and suggests that the alterna-
tive picture painted by Spencer et al. (1984)
is not correct. In addition, the site has pro-
vided the first evidence that pygmy rabbits

may have undergone two major decreases in abundance since terminal Pleistocene times, one at about 10,000 B.P., and one, known from other sites, at about 7000 B.P. Although the avian fauna is very small (see chap. 2), the decrease in pygmy rabbit abundance at the end of DI times appears to have been accompanied by a decrease in the local abundance of Sage Grouse, suggesting a decrease in the abundance of nearby sagebrush habitat. The fauna also documents that both marmots and bushy-tailed wood rats once occupied this area, meeting a prediction of J. H. Brown's biogeographic model. Marmots may have become extinct here at about 10,000 B.P., while bushy-tailed wood rats appear to have survived into the Holocene.

Because I have little information on the mechanisms that accumulated the vertebrate remains in Danger Cave, I have added little to purely archaeological knowledge of that fauna. My analysis of the burned mammalian bone is consistent with Jennings' argument that the deposits of the site were burned en masse after having accumulated to a substantial depth. In addition, I hope I have added to an understanding of the environmental context in which the people who occupied Danger Cave lived.

2. AVIAN REMAINS FROM DANGER CAVE

PAUL W. PARMALEE

Approximately 290 bird bone specimens were examined during this study, 72 percent of which came from strata DI and DII. At least 26 species were represented (table 18); 43 percent of the elements identified to at least ordinal level were those of waterfowl and 33 percent were grouse. For the most part avian bone specimens were well preserved, but, because a large percentage of them were either incomplete and/or abraded, identification to the species and often generic levels (especially in the case of waterfowl) could not be made. Nearly 12 percent of the avian bone specimens exhibited some degree of calcination, but no pattern as to specific bone was discernible. Except for cuts on the neck region of a goose scapula, no butchering or other processing marks were apparent on any of the bones examined. Only one bird bone from the assemblage showed evidence of having been modified: this specimen, from stratum DIII, consisted of a proximal shaft fragment of a right ulna from a bird the size of a Snow Goose (*Chen caerulescens*) that had been scraped and the proximal end removed by the "groove and snap" technique. From descriptions and illustrations presented by Jennings (1957, figs. 176–186), awls and other bone tools and utensils recovered at Danger Cave had all been fashioned from mammal bone. The cave inhabitants had little interest in bird bone as raw material for the manufacture of implements.

"Since birds are among the most mobile of vertebrates, it is difficult to define many of them in terms of their confinement to any special community" (Hayward et al., 1976: 25). Because they are nonmigratory, local populations of grouse inhabiting the surrounding desert shrublands would have provided the Danger Cave inhabitants with a continually available food resource. Although some nesting undoubtedly took place along isolated lakes and ponds (remnants of Lake Bonneville?) or in the Great Salt Lake environs, hunting spring and fall concentrations of migrating waterfowl probably would have realized the greatest return for the energy expended. As a group, waterfowl, es-pecially ducks, appear to have been a valued food resource and were probably hunted whenever available. Feathers of ducks were the most numerous of those in the series reported by Sperry (1957a) from Danger Cave.

In addition to the taxa represented osteologically in Danger Cave, four others (Mallard, Gadwall, Bald Eagle [*Haliaeetus leucocephalus*], and Horned Lark) and three questionable species (Snow Goose, Common Barn Owl [*Tyto alba*], and Northern Saw-whet Owl [*Aegolius acadicus*]) were identified by Sperry (1957a) from feathers. Although there is no question that birds played a role in the food economy of the Danger Cave inhabitants, and in some instances served other purposes ("duck skin with down in place . . . cut into strips and twisted into cord" [Jennings, 1957: 306]), compared with mammals they appear to have been possibly of only seasonal and generally minor importance.

DESCRIPTIVE SUMMRY

Class Aves
Order Podicipediformes—Grebes
Family Podicipedidae—Grebes
Podiceps nigricollis—Eared Grebe

Material: Right humerus (missing proximal end), distal left tibiotarsus: 2 specimens; Minimum number of individuals (MNI), 1.

Remarks: The most abundant grebe in Utah, the Eared Grebe breeds throughout the state in suitable habitat, including the marshes that fringe the Great Salt Lake. Although only occasionally present in the Great Salt Lake area during the winter, individuals may be present year-round in the Great Basin section of Utah (Behle, 1958; Behle and Perry, 1975; Hayward et al., 1976; unless otherwise noted, the information on the modern distribution of birds in Utah presented here is taken from these sources). At Sandwich Shelter, an Archaic site located along the southwestern edge of the Great Salt Lake, 287 elements of *P. nigricollis,* representing 46 individuals, were identified from the avian bone assemblage (Parmalee, 1980). Although

TABLE 18
Numbers of Identified Avian Specimens per Taxon by Stratum at Danger Cave

Taxon	Stratum						Totals
	I	II	III	IV	V	NP	
Podiceps nigricollis	2	—	—	—	—	—	2
Nycticorax nycticorax	—	—	—	—	—	1	1
cf. *Branta canadensis*	—	—	—	—	1	—	1
cf. *Anas crecca*	—	4	—	—	—	—	4
Anas crecca	1	3	—	2	—	—	6
Anas cf. *acuta*	1	—	—	—	—	—	1
Anas cf. *cyanoptera*	—	—	1	—	—	—	1
Anas sp.	9	1	—	—	2	9	21
Aythya collaris and/or *A. affinis*	3	—	—	—	—	—	3
Bucephala albeola	—	1	—	—	—	—	1
cf. *Lophodytes cucullatus*	1	—	—	—	—	—	1
Anatinae, gen. and sp. indet.	11	9	3	—	1	6	30
Circus cyaneus	—	—	—	—	—	2	2
cf. *Aquila chrysaetos*	—	1	—	1	2	2	6
Accipitrinae, gen. and sp. indet.	—	—	—	—	1	—	1
Falco sparverius	—	1	—	—	—	—	1
Falco mexicanus	2	—	—	—	—	—	2
cf. *Centrocercus urophasianus*	13	1	—	—	1	—	15
Centrocercus urophasianus	25	1	—	—	—	4	30
cf. *Tympanuchus phasianellus*	1	—	—	—	—	—	1
Tetraoninae, gen. and sp. indet.	6	2	—	—	—	—	8
Fulica americana		1	—	—	—	1	2
?*Recurvirostra americana*	1	—	—	—	—	—	1
Calidris minutilla	1	—	—	—	—	—	1
Larus spp.	1	1	—	—	—	1	3
Asio otus and/or *A. flammeus*	1	1	—	—	—	—	2
Colaptes auratus	—	—	—	—	—	1	1
Pica pica	1	—	—	—	—	—	1
Bombycilla garrulus	—	3	—	—	—	—	3
Passerines, gen. and sp. indet.	8	—	—	—	—	—	8
Totals	88	30	4	3	8	27	160
Indet. bird bone specimens	72	17	9	5	13	10	126

grebe remains have been reported from other Great Basin sites, they are rarely numerous.

Order Ciconiiformes—Herons, Ibises,
Storks, and Allies
Family Ardeidae—Bitterns and Herons
Nycticorax nycticorax—Black-crowned
Night Heron

Material: Proximal right humerus: 1 specimen; MNI, 1.

Remarks: Although incomplete, this specimen compares closely with *Nycticorax nycticorax,* a common breeding bird along the marshes of the Great Salt Lake with occasional records throughout the year. Remains of Black-crowned Night Herons, and of five

other ardeids, have been identified from a series of sites located along the Great Salt Lake (Parmalee, 1980).

Order Anseriformes—Swans,
Geese, and Ducks
Family Anatidae—Swans,
Geese, and Ducks
cf. *Branta canadensis*—Canada Goose

Material: Fragmentary left scapula: 1 specimen; MNI, 1.

Remarks: Massive size, the shape of the pneumatic foramen, and the position of the coracoidal articulation permit species-level identification of this specimen with some certainty. *B. c. moffitti* is the common breeding

resident of Great Salt Lake, but four subspecies of Canada Goose are known from the state, with western Utah records available for all seasons of the year. This scapula, from stratum DV, is the only goose element present in the sample, and is also the only element from the Danger Cave avifauna exhibiting butchering cuts. Several distinct scored marks, nearly perpendicular to the long axis of the blade, occurred on the dorsal surface in the neck region. These cuts were probably inflicted during the attempt to remove the left wing by severing the head of the humerus from its point of articulation with the scapula, coracoid, and furculum. In the approximately 5050 bird bones recovered from 5 Archaic and 11 Fremont sites in northern and western Utah, remains of the Canada and Snow geese comprised 21 percent of the total (Parmalee, 1980). Although ducks appear to have been hunted with some success by the Danger Cave inhabitants, geese, for whatever reason, were rarely taken.

Anas sp. — Dabbling Ducks

Material: Proximal right humerus, distal right humerus, proximal left humerus, distal left humerus, fragmentary right radius, right carpometacarpus shaft, distal left carpometacarpus, 10 sterna fragments, distal right coracoid, distal left coracoid, distal left tibiotarsus, complete left tarsometatarsus: 21 specimens; MNI, 10.

Remarks: Although these specimens could be identified to the generic level, they lack diagnostic characters that would support assignment to species. All fall within the size range of Gadwall (*A. strepera*), Northern Shoveler (*A. clypeata*), and American Wigeon (*A. americana*); females of such species as the Northern Pintail (*A. acuta*) and Mallard (*A. platyrhynchos*) cannot be excluded from this group. All are common summer residents in suitable lakes and marshes throughout the state, and all may be found here in winter. Feathers from both the Mallard and Gadwall were reported from Danger Cave by Sperry (1957a).

cf. Anas crecca — Green-winged Teal

Material: Proximal left humerus, proximal right humerus, nearly complete right humerus,

complete right radius, proximal left ulna, fragmentary sternum: 6 specimens; MNI, 2.

Anas crecca — Green-winged Teal

Material: 2 proximal right humeri, 2 complete right humeri, proximal left humerus, distal left coracoid with proximal scapula articulated: 6 specimens; MNI, 4.

Remarks: The Green-winged Teal is a common migrant in Utah, but may be present year-round. This small teal was the secondmost abundant of the ducks in the faunas of Hogup Cave (Parmalee, 1970) and the Levee Site (Parmalee, 1979a), both located along the margins of Great Salt Lake.

Anas cf. acuta — Northern Pintail

Material: Left tarsometatarsus: 1 specimen; MNI, 1.

Remarks: The Northern Pintail can be found throughout the year in suitable habitat in western Utah, and may be the most abundant duck in Utah during migration. Northern Pintail remains have been reported from a number of archaeological sites along the margins of the Great Salt Lake (Parmalee, 1979a, 1980), but always in low numbers, perhaps because of the difficulty of identifying incomplete specimens that fall within the Gadwall/Wigeon/Northern Pintail size range.

Anas cf. cyanoptera — Cinnamon Teal

Material: Proximal left humerus: 1 specimen; MNI, 1.

Remarks: Although this incomplete humerus compares closely with *A. cyanoptera*, it is too fragmentary to support secure identification to the species level. Close osteological similarities between this teal and the Blue-winged Teal, *A. discors*, make species determinations tenuous even when complete elements are available. Both Cinnamon and Blue-winged Teal may be found in suitable wetlands during all seasons of the year, but Cinnamon Teal is by far the more common of the two.

Aythya collaris and/or
A. affinis — Ring-necked Duck
and/or Lesser Scaup

Material: Right carpometacarpus (missing distal end), distal right coracoid, complete right coracoid: 3 specimens; MNI, 2.

Remarks: Both *A. collaris* and *A. affinis* are present in northern Utah from spring through fall, although the Lesser Scaup is by far the more common of the two. One or both of these "diving" ducks has been identified from several archaeological sites located along the margins of the Great Salt Lake: 44 elements occurred in the avian assemblage from the Levee Site (Parmalee, 1979a).

Bucephala albeola — Bufflehead

Material: Fragmentary right coracoid: 1 specimen; MNI = 1.

Remarks: At times a common migrant in Utah, the Bufflehead is also present in small numbers in summer and winter; remains of this duck are routinely scarce in archaeological sites in and along the Bonneville Basin (e.g., Parmalee, 1979a, 1980).

cf. *Lophodytes cucullatus* — Hooded Merganser

Material: Distal left humerus: 1 specimen; MNI, 1.

Remarks: Hooded Mergansers are uncommon migrants in western Utah, and may also be present in small numbers during the winter.

Anatinae — Ducks, genus and species indet.

Material: Cranial fragment, left articular, fragmentary premaxilla, proximal right humerus, right humerus shaft, left radius shaft, 2 proximal right ulnae, right carpometacarpus shaft, proximal left carpometacarpus, phalanx I, 2 sternal fragments, 2 proximal left coracoids, 2 distal left coracoids, right coracoid shaft, 2 fragmentary right coracoids, 2 fragmentary furculae, proximal right femur, complete right tibiotarsus, left tibiotarsus shaft, right tibiotarsus shaft, complete left tarsometatarsus, right tarsometatarsus shaft: 30 specimens.

Remarks: The relatively substantial number of specimens of this subfamily in the Danger Cave collection matches the report provided by Sperry (1957a) of numerous "duck" feathers retrieved during the excavations.

Order Falconiformes — Diurnal Birds of Prey
Family Accipitridae — Kites, Eagles, Hawks, and Allies
Circus cyaneus — Northern Harrier

Material: Distal left ulna, left tarsometatarsus (missing proximal end): 2 specimens; MNI, 1.

Remarks: A distal end fragment of a left humerus, consisting only of the entepicondylar prominence and part of the internal condyle, may also be referable to this species. The Northern Harrier is a common resident throughout much of the Great Basin (Ryser, 1985); Hayward et al. (1976) note that 19th-century observations imply that this bird was common to abundant in the eastern parts of the Bonneville Basin.

cf. *Aquila chrysaetos* — Golden Eagle

Material: Frontal, right humerus shaft, left humerus shaft, 2 left femur shafts, left tibiotarsus shaft: 6 specimens; MNI, 2.

Remarks: In addition to the six fragmentary specimens of this common permanent resident of Utah identified from the avian assemblage, Sperry (1957a) reported Golden Eagle feathers from strata DII, DIII, and DIV. It is possible that this bird was of considerable symbolic significance and was especially prized for its feathers and certain body parts.

Accipitrinae, genus and sp. indet. — Hawk

Material: Fragmentary furculum: 1 specimen; MNI, 1.

Remarks: Sperry (1957a: 305–306) reported 24 "hawk" and "hawk?" feathers from the deposits of Danger Cave.

Family Falconidae — Caracaras and Falcons
Falco sparverius — American Kestrel

Material: Complete right ulna: 1 specimen; MNI, 1.

Falco mexicanus — Prairie Falcon

Material: Distal right radius, right tarsometatarsus: 2 specimens.

Remarks: A burned distal half of a right ulna, missing parts of the external and inter-

nal condyles, may also be referable to *F. mex-icanus.* Both the American Kestrel and the Prairie Falcon are common permanent residents of Utah; remains of both birds have been reported from several archaeological sites in Utah (e.g., Parmalee, 1970, 1980), but always in small numbers.

Order Galliformes—Gallinaceous Birds
Family Phasianidae—Partridges, Grouse,
Turkeys, and Quail
cf. *Centrocercus urophasianus*—Sage
Grouse

Material: Quadrate, fragmentary proximal left humerus, right radius (missing distal end), right ulna shaft, right carpometacarpus (missing distal end), phalanx I, fragmentary sternum, distal left coracoid, proximal left scapula, fragmentary synsacrum, distal left femur, proximal right tibiotarsus, distal right tibiotarsus, distal left tibiotarsus, right tarsometatarsus shaft: 15 specimens.

Centrocercus urophasianus—Sage Grouse

Material: Lower mandible fragment, 4 proximal right humeri, proximal left humerus, distal left humerus, proximal half right radius, distal half right radius, distal half right ulna, right carpometacarpus (missing distal end), left carpometacarpus (missing distal end), 2 first phalanges, 5 distal right coracoids, distal left coracoid, proximal left coracoid, proximal right scapula, right femur (missing proximal end), proximal right femur, distal half left femur, proximal left femur, distal right tibiotarsus, complete left tibiotarsus, complete right tarsometatarsus, left tarsometatarsus (missing proximal end): 30 specimens; MNI, 5.
Remarks: Once an abundant and widespread bird throughout the sagebrush and grassy shrublands of the Great Basin, the Sage Grouse was probably valued as a food species by aboriginal groups occupying the region. Remains of Sage Grouse have been reported from nine other Utah sites (Parmalee, 1970, 1980). In addition to the 45 osteological specimens referred to this species from Danger Cave, Sperry (1957a: 305) reported a single feather of this species ("probably sage") from DIII.

cf. *Tympanuchus phasianellus*—
Sharp-tailed Grouse

Material: Distal left coracoid: 1 specimen; MNI, 1.
Remarks: Although now greatly reduced in numbers, Sharp-tailed Grouse were at one time widespread throughout northern and central Utah in suitable sagebrush and grassland habitats. In addition to the coracoid tentatively referred to Sharp-tailed Grouse, a single feather, lacking provenience, is from this species. Remains of Sharp-tailed Grouse occurred in eight of the 16 Archaic and Fremont faunas reported by Parmalee (1980).

Tetraoninae—Grouse, genus and sp. indet.

Material: Fragmentary premaxilla, left ulna shaft, proximal half right coracoid, 2 proximal right femora, proximal left femur, distal left femur, left tarsometatarsus shaft: 8 specimens.

Order Gruiformes—Cranes,
Rails, and Allies
Family Rallidae—Rails,
Gallinules, and Coots
Fulica americana—American Coot

Material: Right humerus (missing proximal end), left femur shaft: 2 specimens; MNI, 1.
Remarks: The American Coot is, as Hayward et al. (1976) note, abundant in Utah in the vicinity of ponds, lakes, and marshes, both during the breeding season and during migration. Given the relative abundance of other waterbirds in the Danger Cave faunal assemblage, it is somewhat surprising that this bird was not more abundant in the collection. In the eastern Bonneville Basin, both the Bear River No. 3 and Levee sites provided relatively substantial numbers of specimens of this bird, but both sites are located along the Bear River marshes, where the American Coot often occurs in large concentrations (Parmalee, 1980).

Order Charadriiformes—Shorebirds,
Gulls, Auks, and Allies
Family Recurvirostridae—Stilts
and Avocets
?*Recurvirostra americana*—American
Avocet

Material: Right humerus shaft: 1 specimen; MNI, 1.

Remarks: Because of its fragmentary condition, this specimen can be referred only very tentatively to *R. americana.* A common breeding species in the marshes of the northern part of the state, small numbers of American Avocets winter in western Utah as well. Avocets have been reported from the deposits of Hogup Cave and from six other sites in Great Salt Lake area; at one of these sites, Levee, five individuals were represented (Parmalee, 1970, 1980).

Family Scolopacidae—Sandpipers,
Phalaropes, and Allies
Calidris minutilla—Least Sandpiper

Material: Right humerus: 1 specimen; MNI, 1.

Remarks: Least Sandpipers may be seen in western Utah in any month of the year, but are most common during migration.

Larus spp.—Gulls

Material: Proximal right humerus, proximal left humerus, right ulna (missing proximal end): 3 specimens; MNI, 2.

Remarks: Osteological similarities among gulls of similar size, plus related problems resulting from incomplete elements, made species determinations of *Larus* remains from Danger Cave tenuous. The proximal humeri compare most favorably with Franklin's Gull, *Larus pipixcan,* a common summer resident in parts of the Bonneville Basin. The right ulna is from a larger species. Indeterminate species of gulls have also been reported from seven archaeological sites in the vicinity of Great Salt Lake. Four elements of California Gull (*L.* cf. *californicus*) have been reported from Deadman Cave, at the southern end of Great Salt Lake, and one from Hogup Cave (Parmalee, 1970, 1980).

Order Strigiformes—Owls
Family Strigidae—Typical Owls
Asio otus and/or *A. flammeus*—Long-eared
Owl and/or Short-eared Owl

Material: Fragmentary sternum, proximal left humerus: 2 specimens; MNI, 1.

Remarks: Emslie (1982) has noted that the Long-eared and Short-eared Owls appear to be indistinguishable by bone morphology alone. Although differences in length, and to a lesser extent breadth, of complete wing elements will enable separation of the two species, the Danger Cave *Asio* specimens will not support such an analysis. Short-eared Owls are common residents of northern and central Utah, especially near marshes and other wetlands; Long-eared Owls are common in riparian and pinyon-juniper woodlands throughout the state. Remains of either or both species were recovered at Hogup Cave (Parmalee, 1970) and in seven of 16 Archaic and Fremont assemblages analyzed by Parmalee (1980).

Order Piciformes—Woodpeckers
and Allies
Family Picidae—Woodpeckers and Allies
Colaptes auratus—Northern Flicker

Material: Right ulna shaft: 1 specimen; MNI, 1.

Remarks: Northern Flickers are common residents throughout the state. As a group, these birds appear to have been of special significance to the aboriginal peoples in most regions of North America. Although not numerous at any one site, osteological remains and feathers of the Northern Flicker have been reported by myself (Parmalee, 1970, 1980) and others from rock shelters and caves in Utah, Nevada, and elsewhere in arid western North America.

Order Passeriformes—Passerine Birds
Family Corvidae—Jays,
Magpies, and Crows
Pica pica—Black-billed Magpie

Material: Complete right humerus: 1 specimen; MNI, 1.

Remarks: Although most abundant in northern Utah, Black-billed Magpies are common residents throughout the state. Although remains of this corvid have been reported from aboriginal sites in Utah (Parmalee, 1970, 1980), Nevada (chap. 6), South Dakota (Parmalee, 1977, 1979b), and elsewhere within the bird's western range, their numbers generally have been small at any one site. Prehistoric Picuris Pueblo in New Mexico represents a notable exception. Here, 99

elements (13 individuals) were identified from an avian assemblage of 1920 bones (Emslie, 1981).

Family Bombycillidae—Waxwings
Bombycilla garrulus—Bohemian Waxwing

Material: Complete right humerus, complete right ulna, distal half right coracoid: 3 specimens; MNI, 1.

Remarks: Bohemian Waxwings may be found in winter and early spring throughout Utah.

Passerines, genus and sp. indet.

Material: Complete and fragmentary ulnae (3), humeri (2), tibiotarsi (3): 8 specimens; MNI, 3.

Remarks: Sperry (1957a) identified Horned Lark, *Eremophila alpestris,* in DII (as *?Otocoris* [=Eremophila]) and DV, on the basis of both feathers and a partial wing. No osteological material referable to this species occurs in the assemblage.

3. LAST SUPPER CAVE

Much of the dissected topography of the northwestern portion of Nevada's Humboldt County owes its distinctive nature to the erosion of the Canon Rhyolite, a series of late Miocene rhyolite flows and welded tuffs (Merriam, 1910; see also Willden, 1964; Bonham, 1969). Last Supper Cave (elev. 1646 m) sits at the exposed base of one of these flows just north of, and approximately 20 m above, Hell Creek. Spring-fed and deeply incised, Hell Creek flows generally eastward to meet Virgin Creek some 2.4 km downstream from Last Supper Cave. Virgin Creek flows northward, ultimately draining via Thousand Creek into Continental Lake, a shallow, alkaline lake that, at times of high water, drains in its turn into Oregon's Alvord Desert (fig. 7). The slopes of Hell Creek Canyon in the vicinity of Last Supper Cave are dotted with saltbush (*Atriplex* cf. *canescens*) and rabbitbrush (*Chrysothamnus* sp.), but are dominated by big sagebrush (*Artemisia tridentata*) and grasses. Along the stream, grasses become dense, and both willows (*Salix* sp.) and roses (*Rosa* sp.) become abundant. Hell Creek itself is perennial but becomes shallow in summer months.

Last Supper Cave is fairly large, some 9.1 m wide at the mouth and 21.3 m deep. It was first tested in 1968 by T. N. Layton, who visited the site while excavations were taking place at Hanging Rock Shelter some 30 km to the southwest (see chap. 6). Layton was intrigued by the fact that the surface of the site displayed three circular stone enclosures 2.4 to 3.7 m in diameter, and by the fact that parts of the surface of the site were littered with the remains of cattle (see chap. 5, fig. 25). He excavated a test unit to a depth of 86 cm, and named the site Last Supper Cave because he felt that the cattle whose remains littered the cave's surface had been butchered by Indians who were then killed by whites for the deed (Layton, 1970, 1977; Layton and Davis, unpubl.).

Layton returned to Last Supper Cave in 1973 in order to gather more information from the surface of the site and to retrieve perishable items from beneath that surface. After 11 weeks of excavation, he had recovered large numbers of perishables and had discovered that the site contained an early Holocene lithic assemblage similar to those known from low-elevation settings adjacent to pluvial lake features elsewhere in the Great Basin. However, although the collection of perishables was sizable, all were from *Neotoma* middens that lined the southern and rear walls of the cave. Much the same is true for the vertebrate fauna from the site, as will be seen.

A final field season occurred at Last Supper Cave in 1974. Because of the stratigraphic complexity of the site, the 7-week 1975 season was directed by the geoarchaeologist J. O. Davis, whose prime research goal was to understand the stratigraphy of the site. Although the artifacts from the site remain unanalyzed, an unpublished manuscript (Layton and Davis, unpubl.) describes the stratigraphic results of this work and forms the basis of my discussion of Last Supper Cave stratigraphy and chronology.

Because the site was excavated with care, including the use of ⅛ in. (0.32 cm) screens throughout, and because preservation in parts of the site was often excellent, a large faunal collection was retrieved: 1431 invertebrate and 9095 vertebrate specimens have now been identified and are discussed in this report. The precise stratigraphic correlation and age of the vast majority of the specimens, however, are unknown. A discussion of the excavated deposits will make it clear why this is the case.

THE LAST SUPPER CAVE DEPOSITS

Davis (in Layton and Davis, unpubl.; unless otherwise cited, all stratigraphic information presented here is from this source) defined three major stratigraphic units for the Last Supper Cave deposits. The lowest of these, the Pink Zone, consisted of at least 2.1 m of bright pink clay loam derived from the weathering of tuffaceous sediments. Of late Miocene age, these sediments contained a few intrusive artifacts in their uppermost portion.

These artifacts came from the overlying White Zone. A thin (2.5 cm) layer of white precipitate capped the Pink Zone and seems to represent the evaporation of gypsum-
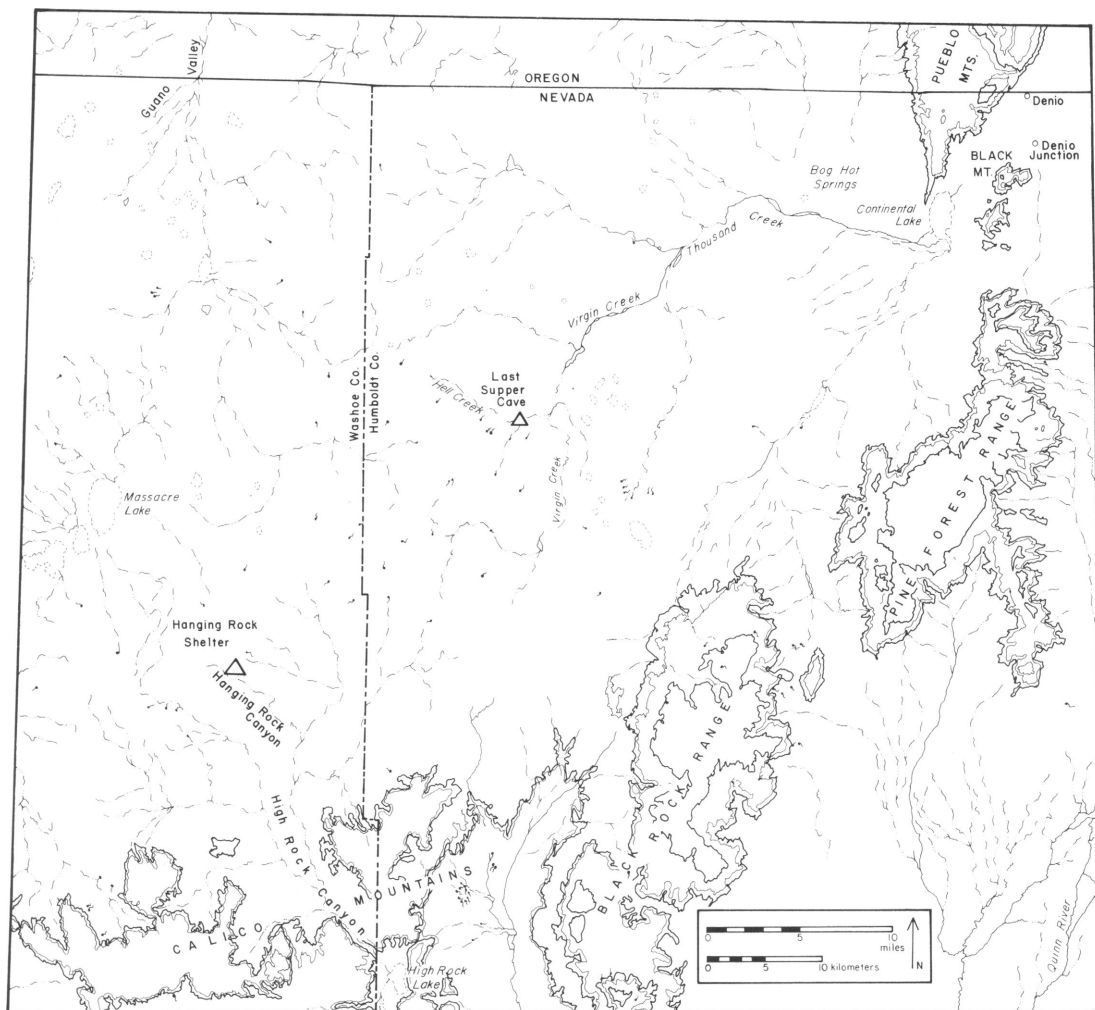
Fig. 7.   The location of Last Supper Cave and Hanging Rock Shelter.

charged waters dripping from the roof of the cave. Above this cap was a stratum of angular rooffall pebbles embedded in a sandy loam matrix from 2.5 to 6.3 cm thick and also permeated with gypsum. Because the cave is now completely dry, Davis observed that the presence of a gypsum precipitate in the site indicated considerably moister climatic conditions than now occur here, and inferred a Pleistocene age for most or all of this zone. Importantly, the earliest cultural materials within Last Supper Cave occur in the upper part of the White Zone and, as discussed below, apparently predate 9000 B.P.

The sediments that lay above the White Zone were approximately 1 m thick, con-

tained Mazama ash close to the base, and were highly variable in content. Because of human- and rodent-caused disturbance, Davis was unable to subdivide the post-Mazama sediments of the site into chronologically discrete units.

Davis also defined five time-stratigraphic stages for these deposits. Because he then correlated these stages with the lithostratigraphic units Layton had defined in the field and had used in excavating the site, a brief discussion of these stages is essential here. Davis' Stage 1 includes those deposits beneath the upper surface of the Pink Zone and is late Miocene in age. Stage 2 incorporates those deposits from the top of the pink clay to the

TABLE 19
Radiocarbon Dates Available for the Correlated Deposits of Last Supper Cave
(from Layton and Davis, unpubl.)

Time-stratigraphic stage	Excavation unit	Material	Years B.P.	Lab no.
Initial Stage 3	O-8	Shell	8790 ± 350	LSU 73-120
Initial Stage 3	N-7	Shell	8630 ± 195	WSU-120
Initial Stage 3	K-5	Charcoal	8960 ± 190	Tx-2541[a]
Initial Stage 3	K-5	Charcoal	8260 ± 90	WSU-1706[a]
Terminal Stage 3	O-4	Charcoal	6905 ± 320	LSU 73-247
Stage 5	N-7	*Artemisia* Bark	1545 ± 360	LSU 73-164
Stage 5	N-9	Willow Post	1043 ± 175	LSU 73-268

[a] Split-sample dates.

top of the White Zone and is Pleistocene in age; judging from the radiocarbon dates available for Stage 3, the uppermost aspect of Stage 2 predates 9000 B.P. Stage 3 includes deposits from the top of the White Zone to the surface on which Mazama ash sits. Five radiocarbon dates are available for this stage, ranging from 6905 to 8790 B.P., while the terminal date for this stratum is provided by the Mazama tephra itself at ca. 6700–7000 B.P. A total of 42 stemmed and 6 lanceolate projectile points, nearly all of which were edge-ground, came from upper Stage 2 and Stage 3 deposits. It was the possibility of examining the late Pleistocene and early Holocene fauna from these well-controlled deposits that sparked my interest in the Last Supper Cave fauna and that led to the analysis presented here. As will be seen, however, the Stage 2 and 3 deposits provided only a small faunal sample.

Stage 4 was defined to include those deposits between the surface on which Mazama ash sits and the upper limit of abundant ash particles, and is estimated to date to between 6000 and 7000 B.P. Stage 5 incorporates those deposits between the upper boundary of abundant ash particles and the surface of the site itself. The organic deposits that comprise much of Stage 5 could not be subdivided, and the stage itself was estimated to cover the last 6000 years. Two radiocarbon dates are available for Stage 5: 1545 ± 360 B.P. and 1043 ± 175 B.P. (see table 19).

Prior to Davis' work, Layton used a series of field names to designate stratigraphic units as they were encountered during excavation. Layton used eight major designations, but employed a total of at least 23 separate names during the course of the fieldwork as a whole in order to designate all stratigraphic units that he felt might be of analytic value. These eight major field units, and the separate field designations subsumed within them, are presented in table 20.

The prime purpose of Davis' work at Last Supper Cave was to unravel the stratigraphic and chronological meaning of these field units. This he accomplished by correlating Layton's field units with his five time-stratigraphic stages. This correlation, with the absolute chronology it implies, is presented in table 21. In some cases, Layton's eight major field stratigraphic units contain more temporal information than Davis' time-stratigraphic stages. Those units referred to as Ash (2) by Layton, for instance, are superimposed on those deposits he referred to as Organic (3), yet both fall within time-stratigraphic Stage 3. As a result, Layton's eight major field stratigraphic units, referred to by number, are used throughout the remainder of this chapter and in chapter 4. The absolute dates for these eight units, however, are those applied by Davis to the time-stratigraphic stages to which the field stratigraphic designations belong.

As I have mentioned, the bulk of the vertebrate fauna, like virtually all of the perishable artifacts, comes not from these units but instead from a series of wood rat (*Neotoma*) middens along the south and rear walls of the cave. For instance, of the 7762 identified subsurface mammalian and avian specimens, only 1815 come from the deposits discussed above. All of the remaining provenienced

TABLE 20

T. N. Layton's Major Field Stratigraphic Designations and Incorporated Field Stratigraphic Units for Last Supper Cave

Num- ber	Major field designation	Incorporated field stratigraphic units
1	Surface	
2	Ash	Ash, Surface Ash, Talus
3	Organic	Organic 1, Organic 2, House Fill, Large Rocky Talus
4	Suborganic	Suborganic 1, Suborganic 2
5	Upper Shell	Upper Shell, Middle Shell, Intermediate Shell, Shell 1, Shell 2
6	Lower Shell	Basal Shell, Terminal Shell, Shell 3, Shell 4, Rocky Shell
7	White	White, White Rocky
8	Pink	Pink, Red

TABLE 21

J. O. Davis' Correlation of Layton's Field Stratigraphic Units with the Last Supper Cave Time-Stratigraphic Units
(from Layton and Davis, unpubl.)

Stage	Age	Major field stratigraphic units incorporated
1	Miocene	8 (Pink)
2	Pleistocene	7 (White)
3	9000–7000 B.P.	6 (Lower Shell) and 5 (Upper Shell)
4	7000–6000 B.P.	4 (Suborganic)
5	6000–0 B.P.	3 (Organic) and 2 (Ash)
—	Historic	1 (Surface)

subsurface mammalian and avian bones and teeth (5938 specimens, or 77% of the subsurface collection) came from the wood rat middens. These were excavated according to 10 cm arbitrary levels and were provisionally correlated with time-stratigraphic Stage 5 by Davis. However, neither he nor Layton attempted to deal with the formidable chronological difficulties posed by these middens.

While I cannot deal with these problems either, it is important to note that Layton and Davis (unpubl.) felt that the large number of perishable artifacts in the Last Supper Cave *Neotoma* middens was due to small-scale plundering by wood rats, who incorporated those materials into their growing structures. While this argument is fully reasonable, it seems more difficult to account for all of the 1810 mountain sheep (*Ovis*) bones excavated from these middens. While wood rats routinely incorporate a wide variety of organic materials, including bone, into their middens, some of the mountain sheep specimens from Last Supper Cave are truly cumbersome—an occipital and complete right horn core (LS-229(1)), for instance, measuring 53 cm in an arc from horn core tip to occipital condyle and weighing 1.41 kg. As impressive as wood rats are, they attain a body length of no more than 22.3 cm (47 cm with tail); the largest of 37 individuals discussed by Hall (1946) weighed 0.58 kg, or 41 percent of the weight of *Ovis* specimen LS-229(1).

The distribution of the 2141 (of 2194)

mountain sheep specimens for which horizontal provenience information is available is provided by figure 8. This figure shows that of these specimens, 1467 (69%) came from the *Neotoma* midden at the rear of the cave. Given this distribution, and given that it seems unlikely that a wood rat could have moved a mountain sheep skull fragment at least 2.4 times its own weight and 2.4 times its body length, along with other similarly sizable specimens, into its midden, it seems possible that much of the *Ovis* material was located in the far rear of the cave because it was tossed there by people (cf. Binford, 1978; Thomas, 1983). While many of these specimens might have been carried into the middens by wood rats, many others might have been incorporated as the middens grew over them.

No matter how the *Ovis* material came to be incorporated into the *Neotoma* middens, however, I have no means of extracting a secure chronology for that aspect of the faunal collection retrieved from them. Chronologically sensitive artifacts remain unanalyzed, and no detailed attempt has been made to analyze the middens themselves. I obtained four radiocarbon dates for the midden at the rear of the cave, but those dates, ranging from 270 to 1780 B.P., bear no relationship to the depth of the dated specimens within the midden (table 22). An argument might be made that this midden spans approximately the last 2000 years, but more dates, and a detailed assessment of the middens themselves, are needed before the chronology of these structures and of the materials they contain can be understood.
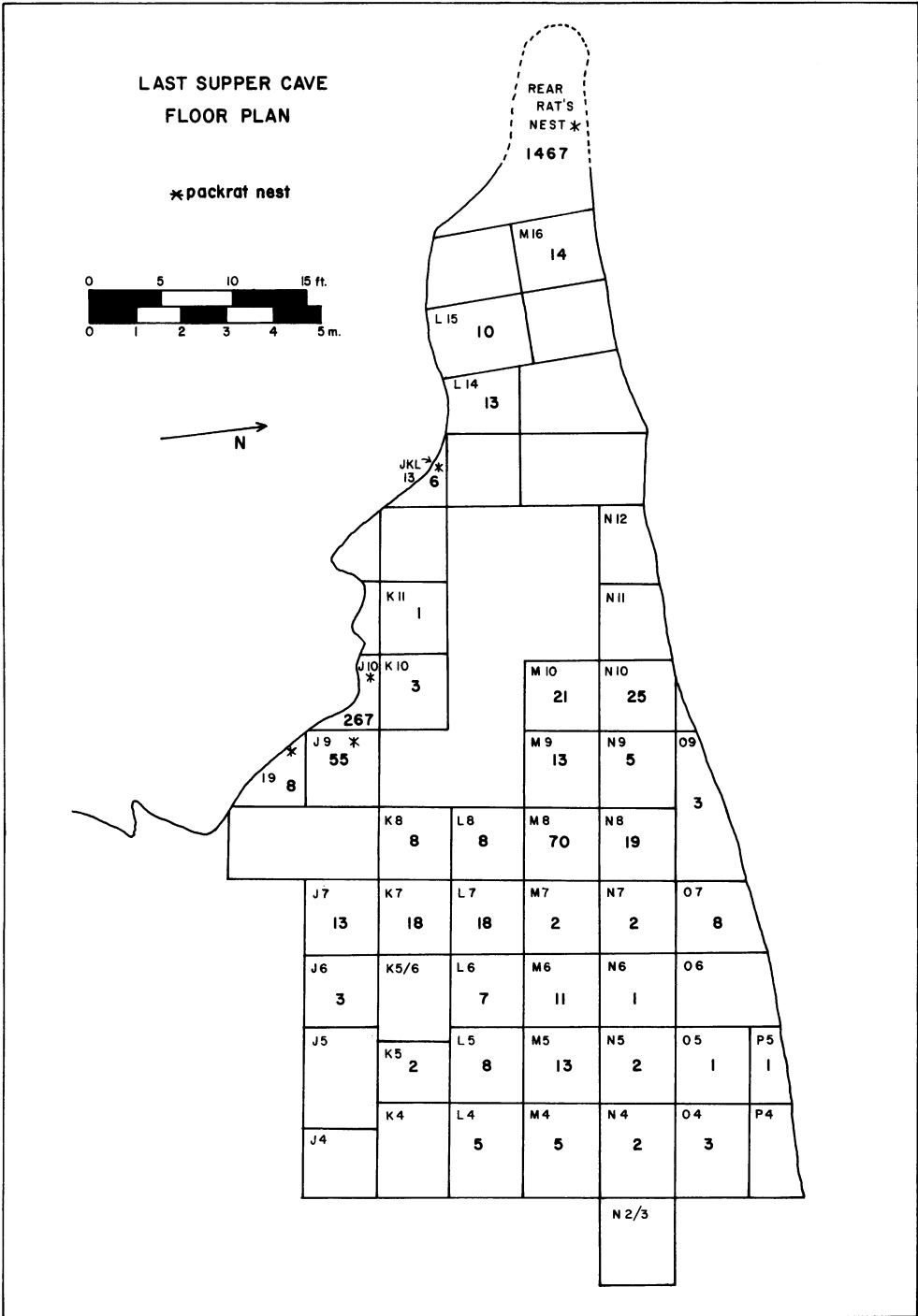
Fig. 8.   The horizontal distribution of the Last Supper Cave *Ovis* specimens (floor plan from Layton and Davis, unpubl.).

Finally, I note that the vast majority of the Last Supper Cave bones have been burned. Although information on burning was routinely recorded as bones were identified, a

TABLE 22
Radiocarbon Dates for the *Neotoma* Midden at the Rear of the Last Supper Cave

Sample no.	Material	Years B.P.	Depth (inches)	Lab no.
LS-371 (157)	*Ovis* horn sheath	1780 ± 60	0–6	A-4255
LS-367 (130)	*Ovis* horn sheath	1120 ± 60	6–12	A-4257
LS-372 (198)	*Ovis* horn sheath	1750 ± 70	18–24	A-4254
LS-369 (305)	*Ovis* horn sheath	270 ± 50	24–30	A-4256

number of burned mountain sheep long bones contain burned pupal cases of dermestid beetles within their shafts. Since dermestid beetles feed only on dried flesh, these burned pupal cases demonstrate that the burning postdated the deposition of the bones by a perhaps substantial amount of time. The fires involved may well have been set by people but they are not functionally related to the bones and no analysis of the distribution of burning across elements or across taxa is presented here.

DESCRIPTIVE SUMMARY

In this section, I provide descriptive information on the 8975 mammalian specimens (table 23) present in the deposits of Last Supper Cave. Where not discussed elsewhere, I also provide the criteria used to identify those taxa. In addition, I discuss the local distribution of the taxa represented in the Last Supper Cave collection. The information provided on the modern distribution of mammals in the Last Supper Cave region depends heavily on the results of two brief small mammal surveys that I conducted in Hell Creek Canyon (162 trap nights) and in Virgin Valley, approximately 3 km north of the confluence of Hell Creek and Virgin Creek (162 trap nights), in September 1983 and August 1984. As with other small mammal surveys that I have conducted in conjunction with the analysis of cave and rockshelter faunas (e.g., Grayson, 1983, 1985), the purpose of this survey was to discover whether certain key taxa represented in the collection, such as marmots (*Marmota flaviventris*), still occur in the area.

Order Insectivora—Insectivores
Family Soricidae—Shrews
Sorex sp.—Long-tailed Shrews

Material: 1 humerus: 1 specimen.
Remarks: Both the vagrant (*S. vagrans*) and

water (*S. palustris*) shrews are known from northwestern Humboldt County (Hall, 1946).

Order Lagomorpha—Rabbits,
Hares, and Pikas
Family Leporidae—Rabbits and Hares
Sylvilagus sp.—Rabbits

Material: 18 skull fragments, 14 mandibles, 27 isolated teeth, 9 scapulae, 9 humeri, 6 radii, 4 metacarpals, 30 vertebrae, 19 innominates, 9 femora, 10 tibiae, 3 calcanea, 8 metatarsals, 8 phalanges, 1 metapodial: 175 specimens.

Sylvilagus idahoensis—Pygmy Rabbit

Material: 49 skull fragments, 57 mandibles, 25 isolated teeth, 32 scapulae, 40 humeri, 7 radii, 6 ulnae, 5 vertebrae, 26 innominates, 28 femora, 69 tibiae, 2 calcanea, 8 metatarsals: 354 specimens.

Sylvilagus cf. *nuttallii*—Nuttall's
Cottontail

Material: 176 skull fragments, 202 mandibles, 146 isolated teeth, 207 scapulae, 253 humeri, 74 radii, 67 ulnae, 16 metacarpals, 164 vertebrae, 16 sacra, 176 innominates, 295 femora, 690 tibiae, 8 astragali, 45 calcanea, 5 other tarsals, 104 metatarsals, 52 phalanges: 2696 specimens.

Sylvilagus nuttallii—Nuttall's
Cottontail

Material: 160 skull fragments, 153 mandibles, 125 isolated teeth: 438 specimens.

Lepus sp.—Hares

Material: 29 skull fragments, 23 mandibles, 37 teeth, 19 scapulae, 20 humeri, 37 radii, 13 ulnae, 3 metacarpals, 11 vertebrae, 11 innominates, 48 femora, 87 tibiae, 1 patella, 8 astragali, 9 calcanea, 2 other tarsals, 15 metatarsals, 13 phalanges: 386 specimens.

TABLE 23
Number of Identified Specimens per Mammalian Taxon by Stratum at Last Supper Cave

Taxon	Stratum										R	NP	Totals
	1	2	3	3/4	4	5	5/6	6	7	8			
Sorex sp.	—	—	—	—	—	—	—	—	—	—	1	—	1
Sylvilagus sp.	5	7	7	—	24	2	—	2	—	—	116	12	175
Sylvilagus idahoensis	27	20	30	—	9	4	—	2	—	—	218	44	354
Sylvilagus cf. *nuttallii*	70	72	183	1	311	55	3	72	19	3	1463	444	2696
Sylvilagus nuttallii	5	2	6	—	48	9	1	20	6	—	284	57	438
Lepus sp.	53	9	18	1	34	7	—	16	30	—	169	49	386
Tamias sp.	—	—	—	—	—	—	—	—	—	—	1	1	2
Marmota flaviventris	10	59	47	2	117	30	7	45	30	—	759	237	1343
Spermophilus sp.	2	—	2	—	1	2	—	—	—	—	3	1	11
Spermophilus cf. *townsendii*	—	—	—	—	—	—	—	—	—	—	1	—	1
Spermophilus townsendii	1	—	—	—	—	—	—	—	—	—	6	—	7
Spermophilus cf. *beldingi*	—	1	—	—	—	—	—	—	—	—	4	—	5
Spermophilus beldingi	—	—	—	—	—	—	—	—	—	—	4	—	4
Spermophilus lateralis	2	—	—	—	3	2	—	—	—	—	2	1	10
Thomomys sp.	—	3	—	—	—	—	—	—	—	—	10	3	16
Thomomys cf. *bottae*	—	—	—	—	1	—	—	1	—	—	1	—	3
Thomomys cf. *talpoides*	—	3	1	—	1	—	—	—	—	—	26	3	34
Thomomys talpoides	—	4	4	—	3	—	—	—	—	—	26	2	39
Perognathus sp.	—	—	1	—	—	—	—	—	—	—	16	4	21
Perognathus parvus	—	—	—	—	—	—	—	—	—	—	7	5	12
Peromyscus sp.	—	—	—	—	—	—	—	—	—	—	6	—	6
Peromyscus maniculatus	—	—	—	—	—	—	—	—	—	—	5	—	5
Peromyscus crinitus	—	—	—	—	—	—	—	—	—	—	1	—	1
Neotoma sp.	—	1	—	—	2	—	1	—	—	—	23	1	28
Neotoma cf. *lepida*	—	1	—	—	1	—	—	—	—	—	61	8	71
Neotoma lepida	—	—	1	—	—	—	—	—	—	—	58	10	69
Neotoma cf. *cinerea*	—	4	3	—	32	13	3	10	1	—	298	37	401
Neotoma cinerea	2	3	1	—	13	2	—	11	1	—	128	33	194
Microtus sp.	—	—	1	—	5	—	—	1	—	—	78	8	93
Microtus montanus	—	—	—	—	1	1	—	—	—	—	16	1	19
Microtus longicaudus	—	1	—	—	—	—	—	—	—	—	12	—	13
Lagurus curtatus	—	—	—	—	—	—	—	1	—	—	63	—	64
Erethizon dorsatum	3	1	—	—	—	—	—	—	—	—	14	2	20
Canis cf. *latrans*	2	—	2	—	—	—	—	—	—	—	13	1	18
Canis latrans	—	4	8	—	1	—	—	—	—	—	37	5	55
Canis lupus	—	—	—	—	—	—	—	—	—	—	1	—	1
Vulpes vulpes	—	—	—	—	—	—	—	—	—	—	1	—	1
Mustela sp.	—	—	—	—	—	—	—	—	—	—	1	—	1
Mustela frenata	—	—	—	—	1	—	—	—	—	—	4	1	6
Taxidea taxus	—	3	3	—	1	—	—	—	—	—	24	9	40
Spilogale putorius	—	—	—	—	—	—	—	—	—	—	2	—	2
Mephitis mephitis	—	—	—	—	—	—	—	—	—	—	—	1	1
Lynx cf. *rufus*	2	—	6	—	1	—	—	2	—	—	36	1	48
Lynx rufus	—	—	1	—	—	—	—	—	—	—	16	—	17
Cervus elaphus	—	1	1	—	—	—	—	—	—	—	6	1	9
Odocoileus cf. *hemionus*	—	—	2	—	—	—	—	—	1	—	15	—	18
Antilocapra americana	—	—	3	—	—	—	—	—	—	—	18	1	22
Ovis canadensis	17	40	142	2	62	—	—	3	3	—	1810	115	2194
Totals	201	239	473	6	672	127	15	186	91	3	5864	1098	8975

Remarks: All leporids identified from the Last Supper collection currently occupy the Hell Creek area (Hall, 1946).

Order Rodentia—Rodents
Family Sciuridae—Squirrels
Tamias sp.—Chipmunk

Material: 1 humerus, 1 tibia: 2 specimens.

Marmota flaviventris—Yellow-bellied
Marmot

Material: 239 skull fragments, 259 mandibles, 301 isolated teeth, 60 scapulae, 97 humeri, 61 radii, 72 ulnae, 10 metacarpals, 14 clavicles, 16 vertebrae, 2 sacra, 23 innominates, 73 femora, 66 tibiae, 5 fibulae, 11 astragali, 6 calcanea, 1 other tarsal, 13 metatarsals, 14 phalanges: 1343 specimens.

Spermophilus sp.—Ground Squirrels

Material: 2 skull fragments, 1 mandible, 1 scapula, 1 humerus, 1 innominate, 2 femora, 2 tibiae, 1 calcaneus: 11 specimens.

Spermophilus cf. *townsendii*—Townsend's
Ground Squirrel

Material: 1 skull fragment: 1 specimen.

Spermophilus townsendii—Townsend's
Ground Squirrel

Material: 3 skull fragments, 4 mandibles: 7 specimens.

Spermophilus cf. *beldingi*—Belding's
Ground Squirrel

Material: 1 mandible, 1 humerus, 1 innominate, 2 femora: 5 specimens.

Spermophilus beldingi—Belding's
Ground Squirrel

Material: 2 skull fragments, 2 mandibles: 4 specimens.

Spermophilus lateralis—Golden-mantled
Ground Squirrel

Material: 6 skull fragments, 4 mandibles: 10 specimens.

Remarks: All of the sciurids represented in the Last Supper Cave fauna are currently present in the Hell Creek area. In 1983, I took a single least chipmunk (*T. minimus*) in a small grassy meadow adjacent to South Hell Creek (elev. ca. 1790 m), approximately 6.2 km west of Last Supper Cave. *Spermophilus lateralis* was common in Hell Creek Canyon in 1984, while three fresh marmot skulls were found on the surface of unconsolidated, active *Neotoma* middens just downstream from Last Supper Cave itself.

The postcranial material assigned to *S.* cf. *beldingi* was assigned on the basis of size: Belding's ground squirrel is the largest ground squirrel currently found in northwestern Nevada.

Family Geomyidae—Pocket Gophers
Thomomys sp.—Smooth-toothed
Pocket Gophers

Material: 7 mandibles, 5 isolated teeth, 3 humeri, 1 innominate: 16 specimens.

Thomomys cf. *bottae*—Botta
Pocket Gopher

Material: 3 mandibles: 3 specimens.

Thomomys cf. *talpoides*—Northern
Pocket Gopher

Material: 10 mandibles, 2 isolated teeth, 7 humeri, 1 ulna, 2 innominates, 7 femora, 4 tibiae, 1 astragalus: 34 specimens.

Thomomys talpoides—Northern
Pocket Gopher

Material: 17 skull fragments, 18 mandibles, 4 isolated teeth: 39 specimens.

Remarks: The only species of *Thomomys* known from northwestern Nevada today are *T. talpoides* and *T. townsendii,* Townsend's pocket gopher. The latter is markedly large and can be readily distinguished from all other Great Basin pocket gophers on this basis alone. *Thomomys bottae* does not occur in northwestern Nevada today, but my tentative identification of this animal in the Last Supper fauna requires discussion.

TABLE 24

Mandibular Alveolar Lengths (p4-m2, in millimeters) for Modern *Thomomys bottae* and *Thomomys talpoides*

	N	Range	x̄	s
Thomomys bottae	54	4.7–7.0	5.7	0.48
Thomomys talpoides	25	4.4–6.3	5.2	0.45

While the identification of fairly complete *Thomomys* skulls, or of mandibles retaining p4, is straightforward (Thaeler, 1980; Grayson, 1983), the identification of edentulous mandibles is not. For a number of years, I have relied on p4-m2 or p4-m3 alveolar lengths for such identification, using *t*-tests to assign edentulous specimens to either *T. bottae* or *T. talpoides,* since the latter species tends to be smaller than the former (e.g., Grayson 1983, 1985; see table 24). Table 25 presents p4-m2 alveolar lengths for all *Thomomys* mandibles in the Last Supper Cave collection. Using *t*-tests, specimens with alveolar lengths of 5.1 mm or less were assigned to *T. talpoides,* those with alveolar lengths of 6.3 and above were assigned to *T. bottae,* and those with alveolar lengths ranging from 5.1 to 5.6 mm were assigned to *Thomomys* sp. Of these mandibles, eight retain p4. In seven cases, identifications based on this tooth alone are consistent with identifications based on alveolar lengths alone. Specimen 355(2), however, has an alveolar length of 6.6 mm, which far exceeds the average size of *T. talpoides* mandibles in my modern sample (*t* with modern *T. talpoides* = 3.05, *p* < 0.01), but also possesses a p4 that securely identifies it as *T. talpoides.* Thus, although the probabilistic approach I have used to identify edentulous *T. bottae* and *T. talpoides* mandibles remains the most secure approach currently available to identify such specimens, it clearly does not allow the secure identification of all individual specimens. Given that there are no specimens in the Last Supper collection that can be unequivocally assigned to *T. bottae,* it seems most likely that the specimens statistically assigned to *T.* cf. *bottae* are, in fact, *T. talpoides.*

Family Heteromyidae—Pocket Mice,
Kangaroo Mice, Kangaroo Rats
Perognathus sp.—Pocket Mice

Material: 3 mandibles, 3 isolated teeth, 1

TABLE 25

Mandibular Alveolar Lengths (p4-m2, in millimeters) of Last Supper Cave *Thomomys* Specimens

LS #/ Stratum	Alveolar length	p4?	Statistical identification	Morphological identification
235(10)/R	4.4	−	*talpoides*	sp.
354(4)/R	4.5	+	*talpoides*	*talpoides*
363(17)/R	4.5	−	*talpoides*	sp.
369(9)/R	4.6	−	*talpoides*	sp.
363(7)/R	4.7	+	*talpoides*	*talpoides*
369(28)/R	4.7	−	*talpoides*	sp.
372(16)/R	4.7	−	*talpoides*	sp.
254(30)/2	4.8	−	*talpoides*	sp.
369(31)/R	4.8	−	*talpoides*	sp.
371(33)/R	4.8	−	*talpoides*	sp.
353(3)/R	4.9	+	*talpoides*	*talpoides*
354(5)/R	4.9	+	*talpoides*	*talpoides*
354(29)/R	4.9	+	*talpoides*	*talpoides*
373(25)/R	4.9	−	*talpoides*	sp.
353(8)/R	5.0	+	*talpoides*	*talpoides*
369(13)/R	5.0	−	*talpoides*	sp.
369(6)/R	5.1	+	sp.	*talpoides*
369(11)/R	5.1	−	sp.	sp.
353(27)/R	5.2	−	sp.	sp.
369(12)/R	5.3	−	sp.	sp.
373(14)/R	5.3	−	sp.	sp.
353(26)/R	5.6	−	sp.	sp.
342(32)/4	6.3	−	*bottae*	sp.
369(1)/R	6.3	−	*bottae*	sp.
055(15)/6	6.4	−	*bottae*	sp.
355(2)/R	6.6	+	*bottae*	*talpoides*

humerus, 2 innominates, 6 femora, 6 tibiae: 21 specimens.

Perognathus parvus—Great Basin Pocket Mouse

Material: 8 skulls, 4 mandibles: 12 specimens.

Remarks: Two species of pocket mouse currently occupy the Hell Creek area: *P. longimembris,* the little pocket mouse, and *P. parvus.* I took two Great Basin pocket mice in this area: one on the slopes above the northern mouth of Virgin Creek gorge in vegetation characterized by big sagebrush (*Artemisia tridentata*), scattered shadscale (*Atriplex* sp.), rabbitbrush (*Chrysothamnus* sp.), and grasses (elev. 1560 m), and a second adjacent to Hell Creek approximately 1 km downstream from Last Supper Cave in dense *A. tridentata* and grasses with occasional rabbitbrush and *Astragalus* sp. (elev. 1600 m).

TABLE 26
Alveolar and Occlusal Lengths (in millimeters) for Last Supper Cave *Peromyscus* Mandibles Retaining at Least One Molar

LS #/Stratum	Alveolar length	Occlusal length			Identification
		m1	m2	m3	
354(1)/R	3.66	1.39	1.27	0.99	*P. maniculatus*
371(3)/R	—	1.36	1.10	0.81	*P. crinitus*
369(4)/R	3.56	1.45	1.27	—	*P. maniculatus*
371(8)/R	3.55	1.49	1.19	—	*P. maniculatus*
369(9)/R	3.41	1.43	1.19	0.82	*P. maniculatus*

Family Muridae—Murids
***Peromyscus* sp.—White-footed Mice**

Material: 6 mandibles: 6 specimens.

***Peromyscus maniculatus*—Deer Mouse**

Material: 1 skull fragment, 4 mandibles: 5 specimens.

***Peromyscus crinitus*—Canyon Mouse**

Material: 1 mandible: 1 specimen.

Remarks: Two species of *Peromyscus* are currently known from the Hell Creek area, both of which are represented in the Last Supper Cave fauna. *P. maniculatus* was abundant along the banks of Virgin Creek, where I took 29 individuals in vegetation ranging from thick willows (*Salix* sp.) along the stream banks just north of the mouth of Virgin Valley gorge (elev. 1536 m) to low *A. tridentata* with scattered grasses on the slopes above the north end of the canyon (elev. 1560 m). It was also abundant along Hell Creek itself: I took 17 individuals along the banks of South Hell Creek in *A. tridentata* with a thick grass understory about 6.2 km west of Last Supper Cave (elev. 1792 m), and eight along Hell Creek in the vicinity of Last Supper Cave (elev. 1600–1610 m), primarily in vegetation characterized by *A. tridentata* and scattered to dense grasses with occasional *Chrysothamnus* sp. and shadscale (*Atriplex* cf. *canescens*). I took six *P. crinitus* along and in the rock rims at the northern end of Virgin Valley gorge (elev. 1560 m), but none along Hell Creek itself.

My identification of *Peromyscus* skulls and mandibles depended on criteria discussed in Grayson (1983, 1985). All identified mandibles retained m1 and were first identified on that basis. In all cases, measurements of these mandibles were consistent with iden-

tifications made on qualitative grounds (table 26; see Grayson, 1985).

***Neotoma* sp.—Wood Rats**

Material: 7 skull fragments, 2 mandibles, 3 isolated teeth, 1 humerus, 8 vertebrae, 1 innominate, 4 femora, 2 tibiae: 28 specimens.

***Neotoma* cf. *lepida*—Desert Wood Rat**

Material: 5 skull fragments, 1 mandible, 2 isolated teeth, 3 scapulae, 14 humeri, 3 ulnae, 7 vertebrae, 1 sacrum, 6 innominates, 18 femora, 11 tibiae: 71 specimens.

***Neotoma lepida*—Desert Wood Rat**

Material: 25 skull fragments, 28 mandibles, 16 isolated teeth: 69 specimens.

***Neotoma* cf. *cinerea*—Bushy-tailed Wood Rat**

Material: 33 skull fragments, 29 mandibles, 3 isolated teeth, 16 scapulae, 59 humeri, 8 radii, 16 ulnae, 22 vertebrae, 3 sacra, 58 innominates, 74 femora, 63 tibiae, 1 astragalus, 9 calcanea, 7 metatarsals: 401 specimens.

***Neotoma cinerea*—Bushy-tailed Wood Rat**

Material: 51 skull fragments, 101 mandibles, 42 isolated teeth: 194 specimens.

Remarks: Both *N. lepida* and *N. cinerea* currently inhabit the Hell Creek area. I took one individual of each species in the rock rims rising above the north bank of Hell Creek just downstream from Last Supper Cave (elev. 1585 m), and two individuals of *N. lepida* at the base of the rock rim at the north end of Virgin Creek gorge.

The morphology of M1 allows secure sep-
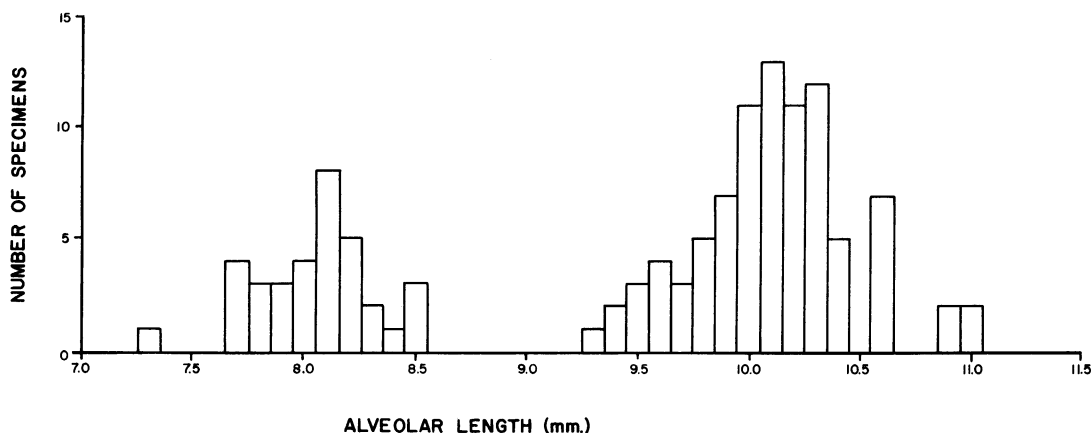
Fig. 9.   Distribution of mandibular alveolar lengths, Last Supper Cave *Neotoma*.

aration of *N. lepida* and *N. cinerea,* while a range of other cranial and postcranial characters allows separation of the two species as well. Many or most of these, however, may be a function of size, since the desert wood rat is much smaller than *N. cinerea.* Size played a major role in my assignment of specimens to *N. cf. lepida* and *N. cf. cinerea,* and also played a major role in my assignment of maxillae, mandibles, and isolated teeth to *N. lepida* and *N. cinerea.*

Mandibular (m1-m3) and maxillary (M1-M3) alveolar lengths for modern *N. lepida* and *N. cinerea* were presented in chapter 1 (table 4). The distribution of alveolar lengths for the 128 Last Supper Cave mandibles for which this measurement could be taken is shown in figure 9. Specimens with alveolar lengths of 8.5 mm or less were assigned to *N. lepida*; those with alveolar lengths of 9.3 mm or more were assigned to *N. cinerea.* A similar approach was taken for *Neotoma* maxillae (see table 27). Maxillae with alveolar lengths of 8.6 mm or less were assigned to *N. lepida*; those with lengths of 9.4 mm or more were assigned to *N. cinerea.*

Occlusal lengths of *Neotoma* teeth were employed to identify isolated teeth and to identify mandibles and maxillae for which alveolar length could not be measured (see chap. 1, table 5). Table 28 presents the occlusal lengths of isolated *Neotoma* molars from Last Supper Cave, as well as for those maxillae and mandibles for which alveolar lengths could not be taken. Because there is considerable overlap in occlusal lengths of modern *Neotoma* molars, *t*-tests were used

to assign these specimens to species (see Grayson, 1985). Two specimens could not be identified in this fashion: an m1 with an occlusal length of 3.18 mm and an M2 with an occlusal length of 2.55 mm. Both are assigned to *Neotoma* sp. in table 23. For all 17 M1 for which occlusal lengths were measured, identifications based on the morphology of the tooth agree with those based on measurements alone.

Microtus sp.—Meadow Voles

Material: 16 skull fragments, 55 mandibles, 22 isolated teeth: 93 specimens.

Microtus montanus—Montane Vole

Material: 19 skull fragments: 19 specimens.

Microtus longicaudus—Long-tailed Vole

Material: 13 skull fragments: 13 specimens.

Lagurus curtatus—Sage Vole

Material: 14 skull fragments, 38 mandibles, 12 isolated teeth: 64 specimens.

Remarks: All three voles represented in the Last Supper Cave fauna are currently present in the Hell Creek area. I took three individuals of *M. montanus* and one of *M. longicaudus* along the banks of South Hell Creek (elev. 1792 m) approximately 6.2 km west of Last Supper Cave, and one individual of each species in small grassy patches adjacent to Virgin Creek just south of the mouth of Vir-

TABLE 27
Maxillary Alveolar Lengths (M1–M3, in millimeters): Last Supper Cave Adult *Neotoma* Assigned to *N. lepida* and *N. cinerea*

	N	Range	$\bar{x}$	s
		Alveolar length		
Neotoma lepida	6	7.9–8.6	8.18	0.26
Neotoma cinerea	22	9.4–11.5	10.22	0.53

gin Creek gorge (elev. 1555 m). I also took two sage voles in Virgin Valley, one at the base of the rock rim on the west side of the northern end of the gorge (elev. 1561 m) in vegetation dominated by *A. tridentata* and grasses, including scattered wildrye (*Elymus* sp.), and one on the slopes above the northern end of the gorge (elev. 1560 m) in the same set of traps that provided *P. parvus* here (see above).

The Last Supper Cave microtines were identified using criteria discussed in Grayson (1983).

Family Erethizontidae—New World Porcupines
Erethizon dorsatum—Porcupine

Material: 3 skull fragments, 6 mandibles, 5 isolated teeth, 2 humeri, 4 vertebrae: 20 specimens.

Remarks: Five articulated cervical vertebrae (C2–C6) and 12 articulated caudal vertebrae, with skin and quills, have been counted as single specimens; both are from Stratum 1. In addition to bones and teeth, the Last Supper Cave deposits also provided a total of 44 porcupine quills (one from Stratum 2, 32 from wood rat middens, and 11 without provenience). Judging from fresh scat accumulations in the rocks on the north side of Hell Creek, porcupines are common in the Hell Creek area today.

Order Carnivora—Carnivores
Family Canidae—Coyotes, Wolves, Foxes, and Dogs
Canis cf. *latrans*—Coyote

Material: 1 mandible, 8 isolated teeth, 2 humeri, 1 metacarpal, 3 vertebrae, 1 metatarsal, 2 phalanges: 18 specimens.

Canis latrans—Coyote

Material: 9 skull fragments, 19 mandibles,

TABLE 28
Occlusal Lengths (in millimeters) of *Neotoma* Molars from Last Supper Cave Assigned to *N. lepida* or *N. cinerea*: Isolated Specimens or Those from Mandibles and Maxillae with Unmeasurable Alveolar Lengths

	N	Range	$\bar{x}$	s
	Neotoma lepida			
M1	6	2.76–3.22	3.03	0.16
M2	1	2.20	—	—
M3	—	—	—	—
m1	7	2.75–3.11	2.97	0.12
m2	6	2.49–2.77	2.59	0.10
m3	—	—	—	—
	Neotoma cinerea			
M1	11	3.28–3.93	3.52	0.17
M2	4	2.64–3.12	2.90	0.20
M3	2	2.25–2.49	2.37	0.17
m1	16	3.32–4.21	3.76	0.25
m2	7	2.88–3.37	3.06	0.16
m3	2	2.32–2.46	2.39	0.10

22 isolated teeth, 1 humerus, 1 ulna, 1 innominate, 1 femur, 1 metatarsal: 55 specimens.

Canis lupus—Wolf

Material: 1 ulna: 1 specimen.

Vulpes vulpes—Red Fox

Material: 1 skull fragment: 1 specimen.

Family Mustelidae—Weasels, Skunks, and Allies
Mustela sp.—Weasels

Material: 1 innominate: 1 specimen.

Mustela frenata—Long-tailed Weasel

Material: 1 skull fragment, 3 mandibles, 2 isolated teeth: 6 specimens.

Taxidea taxus—Badger

Material: 12 skull fragments, 11 mandibles, 6 isolated teeth, 1 radius, 3 ulnae, 1 metacarpal, 2 femora, 1 tibia, 3 phalanges: 40 specimens.

Spilogale putorius—Spotted Skunk

Material: 2 mandibles: 2 specimens.

Mephitis mephitis—Striped Skunk

Material: 1 mandible: 1 specimen.

Family Felidae—Cats and Allies
Lynx cf. *rufus*—Bobcat

Material: 7 skull fragments, 1 mandible, 3 isolated teeth, 2 scapulae, 2 humeri, 2 radii, 5 ulnae, 1 metacarpal, 1 innominate, 1 femur, 3 fibulae, 2 calcanea, 3 other tarsals, 13 phalanges, 2 metatarsals: 48 specimens.

Lynx rufus—Bobcat

Material: 3 skull fragments, 9 mandibles, 5 isolated teeth: 17 specimens.

Remarks: With the exception of *C. lupus* and *V. vulpes,* and the possible exception of *Mustela* sp. (see below), all of the Last Supper Cave carnivores are currently common in northwestern Nevada. Hall's (1946) analysis of both wolves and red foxes suggests that neither was common in Nevada during historic times. Both, however, are represented in a number of prehistoric faunas in the northerly reaches of the Great Basin, although never in substantial numbers. Wolves were present in the late Holocene deposits of Hidden (Grayson, 1985), Danger (this volume), and Lovelock (Livingston, personal commun.) caves, and at the Humboldt Lakebed Site (Nv-Ch-15) in the Humboldt Sink (Livingston, personal commun.). Red foxes have been reported from Gatecliff Shelter (Grayson, 1983), Hidden Cave, Danger Cave, the Connley Caves, and James Creek Shelter (Grayson, in press). Both of these canids seem to have been widespread in at least the northern half of the Great Basin during much or all of the Holocene.

The single specimen of *Mustela* sp. is a small left innominate, complete except for the iliac crest. This specimen represents either *M. frenata* or *M. erminea,* the short-tailed weasel. Biogeographically, the difference is crucial. *M. frenata* is widespread and common in northern Nevada, but *M. erminea* is a boreal mammal known only from six isolated mountain ranges in the Great Basin (Brown and Gibson, 1983). Brown (1971, 1978) has argued that boreal mammals colonized the Great Basin during the Pleistocene, only to become isolated on, and differentially extinct across, the mountains of this area during the Holocene, a position that now has substantial paleontological support (Grayson, 1987). Among other things, Brown's model predicts that *M. erminea* must

at one time have occupied lowland areas in the Great Basin (Grayson, 1987). The Last Supper Cave specimen, if it represents *M. erminea,* would meet this prediction, thus providing further support for Brown's position, and would also provide the first Great Basin record for this mammal outside of its modern range.

Unfortunately, I am unable to identify this specimen. Table 29 presents data for three measures of innominate size from modern *M. erminea* (*M. e. arctica, M. e. bangsi, M. e. cicognanii, M. e. muricus, M. e. richardsonii,* and *M. e. streatori*) and modern *M. frenata* (*M. f. altifrontalis, M. f. longicauda, M. f. nevadensis, M. f. noveboracensis, M. f. oregonensis, M. f. oribasus,* and *M. f. peninsulae*). The variables measured, dictated in part by the fact that the iliac crest of the Last Supper Cave specimen is not present, were: (1) distance from the apex of the ischial spine to the posterior-inferior iliac spine (spine-spine length); (2) maximum length of the obturator foramen (obturator foramen length); and (3) distance from the symphysis pubis to the ischial tuberosity (ischial width). Table 29 also provides the comparable values for the Last Supper Cave specimen, and shows that this specimen falls beneath all three means for *M. frenata* but above all three for *M. erminea.* Table 30 presents the results of *t*-tests comparing the Last Supper Cave specimen with modern *M. erminea* and *M. frenata.* In no case does the specimen differ significantly from *M. erminea,* but it is significantly smaller than *M. frenata* in both obturator foramen length and ischial width. Figures 10, 11, and 12 provide bivariate scattergrams for each possible pair of these three variables and show that in each instance the Last Supper Cave innominate falls on the lower end of the *M. frenata,* and the upper end of the *M. erminea,* plots. Although the results of the *t*-tests suggest this specimen is more likely to be *M. erminea* than *M. frenata,* a convincing assignment does not seem possible.

Order Artiodactyla—Artiodactyls
Family Cervidae—Cervids
Cervus elaphus—Wapiti

Material: 1 mandible, 5 isolated teeth, 1 metacarpal, 1 tarsal, 1 phalanx: 9 specimens.

TABLE 29
Measurements of Innominate Size (in millimeters):
Modern *M. erminea,* Modern *M. frenata,* and Last
Supper Cave *Mustela* sp. Specimen 355

	M. erminea	*M. frenata*	LS-355
1. Spine-spine length			
N	27	37	1
Range	6.2–11.3	8.0–12.9	9.5
x̄	8.3	10.7	—
s	1.4	1.1	—
2. Obturator foramen length			
N	27	37	1
Range	4.1–8.4	6.0–10.8	6.6
x̄	5.6	8.2	—
s	1.2	1.0	—
3. Ischial width			
N	27	36	1
Range	4.9–10.0	7.6–12.5	7.8
x̄	6.9	10.1	—
s	1.5	1.2	—

Odocoileus cf. *hemionus*—Mule Deer

Material: 2 antler fragments, 1 mandible, 1 isolated tooth, 1 scapula, 4 ulnae, 7 tibiae, 1 astragalus, 1 calcaneus: 18 specimens.

Family Antilocapridae—Pronghorn
Antilocapra americana—Pronghorn

Material: 2 mandibles, 1 isolated tooth, 1 humerus, 3 radioulnae, 3 carpals, 1 vertebra, 1 innominate, 2 tibiae, 1 fibula, 1 tarsal, 6 phalanges: 22 specimens.

Family Bovidae—Bovids
Ovis canadensis—Mountain Sheep

Material: 178 skull fragments, 347 mandibles, 549 isolated teeth, 34 scapulae, 78 humeri, 83 radii, 23 ulnae, 55 radioulnae, 84 metacarpals, 64 carpals, 1 sternabra, 219 vertebrae, 9 innominates, 5 femora, 110 tibiae, 47 fibulae, 59 metatarsals, 49 astragali, 27 calcanea, 13 other tarsals, 124 phalanges, 36 metapodials: 2194 specimens.

Of the nine Last Supper Cave wapiti ("elk") specimens, one lacked provenience, six came from the *Neotoma* middens, one came from the Organic Stratum, and one from the Ash. All provenienced specimens thus date to the last 6000 years. Of the wood rat midden specimens, four came from the rear middens and may have been deposited during the last 2000 years. Unfortunately, little more can be said about the age of these specimens. Wapiti are unrecorded historically from northwestern Nevada and adjacent eastern Oregon and while the small number of wapiti specimens in Last Supper Cave could certainly have been transported some distance by people, the growing number of Holocene records for these animals in the more northerly parts of the Great Basin suggests that these animals were once widespread here, though apparently nowhere very abundant. I will return to the possible biogeographic significance of the Last Supper Cave wapiti specimens in chapter 6. The specimen recorded as a tarsal actually consists of an articulated left naviculocuboid, first tarsal, and fused second and third tarsal.

There is no suggestion that white-tailed deer (*O. virginianus*) might have occupied Nevada as far east as the Hell Creek area, and I have assigned all deer specimens to *O.* cf. *hemionus* on purely geographic grounds. Deer remains are routinely uncommon in prehistoric Great Basin faunas (Thomas, 1970a; Grayson, 1982a), and Last Supper Cave is no exception. The mountain sheep remains are discussed in detail below.

TABLE 30
Results of *t*-test Comparisons of Innominate Measurements for Modern *Mustela erminea,*
Modern *M. frenata,* and Last Supper Cave Specimen 355

	LS-355 with:
1. Spine-spine length	*M. erminea:* $t = 0.77, p > 0.10$
	M. frenata: $t = -1.17, p > 0.10$
2. Obturator foramen length	*M. erminea:* $t = 0.82, p > 0.10$
	M. frenata: $t = -1.58, 0.10 > p > 0.05$
3. Ischial width	*M. erminea:* $t = 0.58, p > 0.10$
	M. frenata: $t = -1.89, p < 0.05$
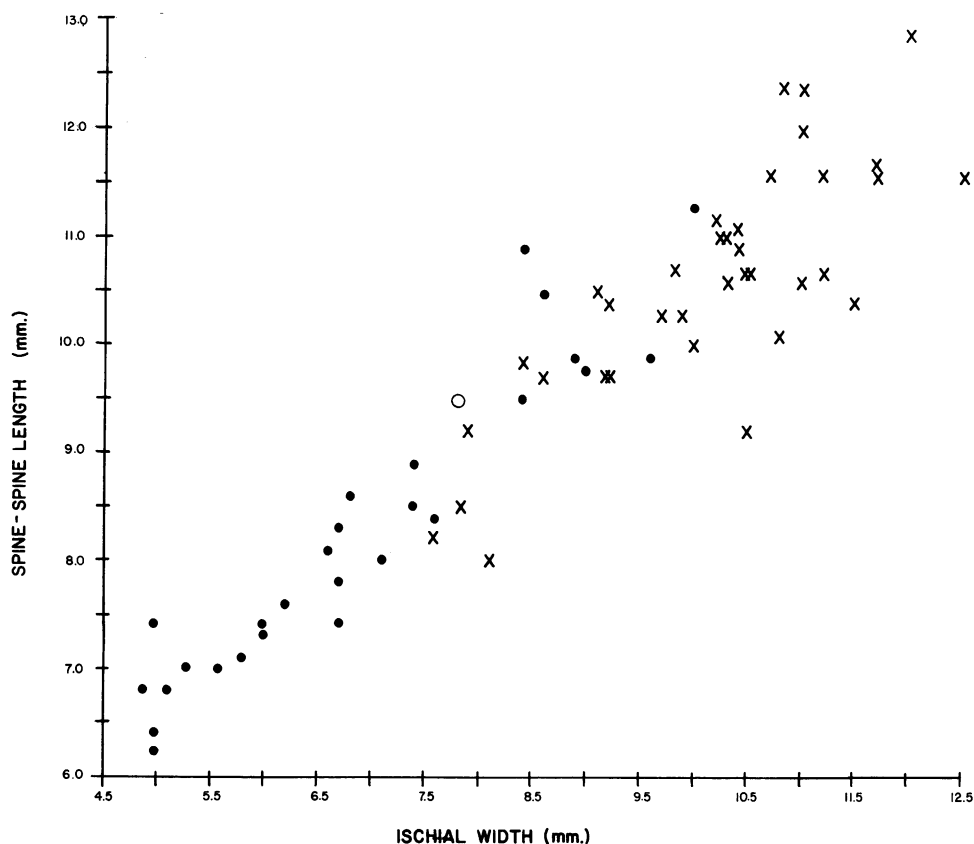
Fig. 10. Modern *Mustela erminea* (solid circles), *M. frenata* (x), and the Last Supper Cave *Mustela* sp. (open circle) innominates compared: ischial width and spine-spine length.

HUMAN MODIFICATION OF THE LAST SUPPER CAVE BONES

The bones of six mammalian taxa represented in the Last Supper Cave faunal assemblage show cut marks attributable to human activity: *Ovis canadensis, Marmota flaviventris, Lepus* sp., *Canis lupus,* and *Neotoma cinerea.* Of these six, only the samples available for mountain sheep and marmots are sufficient to demonstrate patterning in the placement of cut marks, and my discussion will focus on these two taxa.

Ovis canadensis

Of the 2194 identified mountain sheep specimens, 1810 (82.5%) come from the *Neotoma* middens that lined the southern and rear walls of the cave, while an additional 115 (5.2%) specimens lack within-site provenience of any sort (table 23). Given that so

few of the *Ovis* specimens can be placed securely in time, this collection must be analyzed as a single unit if it is to be analyzed at all, and that is the approach I follow here. Although the depositional chronology of this material is poorly controlled, I note that approximately 1470 (67%) of the Last Supper Cave *Ovis* came from the *Neotoma* midden in the rear of the cave (fig. 8). Since that midden has dates that span the last 1700 years, it is possible, and perhaps even likely, that the bulk of the Last Supper Cave *Ovis* material was deposited within that interval.

The mountain sheep specimens from this site have been modified in four very obvious ways. First, the vast majority have been burned. As I have already noted, the presence of burned dermestid beetle pupal cases in the shafts of a number of *Ovis* long bones demonstrates that the burning occurred sometime after the bones had been deposited. As a re-
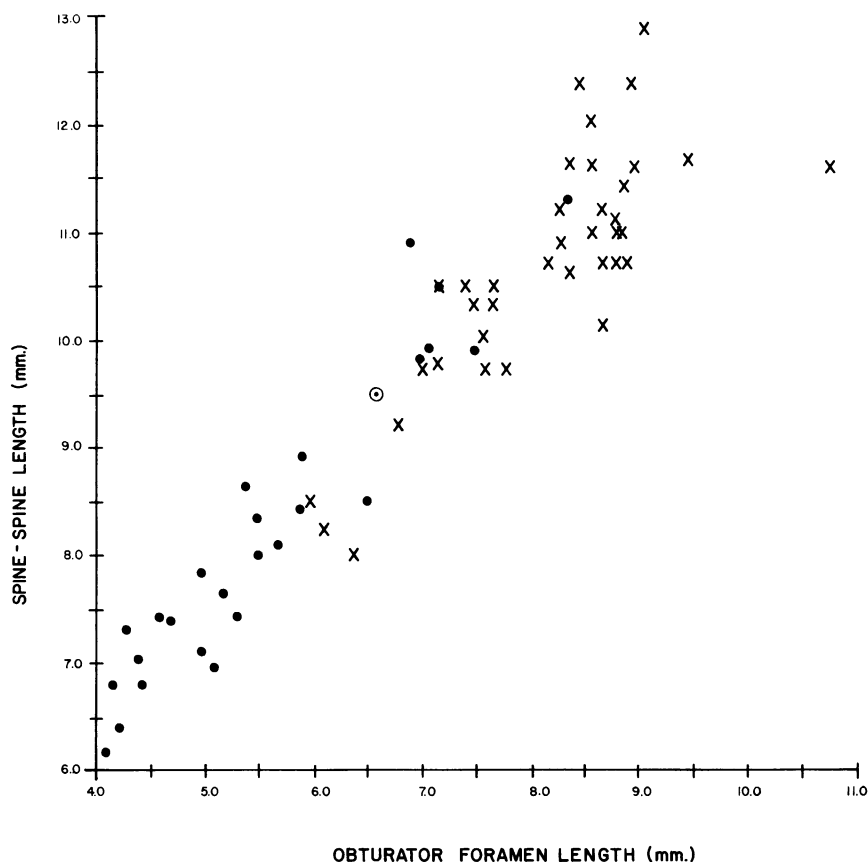
Fig. 11.   Modern *Mustela erminea* (solid circles), *M. frenata* (x), and the Last Supper Cave *Mustela* sp. (open circle) innominates compared: obturator foramen and spine-spine lengths.

sult, I have not analyzed the distribution of burning across elements (or across taxa) here.

Second, many of the *Ovis* bones have been gnawed by rodents, to judge from the paired, parallel, generally flat to slightly rounded depressions that occur on the margins of many of these bones. The size of the tooth scars suggests that a wood rat-size animal was responsible for much of the gnawing, hardly surprising given the provenience of most of the specimens. It is important to note that the often heavy rodent gnawing on these bones has frequently obscured bone surfaces to such an extent that other marks, for instance those made in conjunction with butchering, could not be detected on those surfaces had they once been present. The distal tibia provides an excellent example. There are 55 distal *Ovis* tibiae in the collection that retain the medial malleolus. Of these, nine show cut marks

(Td-3 of Binford, 1981). It would, however, be inaccurate to say that 16.4 percent of the medial malleoli have been so modified because 30 of the 55 have been so heavily gnawed by rodents that the original surface is simply no longer present. Thus, of the 55 medial malleoli in the collection, 55 percent cannot be examined for mark Td-3; of those that can be examined, 36 percent (9/25) show the mark. Nearly all the distal radii and the glenoid fossae of the scapula have been obscured in this fashion, and all other elements except teeth have suffered to one degree or another. As a result, the number of butchering marks and the number of butchered specimens provided below understate actual numbers by some unknown, but perhaps substantial, amount.

Even more obvious than rodent damage on the Last Supper Cave *Ovis* specimens,
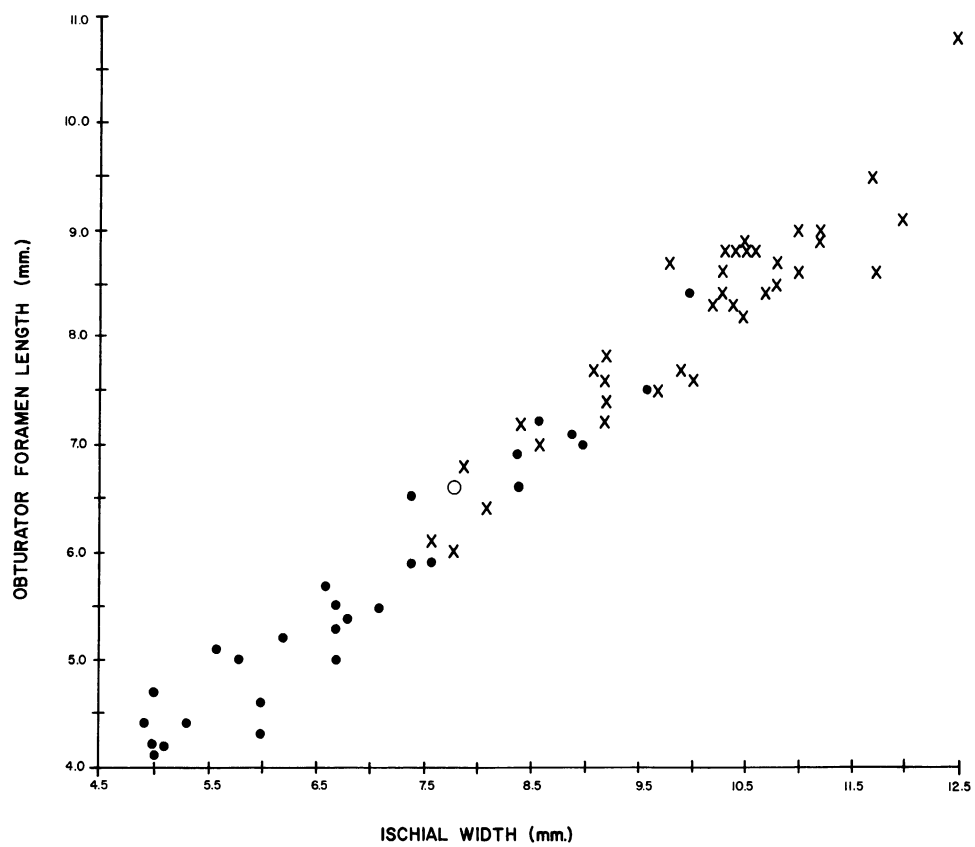
Fig. 12. Modern *Mustela erminea* (solid circles), *M. frenata* (x), and the Last Supper Cave *Mustela* sp. (open circle) innominates compared: ischial width and obturator foramen length.

TABLE 31
Carnivore Damage on Postcranial *Ovis*
Specimens from Last Supper Cave

Element	Number damaged	Total NISP	% damaged
Humerus	8	78	10.3
Radius/ulna	33	161	20.5
Scapula	12	34	35.3
Cervical vertebra	17	69	24.6
Thoracic vertebra	11	59	18.6
Innominate	1	9	11.1
Femur	1	5	20.0
Tibia	10	110	9.1
Astragalus	1	49	2.0
Metapodial	35	179	19.6
Phalanx 1	17	68	25.0
Phalanx 2	10	34	29.4
Phalanx 3	10	22	45.5
All others	0	243	0.0
Totals	166	1120	

however, is damage caused by carnivores. This damage has been substantial even if identified only in terms of two criteria: carnivore tooth impressions and punctures, and multiply notched, denticulate bone edges (e.g., Binford, 1981: figs. 3.40, 3.51). A total of 166 postcranial sheep specimens show such damage, 14.8 percent of the entire *Ovis* postcranial collection. Such marks are not evenly distributed across postcranial elements: only 2.0 percent of astragali have detectable carnivore damage, while 45.5 percent of third phalanges have been so altered (table 31). As with rodent damage, alterations to bone surfaces due to carnivore activity diminish the visibility of marks attributable to human activity.

While rodent and carnivore gnawing has obscured or removed many surfaces that might have held cut marks caused by people, such marks are nonetheless common on the

TABLE 32
Distribution of Last Supper Cave *Ovis* and Small Artiodactyl Specimens by Body Part, Exclusive of Long Bone Shafts and Tooth Fragments

	Frequency				
Element	*Ovis*	Small Artiodactyl	Total	MAU	%MAU
Skull	60	0	60	30	38.2
Hyoid	0	7	7		
Mandible	125	6	131	65.5	83.4
Atlas	33	5	38	38	48.4
Axis	39	3	42	42	53.5
Cervical vertebra	86	40	126	25.2	32.1
Thoracic vertebra	60	11	71	5.5	7.0
Lumbar vertebra	1	1	2	0.3	0.4
Innominate	8	99	107	53.5	68.2
Ribs: head	0	91	91	3.5	4.5
Ribs: total	0	459	459		
Sternum	1	1	2	0.3	0.4
Scapula	34	43	77	38.5	49.0
Humerus: distal	78	35	113	56.5	72.0
Radius: proximal	94	63	157	78.5	100.0
Radius: distal	44	13	57	28.5	36.3
Ulna: proximal	44	18	62	31	39.5
Ulna: distal	33	6	39	19.5	24.8
Carpals	64	8	72	6.0	7.6
Metacarpal: proximal	42	42	84	42	61.2[a]
Metacarpal: distal	42	1	43	21.5	51.0[b]
Femur: proximal	2	1	3	1.5	1.9
Femur: distal	3	1	4	2.0	2.6
Tibia: proximal	1	1	2	0.5	0.6
Tibia: distal	109	44	153	76.5	97.5
Tarsals	13	17	30	7.5	9.6
Astragalus	49	25	74	37.0	47.1
Calcaneus	27	30	57	28.5	36.3
Metatarsal: proximal	22	35	57	28.5	44.0[a]
Metatarsal: distal	37	0	37	18.5	47.1[b]
Phalanx 1	68	15	83	10.4	13.3
Phalanx 2	34	20	54	6.8	8.7
Phalanx 3	22	19	41	5.1	6.5
Metapodial: proximal	0	24	24		
Metapodial: distal	36	38	74		
Totals	1311	1222	2533		

[a] Includes half the total for proximal metapodials.
[b] Includes half the total for distal metapodials.

Last Supper Cave sheep specimens. They are also present on small artiodactyl specimens that could not be securely identified as *Ovis*, but that almost undoubtedly are mountain sheep. Of the 2234 identified small artiodactyl (*Odocoileus, Antilocapra, Ovis*) specimens, 98.2 percent are *Ovis*. It is reasonable to assume that since this is the case, an equivalent ratio of the small artiodactyl specimens that could not be identified to genus is also *Ovis*. Accordingly, my discussions of both the butchering marks on sheep bones and of skeletal part frequencies are based on the combined *Ovis* and small artiodactyl samples (table 32).

As Lyman (1987) has noted, we lack true diagnostics for the identification of all human-caused cut marks. The marks I have

TABLE 33

Descriptive Summary of Cut Marks on the Last Supper Cave *Ovis* Bones: Marks on the Binford (1981) Inventory

Element	Code number	Frequency
Skull	S-2	1
	S-4	3
Mandible	M-2	2
	M-3	4
	M-4	2
Thoracic vertebra	TV-2	8
Innominate	PS-7	1
	PS-8	13
	PS-9	2
	PS-10	1
Scapula	S-2	3
	S-3 (above and below spine)	2
Humerus: distal	HD-2 (anterior)	22
	HD-3	15
	HD-4	1
Radius: proximal	RCp-5 (medial)	15
	RCp-5 (anterior)	4
	RCp-6 (medial)	4
	RCp-6 (anterior)	1
Radius: distal	RCd-3 (lateral)	1
	RCd-3 (anterior)	1
Ulna: proximal	RCp-3	1
	RCp-5	5
	PCp-7	1
Tibia: distal	TD-3 (medial malleolus)	9
Astragalus	TA-2	14
Metatarsal: proximal	MTp-3	2
Metapodial: distal	MTd-2	3
Total		141

identified as such were linear, narrow, had V-shaped cross sections, and often occurred in parallel sets. I eliminated from consideration as human-inflicted any mark that terminated in a notch or in any other feature reflecting carnivore activity; eliminated as well were all marks whose color contrasted with that of the surrounding bone and thus suggested postdepositional origin.

The majority (64.5%) of human-inflicted cut marks identified in this fashion are extremely well-described by the inventory assembled by Binford (1981, table 4.04), and I have accordingly used Binford's inventory codes to summarize those marks (table 33). In a number of instances, Binford's codes describe marks of apparently similar function

but slightly different position: mark RCp-5, for instance, can appear on the medial or anterior aspect of the proximal radius. In order to clarify the precise position of cut marks on the Last Supper sheep specimens, I have added positional indicators to Binford's code marks as needed in table 33. I note that of the 141 examples of marks that fall into categories analyzed by Binford (1981), 118 (83.7%) are in categories ascribed by him to dismemberment. However, although I find Binford's categories to be of extraordinary value, I remain unconvinced that only the activities listed by him could have produced these marks (Grayson, 1982a; see also Lyman, 1987).

In addition to marks that appear in locations inventoried by Binford (1981), there are 76 marks that do not appear in the Binford inventory. These are listed and described in table 34; most are illustrated in figures 13 through 15. It may be significant that a higher degree of redundancy is present for those marks inventoried by Binford (1981) and present on the Last Supper Cave sheep specimens (6.4% of the marks in table 33 occur only once) than for those marks not on the Binford inventory (17.1% of the marks in table 34 occur only once). Assuming that patterning implies an agent that acts in a patterned way, the relative lack of redundancy for the latter set of marks might reflect failure of the criteria I employed in identifying these marks to adequately discriminate against other sources of bone damage. Marks similar to some of the nonreplicated examples in table 34, however, do appear to exist in other Great Basin collections (Thomas and Mayer, 1983).

The 217 cut marks on the *Ovis* specimens from Last Supper Cave document a significant human role in the accumulation of this collection. What tables 33 and 34 do not show, however, is that there are a number of apparent oddities in the frequency distribution of the skeletal parts represented in the Last Supper Cave sheep collection, oddities that remain when material identified only as small artiodactyl is included. There are, for instance, 107 innominate fragments, contributed by roughly 53.5 (107/2) individuals. There are 38 atlas bodies, requiring 38 sheep for their presence. There are, however, no sacra and no proximal humeri. Binford (1978)

TABLE 34
**Descriptive Summary of Cut Marks on the Last Supper Cave *Ovis* Bones: Marks
Not on the Binford (1981) Inventory**

Element	Description	Frequency
Skull	Between infraorbital foramen and nasal border, parallel to tooth row or superior premaxillary border (fig. 13a)	8
	Oblique cuts above P4-M1 (fig. 13b)	1
	Above, beneath, or anterior to facial tuberosity (fig. 13c)	3
Mandible	At base of coronoid process, from anterior border of ramus to beneath mandibular notch (fig. 14a)	12
	On posterolateral edge of ascending ramus, immediately to 2.5 cm beneath condyle (M-5?) (fig. 14b)	7
	Beneath m3 at right angle to ventral border of body (fig. 14c)	1
	Between i4 alveolus and mental foramen	1
	On superior surface of diastema	1
Vertebra: cervical	On ventral surface of anterior zygapophysis parallel to spine	1
Innominate:	Just posterior to auricular surface along ventral border of ilium	1
Scapula	As Binford S-1 but costal	5
	As Binford S-2 but costal	1
	On anterior border of head at base of tuberosity	3
Radius: proximal	As Binford RCp-6 but lateral	2
Metacarpal: proximal	On anterior face of shaft parallel to proximal articular surface, 1–2 cm distal to that surface (MCp-1?)	3
Rib	On dorsal surface of body, oblique to main axis (fig. 15a)	5
	On ventral surface of body, oblique to main axis (fig. 15b)	1
	Immediately distal to tubercle:	
	cranial border (fig. 15c)	3
	dorsal surface (fig. 15d)	2
	caudal border (fig. 15e)	3
Femur:	On posterior shaft at mid-section	2
Tibia: distal	On anterior or anterolateral border of shaft 3–5 cm proximal to distal end of medial malleolus	3
	In flexor digitalis longus groove	1
	In muscle scar at base of medial malleolus	1
	On medial face of distal shaft	1
Phalanx 1	On dorsal surface of shaft	1
	On lateral surface of shaft	2
	On ventral surface of shaft	1
Total		76

has argued that analysis of such differential abundances of skeletal parts can be combined with knowledge of the economic anatomy of large mammals to better understand the human adaptive strategies that led to the accumulation of a given faunal assemblage.

Binford's approach is now well-known. His measure of economic utility is the Modified General Utility Index, or MGUI, which assigns relative economic importance to skel-etal parts by assessing amounts of meat, marrow, and grease associated with those parts (Binford, 1978). If, Binford (1978) reasoned, people utilized large mammals in line with the economic utility of parts of those mammals, such usage should be evident in the relationship between the relative frequency of skeletal parts in a faunal assemblage and the economic importance of those parts. To examine this relationship, Binford required
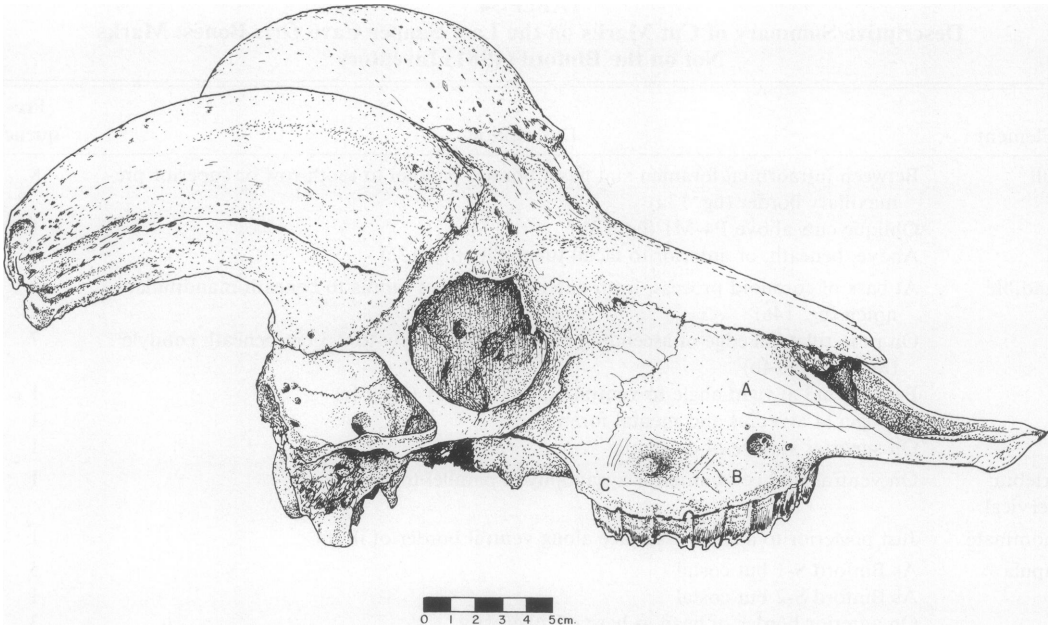
Fig. 13.   Cut marks on Last Supper Cave *Ovis* skulls (letters are keyed to descriptions in table 34).

two measures: a measure of economic utility, and a measure of relative skeletal abundance. The former is provided by the MGUI. The latter is provided by the "minimal animal unit" (MAU), or the number of identified specimens per anatomical unit (for instance, the number of proximal humeri) divided by the number of times that part occurs in the
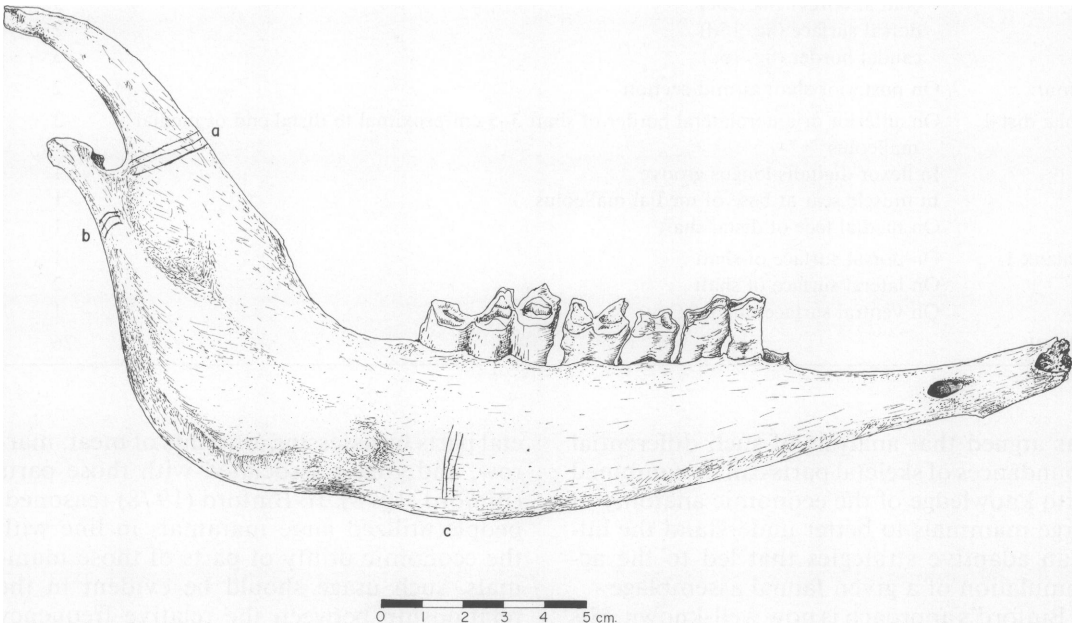
Fig. 14.   Cut marks on Last Supper Cave *Ovis* mandibles (letters are keyed to descriptions in table 34).

skeleton of the animal involved (twice for the proximal humerus). Relative skeletal abundance is then calculated by setting the highest MAU to 100 percent, and scaling the remaining values accordingly.

Arraying relative skeletal abundances against MGUI values in this fashion can yield a family of curves, each of which is associated with a very different animal utilization strategy (Binford, 1978; Thomas and Mayer, 1983). In a gourmet strategy, for instance, only those parts of extremely high utility are kept, the rest discarded, producing a parabolic curve that extends upwards from lower left to upper right (see Binford, 1978: fig. 2.18; Thomas and Mayer, 1983: fig. 188D). In a reverse utility strategy, elements of generally higher utility tend to be kept while elements of generally lower utility tend to be discarded, thus producing a negative hyperbolic (L-shaped) curve (Thomas and Mayer, 1983: fig. 188A). As Thomas and Mayer (1983) note, the archaeologist's monitoring perspective plays a crucial role in analyzing such curves. The pattern that results from the application of a reverse utility strategy will look one way at a kill site but quite a different way at the point of consumption. Plots of the sort pioneered by Binford (1978) have tremendous potential in analyzing prehistoric subsistence strategies, *assuming that* economic considerations of the sort considered and quantified by Binford (1978) were key to the prehistoric decision-making process, and assuming that the pattern of bone preservation in a given assemblage reflects decisions based on those considerations.

Thomas and Mayer (1983: 370) applied Binford's approach to the very sizable *Ovis* collection from Horizon 2 (ca. A.D. 1300) of Gatecliff Shelter, Toquima Range, central Nevada (table 35), and found that "the Horizon 2 curve almost exactly corresponds to the *ideal reverse utility strategy*—a kill-butchering site model reflecting discard of relatively low utility parts and retention (transport) of faunal elements relatively high in economic utility" (see fig. 16). Although curious exceptions existed (for instance, the innominate), a reverse utility model fit the Horizon 2 setting extremely well.

On at least superficial levels, Gatecliff Shelter and Last Supper Cave are similar sites:

Fig. 15.   Cut marks on Last Supper Cave *Ovis* ribs (letters are keyed to descriptions in table 34).

upland shelters in areas that prehistorically supported large numbers of mountain sheep. In addition, both contained substantial numbers of mountain sheep bones, the Horizon 2 material deposited at approximately A.D. 1300, the Last Supper Cave material apparently largely within the past 1700 years. More detailed comparisons are difficult to make, since the Last Supper Cave artifacts remain unanalyzed. However, the superficial similarities suggest that Last Supper Cave was a kill-butchering station at which cuts of higher economic utility were removed from mountain sheep carcasses for transport to residential sites elsewhere, just as Thomas and Mayer (1983) suggested for Gatecliff Horizon 2.

Producing a comparable plot for the Last Supper Cave sheep assemblage requires MGUI values for sheep, provided by Binford (1978: 74), and a measure of relative skeletal abundance. As normed specimen counts, Binford's MAU values present some difficulties even when dealing with well-preserved ethnographic material (Grayson,

<div align="center">

TABLE 35

Relative Skeletal Abundances for Mountain Sheep: Last Supper and Gatecliff Horizon 2 Compared

</div>

Element	Last Supper		Gatecliff Horizon 2	
	%MAU	Rank	%MAU	Rank
Radius: proximal (PR)	100.0	1	75.6	2
Tibia: distal (DT)	97.5	2	68.9	6
Mandible (Mand)	83.4	3	71.1	5
Humerus: distal (DH)	72.0	4	73.3	3.5
Innominate (Pelv)	68.2	5	100.0	1
Metacarpal: proximal (PMc)	61.2	6	48.9	14
Axis (Ax)	53.5	7	48.9	14
Metacarpal: distal (DMc)	51.0	8	17.8	24
Scapula (Scap)	49.0	9	53.3	10.5
Atlas (At)	48.4	10	48.9	14
Astragalus (Ast)	47.1	11.5	66.7	7
Metatarsal: distal (DMt)	47.1	11.5	35.6	18
Metatarsal: proximal (PMt)	44.0	13	73.3	3.5
Ulna: proximal (PU)	39.5	14	53.3	10.5
Skull (Sk)	38.2	15	26.7	20.5
Calcaneus (Calc)	36.3	16.5	62.2	8.5
Radius: distal (DR)	36.3	16.5	62.2	8.5
Cervical vertebra (CV)	32.1	18	9.8	30
Ulna: distal (DU)	24.8	19	33.3	19
Phalanx 1 (Ph1)	13.3	20	50.0	12
Tarsals (Tars)	9.6	21	22.2	23
Phalanx 2 (Ph2)	8.7	22	24.4	22
Carpals (Carp)	7.6	23	11.1	29
Thoracic vertebra (TV)	7.0	24	3.3	33
Phalanx 3 (Ph3)	6.5	25	13.3	26.5
Rib: head (Rib)	4.5	26	3.8	31
Femur: distal (DF)	2.6	27	42.2	17
Femur: proximal (PF)	1.9	28	26.7	20.5
Tibia: proximal (PT)	0.6	29	44.4	16
Lumbar vertebra (LV)	0.4	30.5	11.4	28
Sternum (ST)	0.4	30.5	3.6	32
Humerus: proximal (PH)	0.0	32.5	15.6	25
Sacrum (Sac)	0.0	32.5	13.3	26.5

1984). Truly significant problems arise, however, when dealing with highly fragmented collections because such collections require the reconstruction of the "minimum numbers of elements" (MNE: see Binford, 1981, 1984), units that are characterized by all the flaws that debilitate the "minimum number of individuals" as a counting unit in faunal work (Grayson, 1984). In order to apply Binford's approach while attempting to reduce the problems associated with the calculation of MNE values, I adopted a number of counting conventions similar to those used by Davis (1985) and Thomas and Mayer (1983). In particular, I determined the best-represented section of a given element and based my counts on it. For the innominate, for instance, counts are based on the acetabulum; for the scapula, on the glenoid fossa; for phalanges, on the proximal end; for vertebrae, on the centrum. Counts for both maxillae (skulls) and mandibles are based on alveolar overlap. With one partial exception, MAU values were then derived just as Binford (1978, 1984) derives them: the count for a given element is divided by the number of times that element occurs in a sheep skeleton.

The partial exception was made for ribs. As Thomas and Mayer (1983) note, archaeological ribs are generally head and body fragments, and MAU values based on these two very different parts may vary considerably. Thomas and Mayer (1983) solved this problem by counting ribs in two different ways.
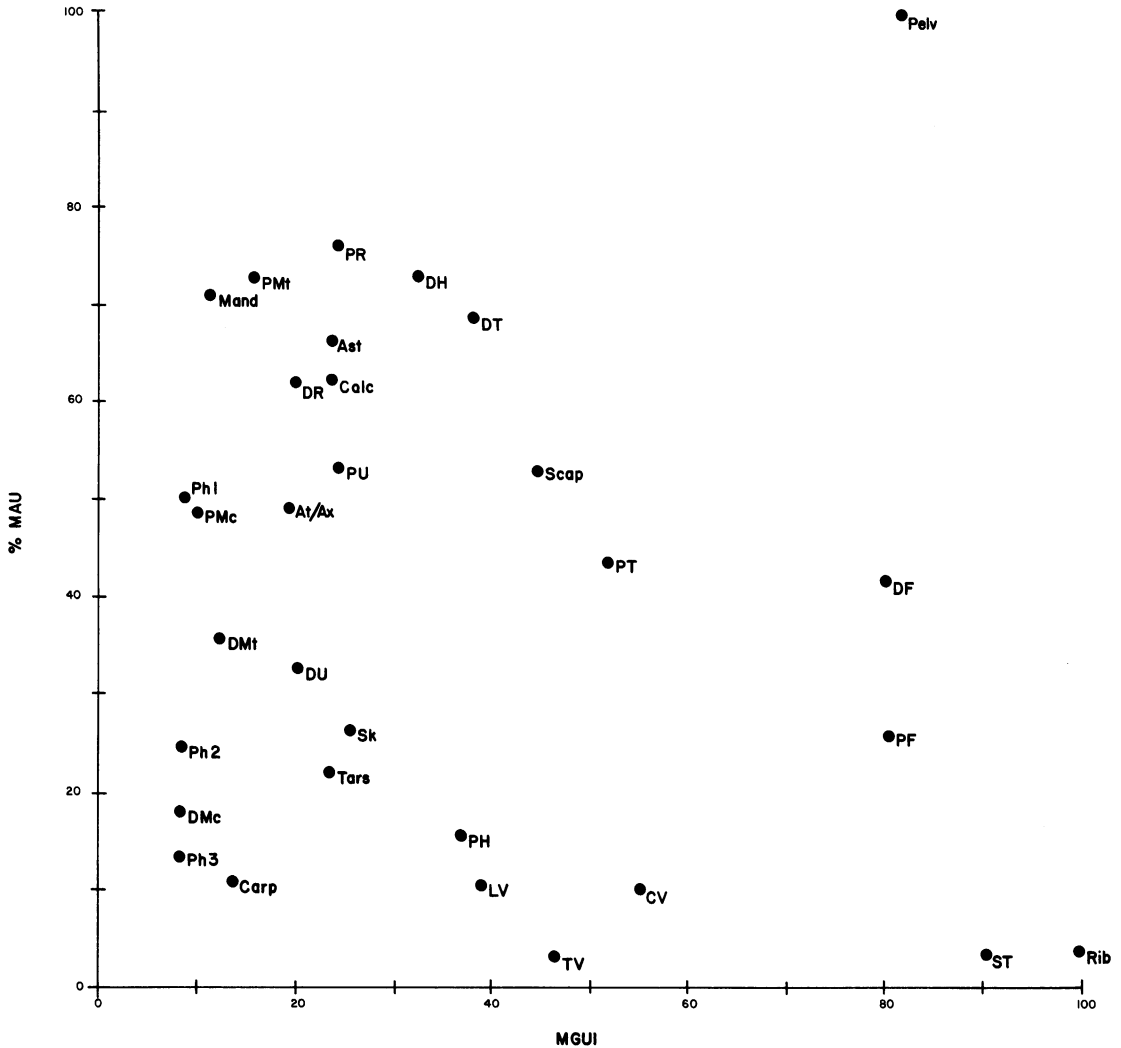
Fig. 16.   The relationship between MGUI and %MAU, Gatecliff Horizon 2 *Ovis* (from Thomas and Mayer, 1983; see table 35 for key to abbreviations).

First, they simply divided the total number of rib heads by 26, the number of ribs found in a mountain sheep skeleton. Second, they measured the length of all rib body fragments and divided that length by the 630 cm of ribs found in an average mountain sheep skeleton. They did not claim that this second calculation provided a reasonable estimate of the number of sheep represented by ribs in the collection, but instead used the resultant figure only to assess the magnitude of difference between it and that which resulted from the first calculation. They discovered that no matter which measurement they used, ribs were poorly represented in the Gatecliff Ho-

rizon 2 collection. The same is true at Last Supper Cave. There are 91 articular ends of ribs in this collection, or 3.5 individuals in Binford's sense. There are 368 rib body fragments; these, along with the 91 articular ends, represent 2942 cm of ribs, or 4.7 individuals in Thomas and Mayer's sense. Again, no matter which measure is used, ribs are poorly represented in the collection: 4.5 percent of the maximum MAU on the one hand, 5.9 percent on the other.

   The figures that result from these counting procedures are provided in tables 32 and 35. Arraying the %MAU values against corresponding MGUI values for sheep (Binford,
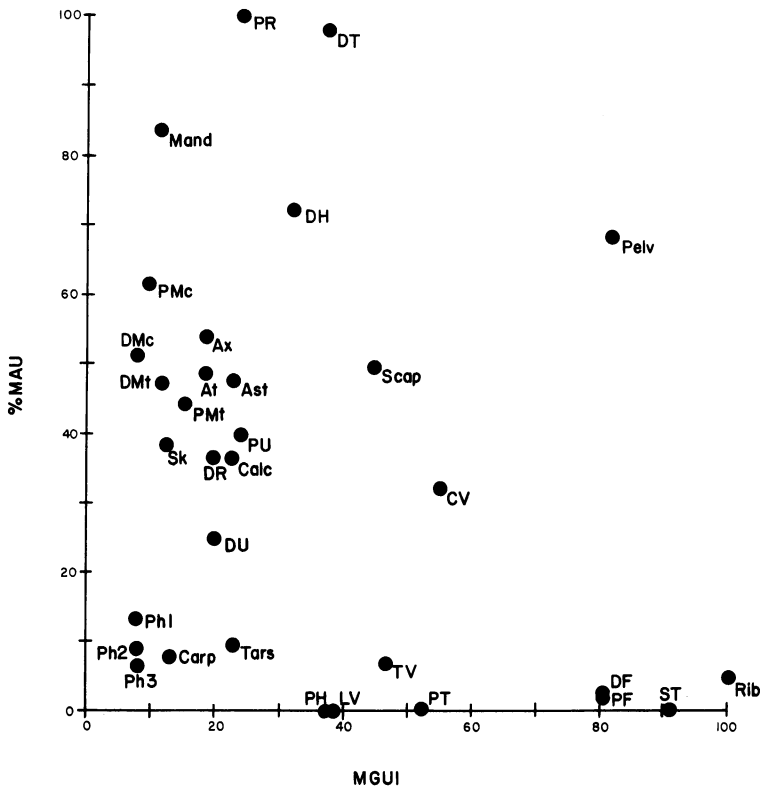
Fig. 17.   The relationship between MGUI and %MAU, Last Supper Cave *Ovis* (see table 35 for key to abbreviations).

1978: 74) provides the plot shown in figure 17. This plot is extremely similar to that provided by Thomas and Mayer (1983) for the Gatecliff Horizon 2 sheep (fig. 16).

Similarity in general form between hand-fit "Binfordian" faunal curves, however, does not necessarily mean similarity in detail. A reverse utility curve, for instance, is built on the relative abundance of elements that fall high on the MGUI scale. Thus, ribs must be low in abundance if a reverse utility curve is to emerge. The proximal radius, on the other hand, can be low or high because it falls on the "vertical" portion of these hand-fit curves, and the same is true for the relative abundances of cervical vertebrae, metacarpals, metatarsals, and for any element whose MGUI value is less than 30 percent or so. Reverse utility curves result not from the behavior of low ranked elements, but from the behavior of high ranked ones.

As a result, the fact that the general shapes of the %MAU-MGUI relationship are similar for the Gatecliff Horizon 2 and Last Sup-

per Cave mountain sheep assemblages does not imply that the two are similar in detail or that the placement of particular elements is similar. A glance at figures 16 and 17, however, suggests that the similarities do extend to details: the innominate is the obvious outlier on both plots, ribs are similarly rare on both, the proximal radius is the most abundant Last Supper Cave element, the second most abundant on Gatecliff Horizon 2. Figure 18 plots Gatecliff Horizon 2 %MAU values against those for Last Supper Cave and shows how similar the relative skeletal frequencies are at both sites. Spearman's rank-order correlation coefficient (r_s) between the two sets of values is +0.745 ($p < 0.001$).

It seems reasonable to conclude that similar mechanisms are structuring the relative skeletal abundances in these two assemblages, and it is tempting to conclude with Thomas and Mayer (1983) that human behavior provides that mechanism. Lyman (1985), however, has provided a significant caution to any such conclusion. Using bone
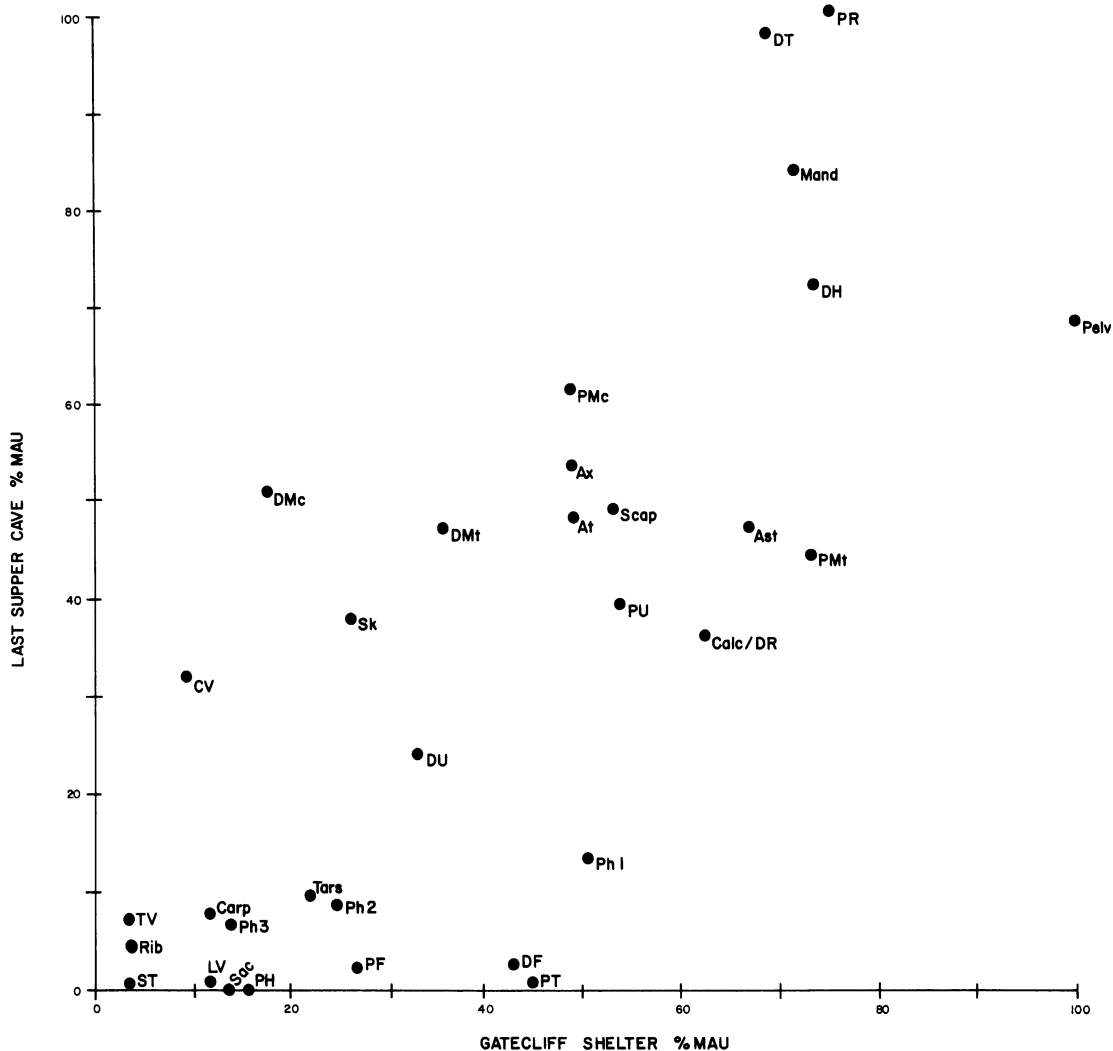
Fig. 18.   The relationship between the Gatecliff Horizon 2 and Last Supper Cave *Ovis* in terms of %MAU (see table 35 for key to abbreviations).

density values derived from the most detailed analysis of nonhuman bone density yet conducted (Lyman, 1984), Lyman (1985) observed that many bones that rank high on the MGUI index rank low in bone density, while many that rank low in economic utility rank high in density. As a result, inverse correlations between MGUI and %MAU may reflect either differential bone transport by people or bone destruction by any agent. Indeed, Lyman (1985) showed a significant correlation between bone density and relative skeletal abundance for the Gatecliff Horizon 2 sheep assemblage (Kendall's tau = +0.354,

$p = 0.006$). While Lyman did not argue that Thomas and Mayer (1983) had erred in attributing the Horizon 2 negative hyperbolic relationship to human behavior, he did note that bone destruction by a nonhuman agent could have caused this pattern.

Lyman's argument is critically important: the Last Supper and Gatecliff patterns are predicted by both human transport and human or nonhuman destruction models. Which best accounts for these patterns?

Lyman (1985) demonstrated that at the Garnsey bison kill site in New Mexico (Speth, 1983), the correlation between bone density

TABLE 36
The Anavik Spring Caribou Kill-Butchering Site:
%MAU, MGUI, and Bone Density Values
(Data from Binford, 1978; Lyman, 1984, 1985)

Element	%MAU	MGUI	Bulk density
Antler	100.0	1.02	—
Skull	83.0	8.74	—
Mandible	73.5	13.89	0.57
Atlas	75.4	9.79	0.13
Axis	83.0	9.79	0.16
Cervical vertebra	79.2	35.71	0.19
Thoracic vertebra	37.7	45.53	0.24
Lumbar vertebra	45.2	32.05	0.29
Sacrum	35.8	—	0.19
Innominate	42.4	47.89	0.27
Ribs	26.4	49.77	0.25
Sternum	28.3	64.13	0.22
Scapula	33.9	43.47	0.36
Humerus: proximal	28.3	43.47	0.24
Humerus: distal	31.1	36.52	0.39
Radius: proximal	36.7	26.64	0.42
Radius: distal	46.2	22.23	0.43
Ulna: proximal	36.7	26.64	0.30
Ulna: distal	46.2	22.23	0.44
Carpals	56.0	15.53	—
Metacarpal: proximal	59.4	12.18	0.56
Metacarpal: distal	59.4	10.50	0.49
Femur: proximal	16.9	100.00	0.36
Femur: distal	16.9	100.00	0.28
Tibia: proximal	24.5	64.73	0.30
Tibia: distal	25.4	47.09	0.50
Tarsals	32.6	31.66	0.39
Astragalus	39.6	31.66	0.47
Calcaneus	38.6	31.66	0.64
Metatarsal: proximal	41.5	29.93	0.55
Metatarsal: distal	43.3	23.93	0.46
Phalanx 1	69.0	13.72	0.42
Phalanx 2	68.4	13.72	0.25
Phalanx 3	67.1	13.72	0.25

and relative skeletal frequency is not significant (tau = −0.162, p = 0.214), and that some of the least dense bison bones are among the most frequent in the assemblage. This pattern, Lyman (1985) argued, supports Speth's contention that the pattern of element representation in the Garnsey collection is best accounted for by human transport behavior. I expand Lyman's approach here in order to assess whether human or nonhuman factors can best account for the Gatecliff Horizon 2 and Last Supper Cave *Ovis* patterns.

In a reverse utility curve, skeletal parts that are high on the MGUI scale are low in relative abundance; those parts that are low on this scale are high in abundance. As a result of this inverse relationship, rank-order correlation coefficients between MGUI and %MAU are both significant and negative in the reverse utility setting. On the other hand, and as Lyman (1985) observed, where bone destruction is producing a negative hyperbolic relationship between %MAU and MGUI, that relationship occurs because low-density bones of high utility have been destroyed, while high-density bones of low utility have survived. Thus, in this situation bones of high density have preferentially survived, which should create a significant but positive rank-order correlation between %MAU and bone density.

In short, situations in which human transport of bones played the major role in producing a negative hyperbolic %MAU-MGUI curve should be characterized by significant negative correlations between %MAU and MGUI, but insignificant correlations between %MAU and bone density. The data provided by Binford (1978: 78) for the Anavik spring caribou kill-butchering site show these relationships extremely well (table 36). The correlation (r_s) between caribou %MAU and MGUI at this site is −0.737 (p < 0.001): that is, just as the transport hypothesis predicts, the correlation is significant and negative. Bone density data are not available for caribou, but Lyman (1984) provides bulk density figures for a large number of anatomical sites on the deer (*Odocoileus* spp.) skeleton, excluding the skull and carpals. Assuming that the rank orders of bulk density are similar between deer and the confamilial caribou, and excluding the skull and carpals from the comparison, the relationship between caribou % MAU and skeletal part bulk density at Anavik is insignificant: r_s = −0.019 (p > 0.20; the correlation between caribou % MAU and caribou MGUI excluding the skull and carpals is r_s = −0.688, p < 0.001). Were Anavik archaeological, it would be safe to conclude that the pattern represented here resulted from transport.

Situations produced not by transport but by destruction should be characterized by relationships between %MAU and MGUI that are not significant, but between %MAU and

TABLE 37
Predictions of Rank-Order Correlation Coefficient Values Made by Transport and
Destruction Models in "Reverse Utility" Settings

Causal factor	Variables	Predicted coefficient value
Transportation	%MAU—Bone density	Insignificant
	%MAU—MGUI	Significant/negative
Destruction	%MAU—Bone density	Significant/positive
	%MAU—MGUI	Insignificant

bone density that are significant and positive. The interpretation of other combinations— for instance, of a significant positive correlation between %MAU and bone density with a significant negative correlation between %MAU and MGUI—will be more difficult to interpret. At least, however, the two combinations I have discussed seem relatively unambiguous (table 37).

Can this approach help determine why the Last Supper Cave and Gatecliff Horizon 2 *Ovis* plots look the way they look? Unfortunately, bone density data of the sort made available by Lyman (1984) for deer are not available for mountain sheep. Lacking such data, I will use Lyman's *Odocoileus* values in my analysis, assuming that the rank orders of density values are the same for both genera. I see little reason to doubt that this is the case, with the exception of the cervical vertebrae, whose robusticity in *Ovis canadensis* far exceeds that in *Odocoileus,* presumably because of the heavy nuchal musculature needed to support the massive horns of males and to withstand the stresses generated by male head-butting. Accordingly, I have eliminated cervical vertebrae from my analysis. I have also eliminated the skull and carpals, for which density measurements are unavailable. Lyman (1985) used the bulk density value for the body of the rib in his study. Because the Last Supper Cave and Gatecliff Horizon 2 counts are for the articular ends of ribs, I have used Lyman's measurement RI2, for the tubercular area of the rib (Lyman, 1984).

At Last Supper Cave, the relationship between bone density and %MAU is positive and very significant ($r_s = +0.704, p < 0.001$); the relationship between %MAU and MGUI is negative but insignificant ($r_s = -0.312, p > 0.05$). The pattern for Gatecliff Horizon 2 is equally clear. The relationship between

%MAU and bone density is again positive and highly significant ($r_s = +0.667, p < 0.001$), that between %MAU and MGUI barely negative and insignificant ($r_s = -0.045, p > 0.10$; see table 38). These results are compelling. Although there can be no doubt that humans were involved in the accumulation of the mountain sheep bones at both sites— as the butchering marks clearly document— bone destruction provides a much better explanation for the pattern of relative skeletal abundance, and for the "reverse utility curves," seen at both sites than does the human transport model.

The question remains, of course, as to the identity of the agent of destruction. There are no complete long bones in the Last Supper Cave *Ovis* assemblage, but only occasionally is the agent of breakage clear. It is, for instance, clear in the case of the distal humerus. Of the 78 distal humeri in the collection, 66 retain sufficient amounts of shaft to observe the nature of breakage on the proximal end of that shaft. Of those 66, 63 show impact

TABLE 38
Correlation Coefficients for %MAU and Bone Density, and %MAU and MGUI Values for the Anavik Caribou, Last Supper Cave *Ovis,* and Gatecliff Horizon 2 *Ovis* Assemblages

Assemblage	r_s	p
Anavik:		
%MAU—Bone density	−0.019	>0.20
%MAU—MGUI	−0.688	<0.001
Last Supper Cave:		
%MAU—Bone density	+0.704	<0.001
%MAU—MGUI	−0.312	>0.05
Gatecliff Horizon 2:		
%MAU—Bone density	+0.667	<0.001
%MAU—MGUI	−0.045	>0.20

scars suggestive of dynamic loading, with single notches at the point of impact. Of these 63, 53 show wedge flakes roughly opposite the point of impact (terminology follows Johnson, 1985). While carnivore damage might produce generally similar damage, only seven of these 63 specimens show such clear evidence of carnivore damage as tooth impressions and punctures, and only four show such evidence on the shaft. The radius, tibia, and metapodials also show similar breakage in the absence of carnivore damage, but no other element shows the combination of spiral fracture, single impact notches, and wedge flakes in numbers comparable to that on the distal humerus. People were clearly breaking mountain sheep bones by percussion at Last Supper Cave, and Thomas and Mayer (1983) document similar behavior in the Gatecliff Horizon 2 collection.

Because people were clearly breaking bones by percussion at both Last Supper Cave and Gatecliff Shelter, it is certainly possible that at least some of the density mediated destruction in both *Ovis* assemblages was caused by people. However, evidence for human-caused long bone breakage in the Last Supper Cave assemblage is largely confined to the shafts of those bones, while carnivore damage is more evident on articular ends. This pattern—that people attack shafts while carnivores attack articular ends—has been noted elsewhere (Binford, 1978, 1981). Given the heavy amount of carnivore damage sustained by both the Last Supper Cave mountain sheep specimens (table 31) and the Gatecliff Shelter Horizon 2 materials (Thomas and Mayer, 1983), carnivores seem by far the most likely cause of the "reverse utility curves" derived for both assemblages. Most importantly, regardless of the agent of destruction, neither curve seems likely to have been produced by human transport of economically valuable body parts of *Ovis*.

Marmota flaviventris

Twenty marmot mandibles in the Last Supper Cave faunal assemblage have been cut in one or more of three places. Sixteen of these mandibles show one or more cut marks on the buccal face of the body and ascending ramus, cuts that begin just beneath the alveoli and extend to the posterior border of the ascending ramus, running roughly parallel to the ventral border of the ramus. Two of these mandibles show oblique cuts at or immediately anterior to the point where the superior and inferior masseteric lines join, while two show oblique cuts along the ventral border of the body beneath p4 and the mental foramen. One specimen combines all three marks; all others occur singly (fig. 19).

The cuts across the ascending ramus appear to have been placed to sever the masseter, presumably to remove the mandible. Why the mandible was removed is a different issue. This could have been done either as part of processing marmot carcasses for consumption, or to remove the mandible intact for use as a tool. Echlin et al. (1981), for instance, have suggested that archaeological *Lepus* mandibles with their broad, flat incisors were used as flakers, and a similar use might be posited for the Last Supper Cave specimens. The occlusal surfaces of the marmot incisors from this site, however, are too fragmentary to examine this notion by looking for wear on those surfaces.

Whatever the reason, however, marmot mandibles were being removed in this fashion in several parts of the Great Basin. Hanging Rock Shelter provided a single specimen cut in an identical fashion (see below), while Alta Toquima Village, at an elevation of 11,000 ft (3353 m) in the Toquima Range of central Nevada, provided two such examples (Thomas, 1982; Grayson, unpubl.). Unfortunately, only the Alta Toquima specimens can be dated with any precision: this site was occupied between A.D. 1300 and very early historic times. The Hanging Rock Shelter specimen comes from stratum 2 (Suborganic), which spans much of the Holocene. Ten of the Last Supper Cave specimens are from *Neotoma* middens, seven lack secure provenience, while one is from stratum 2 (Ash) and is thus late Holocene in age.

An additional 24 marmot bones show various cuts, nicks, and scrapes, some of which might have been caused by human activities. However, none of these are localized at a given spot on a given specimen. There are, for instance, 15 femur shafts with cuts at right angles to the main axis of the shaft, but these may be found anywhere along the length of the posterior aspect of the shaft. The same is true for similar marks on the lateral aspect of the shafts of two ulnae and four radii, and on the lateral (two specimens) and posterior

(one specimen) surfaces of the tibial shaft. A human origin for these marks appears unlikely. Only the mandible shows clear signs of human-inflicted cut marks among the bones of the Last Supper Cave marmots.

Other Taxa

Five other specimens, from four additional taxa, show human-caused cut marks. Two *Lepus* tibiae have been cut at the distal end of the shaft, at right angles to the main axis of the bone, one on the posterior face of the shaft (Surface), the other on both posterior and anterior aspects of the shaft (*Neotoma* midden). A single *Sylvilagus* cf. *nuttallii* tibia has been scored and snapped at midsection (Organic), while a *Canis lupus* ulna has been treated in an identical way, with the scoring 2.5 cm distal to the radial notch (LS-367, *Neotoma* midden). Finally, a single *Neotoma cinerea* mandible (LS-254, Ash) bears a cut mark that extends across the ascending ramus at toothrow level, parallel to the toothrow. This placement is identical to that seen in the 16 marmot mandibles noted above and likewise seems to represent severing of the masseter muscle.

CONCLUSIONS

Analysis of the Last Supper Cave mountain sheep assemblage suggests that while the negative hyperbolic curves that so frequently characterize the relationship between artiodactyl relative skeletal part abundance (%MAU) and Binford's modified general utility index (MGUI) in archaeological sites might be analytically meaningful, it may be extremely difficult to discover precisely what that meaning is outside of the well-controlled ethnoarchaeological settings that led to such analyses in the first place. At Last Supper Cave, the "reverse utility curve" that emerges from the analysis of nearly 2000 *Ovis* specimens seems better explained by bone destruction, probably by carnivores, than by economically based decisions by people that led to differential bone transport either into or out of the cave. The same seems to be true for the "reverse utility curve" derived for Horizon 2 at Gatecliff Shelter by Thomas and Mayer (1983). Last Supper Cave suggests that extreme caution is needed in analyzing such curves, even if we accept the analytic assumptions on which they are based.
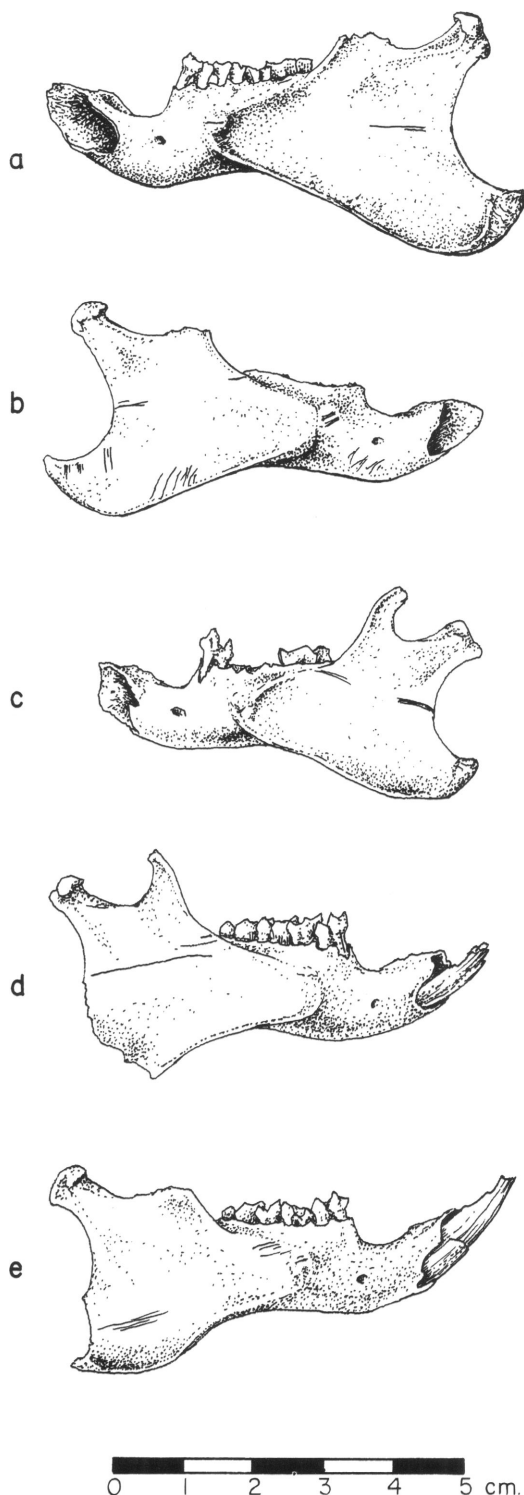
Fig. 19. Cut marmot mandibles from Last Supper Cave (**a**, LS-256/84; **b**, LS-333/70; **c**, LS-373/15; **d**, LS-256/40; **e**, LS-353/42).

Until further information is available on the chronology of the Last Supper Cave deposits and on the artifacts they contained, little more can be said of the large mammalian fauna provided by this site. However, the site also provided a substantial collection of invertebrates and a small sample of bird remains. In addition, the cave itself earned its name not from the subsurface fauna, but from the remains of the domestic animals that littered its surface. These materials are the subject of the following two chapters.

4. MOLLUSKS AND BIRDS FROM LAST SUPPER CAVE

PAUL W. PARMALEE

FRESHWATER MOLLUSKS

One species of freshwater mussel, *Margaritifera falcata,* was represented in the Last Supper Cave midden material available to us. The majority of the valves, although broken, were well-preserved with varying amounts of the periostracum still present. A total of 1412 valves were present, all of which came from excavation unit J-10 and all of which either lack stratigraphic provenience or came from the *Neotoma* midden along the south side of the cave (see table 39).

The bulk of the Last Supper Cave bivalves have apparently been misplaced or discarded. Both Layton and Davis (unpubl.) and Layton (1979) indicate that large numbers of bivalves were retrieved from well-provenienced settings throughout much of the site, and that all Last Supper Cave strata above stratum 8, of late Miocene age, contained varying numbers of *Margaritifera* sp. shells. Layton and Davis (unpubl.) also note that the only significant concentrations of those shells were in strata 5 and 6, dating to between 9000 and 7000 B.P. Not only did the abundance of bivalves in these two strata lead to these units being termed "Upper" and "Lower" Shell in the field (tables 20 and 21), but Layton and Davis (unpubl.; see also Layton, 1979) emphasized the probable climatic meaning of this concentration in their analysis of the Last Supper Cave sediments. Clearly, there is a great contrast between the material retrieved from the site and the collection we have been able to locate; in the absence of the shells themselves, we are unable to discuss this material in any detail.

Roscoe (1967) and Lyman (1980) have provided succinct discussions of the possible role freshwater mussels played in the subsistence strategies of aboriginal peoples once inhabiting the Deschutes River basin, Oregon, and the Columbia Basin, respectively. Both these authors, as well as others (e.g., Cressman, 1956), conclude that mussels were an important food resource rather than just an occasional or supplemental dietary item. However, this view has been subject to ques-

tion, even in eastern North America where aboriginal "shell mounds" may contain hundreds of thousands of freshwater mussel valves and aquatic gastropod shells. The caloric value of mussels has proven to be low (Parmalee and Klippel, 1974) and, although often an abundant and readily available food resource, they appear to have been of minor dietary significance compared with the quantity of meat derived from deer and other vertebrates.

Margaritifera falcata is widely distributed in western North America, including northern Nevada (Burch, 1975). This species, like the circumboreal *M. margaritifera* and the southeastern *M. hembeli,* may occur only in localized beds throughout the length of a stream, but where they are present they may occur in huge numbers.

Margaritifera does not appear to exist in the Hell Creek drainage today, although Virgin Creek supports small numbers (Layton and Davis, unpubl.). Both Layton and Davis (unpubl.) and Layton (1979) observed that the reduction in the numbers of *Margaritifera* valves incorporated in the deposits of Last Supper Cave after 7000 B.P. implies that flow in Hell Creek was reduced at this time. The deposition of Mazama Ash in both Hell and Virgin creeks at about 7000 B.P. may also have had a detrimental effect on the aquatic faunas of these creeks. Perhaps a combination of these factors, in addition to possible overexploitation of mussel beds in the immediate vicinity of Last Supper Cave, resulted in the paucity of *M. falcata* valves in deposits representing occupations above stratum 5. Except for three valves that exhibited small drill holes, none of the *M. falcata* shells showed evidence of having been modified.

Nineteen shells of aquatic gastropods were recovered in the Last Supper Cave midden and all but five were either juveniles or fragmented. Although of no significance to the occupants of the site, these snails are of interest in serving as indicators of local aquatic habitats prevailing during at least part of the time the site was occupied. The specimens

TABLE 39
Margaritifera falcata from Last Supper Cave

Provenience	Stra-tum	Valves		
		Right	Left	Totals
J-10 (White Ashy)	NP	56	75	131
J-10 (Rat Nest, Level 1)	R	68	72	140
J-10 (Rat Nest, Level 2)	R	61	76	137
J-10 (Rat Nest, Level 3)	R	258	258	516
J-10 (Rat Nest)	R	231	257	488
Totals		674	738	1412

compare most closely to *Juga* (*Oreobasis*) *laurae,* a species first described by Goodrich (1944) as *Goniobasis laurae* based on specimens found in springs in Long Valley, Washoe County, Nevada. A very closely related species, *Juga* (*Oreobasis*) *interioris,* was also first described by Goodrich (1944), based on specimens found in the outlet of artesian wells 9 miles west of Gerlach, Washoe County. Based on the known habitat of these species, it may be safely assumed that similar conditions existed at or near Last Supper Cave: springs and well outlets provided a continual flow of water into Hell Creek, enabling it to maintain a constant flow.

Roscoe (1963) reported 25 specimens of *Goniobasis* (=*Juga*) in association with approximately 1000 specimens of *Margaritifera margaritifera* (= *M. falcata*) from archaeological deposits in two rockshelters near the confluence of the Metolius and Deschutes rivers, Jefferson County, Oregon. Roscoe (1963) concluded that the goniobases in these sites represented individuals that had been attached to the valves of the freshwater mussels, and had been fortuitously transported into these sites as a result. The presence of *Juga* in the Last Supper Cave deposits is perhaps best explained in the same fashion.

THE LAST SUPPER CAVE BIRDS

Bird bones from Last Supper Cave were, for the most part, in an excellent state of preservation although the majority were incomplete and some exhibited varying degrees of abrasion. Compared with the number of mammal remains recovered from the cave, the sample of bird bones is extremely small. The avian sample consisted of approximately 135 bone specimens and between 150 and 200 feathers and feather fragments. Although only a few of the feathers were identified during this study, there are others that probably can be determined by means of detailed structural analyses. Eighty-two elements, or approximately 75 percent of the recovered bird bones, were identified to at least the ordinal level; a minimum of 20 species was represented (see table 40).

The varied avian species assemblage from Last Supper Cave and the small number of individuals representing each species suggest that birds were of little importance to the cave occupants. With the possible exception of raptors, the taking of birds appears to have been only an occasional activity based possibly on local occurrence and abundance of species. Remains of hawks and owls (at least six species) comprised 64 percent of bird bones identified to the generic level; this high percentage may be indicative of special hunting/trapping efforts to capture these birds valued for their feathers and/or body parts. Based on the total faunal assemblage from Last Supper Cave, birds contributed very little to the food economy of these people.

DESCRIPTIVE SUMMARY

Order Podicipediformes—Grebes
Family Podicipedidae—Grebes
Podiceps nigricollis—Eared Grebe

Material: Distal left tarsometatarsus: 1 specimen; MNI, 1.

Remarks: The Eared Grebe is a permanent resident in Nevada, but is most numerous during migration. Although encountered more often in ponds and lakes than in small creeks, grebes will occasionally use creeks and streams on a temporary basis, such as during migration (Linsdale, 1951).

Order Anseriformes—Swans,
Geese, and Ducks
Family Anatidae—Swans,
Geese, and Ducks
Anas sp.—Ducks

Material: Distal right humerus, distal left tibiotarsus: 2 specimens; MNI, 2.

Remarks: The humerus compares closely to that of Mallard, *Anas platyrhynchos,* and the tibiotarsus with Pintail, *A. acuta,* but nei-

TABLE 40
Number of Identified Specimens per Avian Taxon by Stratum at Last Supper Cave

Taxon	Stratum					Total
	1	2	4	R	NP	
Podiceps nigricollis	—	—	—	1	—	1
Anas sp.	—	—	—	2	—	2
Oxyura jamaicensis	—	—	—	1	—	1
cf. *Circus cyaneus*	—	—	—	1	—	1
Buteo sp.	—	—	—	6	—	6
Falco sparverius	—	—	1	9	1	11
Falco cf. *mexicanus*	—	—	—	3	—	3
cf. *Dendragapus obscurus*	—	—	—	2	—	2
Centrocercus urophasianus	—	—	—	4	—	4
Tetraoninae, gen. and sp. indet.	—	—	—	2	1	3
cf. *Charadrius vociferus*	—	—	—	1	—	1
Bubo virginianus	—	—	1	8	2	11
Asio otus and/or *A. flammeus*	—	—	1	2	—	3
cf. *Phalaenoptilus nuttallii*	—	—	—	1	—	1
Colaptes auratus	—	—	—	5	—	5
Eremophilia alpestris	—	—	—	1	—	1
Swallow, gen. and sp. indet.	—	—	—	1	—	1
cf. *Gymnorhinus cyanocephalus*	—	—	—	1	—	1
Corvus corax	—	—	—	—	1	1
cf. *Lanius* sp.	—	—	—	1	—	1
Passerines, gen. and sp. indet.	—	—	—	22	4	26
Totals	—	—	3	74	9	86
Indet. bird bone specimens	1	1	4	32	10	48

ther specimen is sufficiently complete to allow secure identification to the species level. Both of these ducks, as well as a wide variety of other species of *Anas,* occur commonly in suitable aquatic habitat during migration and as summer residents in Nevada.

Oxyura jamaicensis—Ruddy Duck

Material: Left humerus: 1 specimen; MNI, 1.

Remarks: Linsdale (1951) observed that the Ruddy Duck is present in Nevada year-round, but that few appeared to remain during the winter in the northern part of the state. This small duck is reported to be locally abundant throughout the year in the Lahontan Valley, some 200 km to the south (Alcorn, 1946; see also Grayson, 1985). The paucity of waterfowl and of other aquatic species in the Last Supper deposits suggests that the inhabitants rarely had the opportunity to exploit such a potentially valuable, although perhaps periodic, food resource. The local creeks probably attracted few ducks and other aquatic species.

Order Falconiformes—Vultures, Hawks, and Falcons
Family Accipitridae—Kites, Eagles, Hawks, and Allies
cf. *Circus cyaneus*—Northern Harrier

Material: Fragmentary proximal right carpometacarpus: 1 specimen; MNI, 1.

Remarks: A common resident throughout the Great Basin (Ryser, 1985), the Northern Harrier is most often found in association with wet meadows and marshes in Nevada (Linsdale, 1951). Riparian habitat associated with both Hell and Virgin creeks could have provided suitable habitat for this bird.

Buteo sp.—Broad-winged Hawks

Material: Distal lower mandible, fragmentary right carpometacarpus, proximal left humerus, right coracoid, left tarsometatarsus shaft, proximal right tibiotarsus: 6 specimens; MNI, 2?

Remarks: At least five species of *Buteo* occur as either permanent residents or migrants in Nevada: the Red-tailed (*B. jamaicensis*)

and Rough-legged (*B. lagopus*) probably being the most numerous (Linsdale, 1951; Ryser, 1985). None of the Last Supper Cave *Buteo* specimens were sufficiently diagnostic to support species-level identification.

Family Falconidae—Caracaras and Falcons
Falco sparverius—American Kestrel

Material: Distal left humerus, distal right humerus, right humerus shaft, left humerus shaft, complete right humerus, distal right ulna, proximal right ulna, proximal right carpometacarpus, distal right coracoid with fused scapula, mummified carcass, rectice: 11 specimens; MNI, 3.

Remarks: A common permanent resident in the Great Basin, the American Kestrel is the most abundant of all Great Basin raptors during the summer months (Ryser, 1985). Occupants of Last Supper Cave probably captured this small falcon whenever possible for its feathers.

Falco cf. *mexicanus*—Prairie Falcon

Material: Right femur, fragmentary left carpometacarpus, proximal left tarsometatarsus: 3 specimens; MNI, 1.

Remarks: This falcon is a fairly common, widely distributed permanent resident in Nevada (Linsdale, 1951). Although the Peregrine Falcon (*F. peregrinus*) probably occurred in the vicinity of Last Supper Cave, the three specimens reported here compare most closely with *F. mexicanus*. A right radius shaft, cf. *Falco,* may also represent this species.

Order Galliformes—Grouse, Quails, Pheasants, and Turkeys
Family Phasianidae—Partridges, Grouse, Turkeys, and Quail
cf. *Dendragapus obscurus*—Blue Grouse

Material: Complete left humerus, complete left coracoid: 2 specimens; MNI, 1.

Remarks: In addition to these two specimens, a second left coracoid (two sections, both calcined) may also be referable to this species. Ryser (1985: 275–276) notes that in the Great Basin, the Blue Grouse is "mainly confined to fir and multineedled pine forests

on the higher mountain ranges." The area surrounding Last Supper Cave today certainly does not provide appropriate habitat for these birds, although it is possible that they were transported here from afar by people. Unfortunately, the age of these specimens is essentially unknown: both came from the undated *Neotoma* midden in the rear of the cave.

Centrocercus urophasianus—Sage Grouse

Material: Proximal right tarsometatarsus, left humerus lacking distal end, left humerus shaft, fragmentary right innominate: 4 specimens; MNI, 2.

Remarks: The Sage Grouse is resident in the northern parts of Nevada; as the name implies, it is a bird of open sagebrush grasslands and shrublands. It was more widespread and abundant prior to European settlement and the associated modification of the bird's habitat.

Tetraoninae—Grouse, gen. and sp. indet.

Material: Fragmentary distal right tibiotarsus, distal left femur, distal left tarsometatarsus: 3 specimens; MNI, 1.

Order Charadriiformes—Shorebirds, Gulls, Auks, and Allies
Family Charadriidae—Plovers and Lapwings
cf. *Charadrius vociferus*—Killdeer

Material: Distal left carpometatarsus: 1 specimen; MNI, 1.

Remarks: Adaptable to a variety of habitats associated with streams or lakes, the Killdeer is the most widespread shorebird found in Nevada (Ryser, 1985) and the presence of this bird along Hell and Virgin creeks would not be unexpected.

Order Strigiformes—Owls
Family Strigidae—Typical Owls
Bubo virginianus—Great Horned Owl

Material: Proximal shaft section of left humerus, fragmentary right carpometacarpus, fragmentary left coracoid, fragmentary left scapula, complete right tarsometatarsus, fragmentary left tarsometatarsus, distal left tarsometatarsus, 2 tarsals, 2 claws: 11 specimens; MNI, 3.

Remarks: As Ryser (1985: 263) notes, "the Great Horned is a common and widespread resident of the Great Basin, inhabiting every conceivable type of desert and montane habitat." In addition to the osteological remains, representing at least three individuals, several feathers and feather fragments probably referable to *B. virginianus* were also recovered at Last Supper Cave.

Asio otus and/or
A. flammeus—Long-eared Owl
and/or Short-eared Owl

Material: Distal left coracoid with articulated scapula head, proximal right femur, distal shaft of left humerus: 3 specimens; MNI, 1.

Remarks: As with the Danger Cave material (chap. 2), none of the Last Supper Cave *Asio* specimens would support the quantitative analysis needed to identify the species of owl involved (Emslie, 1982). In Nevada, the Long-eared Owl is common in areas that support tall shrubs and trees, and may be the most abundant owl in the state (Linsdale, 1951). The Short-eared Owl is resident throughout much of the Great Basin (Ryser, 1985).

Order Caprimulgiformes—Goatsuckers
and Allies
Family Caprimulgidae—Goatsuckers
cf. *Phalaenoptilus nuttallii*—Poor-will

Material: Distal half of left coracoid with articulated scapula: 1 specimen; MNI, 1.

Remarks: The Poor-will is a common summer resident throughout most of Nevada (Linsdale, 1951).

Order Piciformes—Woodpeckers and Allies
Family Picidae—Woodpeckers
and Wrynecks
Colaptes auratus—Northern Flicker

Material: Complete left tibiotarsus, 4 primaries: 5 specimens, MNI, 1.

Remarks: In addition to the tibiotarsus, a proximal shaft section of a left humerus was recovered that compares in size and configuration with Northern Flicker, but it is too fragmentary to be identified to species. The Northern Flicker is the most abundant and widely distributed woodpecker in Nevada (Linsdale, 1951).

Order Passeriformes—Passerine Birds
Family Alaudidae—Larks
Eremophila alpestris—Horned Lark

Material: Proximal left humerus: 1 specimen; MNI, 1.

Remarks: A widespread and abundant resident in the Great Basin, Horned Larks typically "inhabit areas where the vegetation is low or widely scattered with some bare ground showing" (Ryser, 1985: 347).

Family Hirundinidae—Swallows
Swallow, gen. and sp. indet.

Material: Fragmentary left humerus: 1 specimen; MNI, 1.

Remarks: Although this element is close to that of Barn Swallow (*Hirundo rustica*), the diagnostic characters are eroded and a species-level identification cannot be made. The Cliff Swallow is osteologically similar to the Barn Swallow and may also be represented. Both are common throughout the Great Basin as breeding species and as migrants (Ryser, 1985).

Family Corvidae—Jays, Magpies,
and Crows
cf. *Gymnorhinus cyanocephalus*—
Pinyon Jay

Material: Proximal left humerus: 1 specimen; MNI, 1.

Remarks: The Pinyon Jay is perhaps the most numerous and widespread corvid in Nevada, found most abundantly in pinyon-juniper woodland (Linsdale, 1951), although it is also commonly seen in pure stands of juniper (*Juniperus* spp.).

Corvus corax—Common Raven

Material: Distal right femur: 1 specimen; MNI, 1.

Remarks: The Common Raven is a common and widespread resident in the Great Basin (Ryser, 1985), found in settings ranging from open deserts to mountaintops. Its use as a totem by aboriginal peoples as well as its role in symbolism and ceremonialism is well established. Remains of *C. corax* are not infrequently found in archaeological sites: 10 percent of nearly 2600 identified bird bones in a large sample of Arikara sites in South

Dakota were contributed by this bird (Parmalee, 1977), while Hidden Cave provided 11 specimens of Common Raven (Grayson, 1985).

Family Laniidae—Shrikes
cf. *Lanius* sp.—Shrike

Material: Proximal half of left humerus: 1 specimen; MNI, 1.

Remarks: The Northern Shrike (*Lanius ex-cubitor*) is an uncommon winter visitor to the Great Basin, while the Loggerhead Shrike (*L. ludovicianus*) is a common summer resident here (Ryser, 1985).

Passerines, gen. and sp. indet.

Material: Both complete and fragmentary humeri, ulnae, coracoids, femora, tibiotarsi, and tarsometatarsi: 26 specimens; MNI, 6?

5. WAS THERE A LAST SUPPER AT LAST SUPPER CAVE?

R. LEE LYMAN

Last Supper Cave, nearby Denton's Cave, and Hanging Rock Shelter (chap. 6) provided what Layton (1977: 367) interpreted as evidence that "small groups of Indians continued to follow a modified hunting and gathering existence well into the early twentieth century." The evidence that led Layton (1970, 1977) to this conclusion consisted of the surficial bones of domestic mammals, primarily cattle, that he felt had been butchered and cooked by Native Americans. Layton's "modified hunting and gathering existence" thus included the rustling and consumption of domestic cattle. He did not, however, analyze in detail the faunal material that led him to this conclusion. Because the possible continuance of a hunting and gathering way of life, with aboriginal hunting techniques simply transferred to European domesticates, is of potentially high significance (e.g., Jones, 1980), I provide that detailed analysis here. I conclude that the faunal evidence contains little suggestion of direct human involvement in the accumulation of the remains of domestic mammals at either Last Supper Cave or Denton's Cave. We were unable to locate the cattle remains from Hanging Rock Shelter (see chap. 6); hence this material remains unanalyzed.

HISTORIC BACKGROUND

Northwestern Nevada was first settled by Europeans in the 1850s; by the 1870s, the potential of vast acreages for livestock grazing had led to the establishment of large cattle-raising operations here. At first, Texas longhorns, derived from the dry ranges of west Texas, were favored. These animals could feed in the mountains of the western Great Basin during the summer, and winter in the protection of the basins between those ranges (Peterson, 1946). During the 1880s and 1890s, the more quickly maturing purebred Hereford and Shorthorn breeds were introduced and soon replaced the Texas longhorns (Smith et al., 1983). Cattle ranching in this area was not easy. Most ranchers practiced open-range feeding and only some raised

hay for winter feed. As a result, severe weather could deplete the herds, as many discovered during the years 1890–1891, when a particularly severe winter was followed by drought (Peterson, 1946).

Throughout the Great Basin, the indigenous human populations initially responded to the introduction of large domestic mammals by treating them as a food source. Commonly, animals associated with wagon trains were shot with arrows, then taken when they lagged behind the moving train (Gould et al., 1972). Others were simply rustled and then slaughtered (e.g., Jones, 1980). As Layton (1970) notes, Indians in northwestern Nevada were initially both hostile and aggressive. By 1866, however, they began to become attached to European settlements, or to be moved onto reservations. Nonetheless, Hattori (1975) has pointed out that the 1894 census estimated that as many as 400 Indians continued to follow a hunting and gathering lifestyle in Nevada, particularly in the isolated northwestern and southcentral parts of the state.

LAST SUPPER CAVE

LAYTON'S INTERPRETATION

Layton collected a large series of cow bones from Last Supper Cave in 1968. His interpretation of that material is quoted extensively here to provide background for my analysis:

The butchered and cooked semi-articulated remains of at least one horse, three cows, and one antelope (by skull count) are scattered about the floor of the cave . . . . The foramen magnum on each of the skulls has been broken open to facilitate extraction of the brain, and many of the long bones have been cracked open for extraction of the marrow. The absence of any trace of the hide suggests that the skins were carefully removed and saved by the Indians. Almost all of the larger bones, particularly skulls, articulated sections of vertebra, and articulated lower legs and hooves are concentrated in the dark extreme rear of the cave behind a pile of rocks . . . . That these bones are hidden in the extreme

rear of the cave, indicates that these animals were rustled and that the Indians feared reprisals (Layton, 1970: 200–201).

Due to the lack of associated historic remains, the dating of rustling activities at Last Supper Cave [is] difficult. [Based on historic records] it seems likely that . . . Last Supper Cave [was] used by the same band of Indian Rustlers over an extended period prior to 1913. Thirteen sharpened wooden stakes, some of them bloodstained, were scattered among the bones of the butchered cattle in this totally dry cave. All bore the clean regular cut of a metal knife. They were used to peg out and stretch the cow hides (Layton, 1977: 369–371).

Layton thus used five lines of evidence to support his assertion that the Last Supper Cave cattle had been rustled and butchered by Indians: (1) broken occipitals representing brain extraction; (2) skinned and broken bones representing hide removal and marrow extraction; (3) cooked (burned?) bones; (4) bones distributed in the rear of the cave behind a low rock wall; and (5) bloodstained, metal-cut wooden stakes. In the sections that follow, I will examine each of these lines of evidence, and will augment this examination with a series of recently developed analytic techniques.

DESCRIPTIVE SUMMARY

Family Equidae—Horses, Zebras, Mules, and Allies
cf. *Equus* sp.—Horse

Material: 3 molariform fragments: 3 specimens.

Equus sp.—Mule and/or Horse

Material: 1 incisiform fragment, 7 molariform fragments, 1 lower molariform fragment and associated horizontal ramus fragment, 1 right m3, 1 right m3 and associated horizontal ramus fragment, 1 left mental symphysis and 2 associated incisiform fragments, 1 right ascending ramus fragment, 1 metapodial diaphysis fragment, 1 proximal accessory metapodial, 1 right third carpal: 16 specimens.

Equus caballus—Horse

Material: 1 upper molariform: 1 specimen.
Remarks: The three specimens referred to

Equus sp. are very fragmentary, but are clearly hypsodont molariforms. They are more robust than the bovid teeth in the collection, and hence are tentatively assigned to *Equus*. The single specimen assigned to horse (*Equus caballus*) possesses a pli-caballan fold, absent in the molars of mule and burro (Olsen, 1978). These 20 specimens represent a minimum of two individual animals.

Haines (1938) suggests horses would have become available in northwestern Nevada at about A.D. 1700. Steward (1938: 235) noted that because horses ate plant foods vital to human existence and because they were of little use in hunting, horses acquired by Northern Paiute were usually eaten. The sample of equid bones from Last Supper is so small that little evidence of butchering might be present even if these animals were eaten by people, a problem compounded by the fact that 10 of the 17 specimens are teeth, on which butchering marks are not to be expected. Hence, the absence of such marks on these 17 elements may mean little. One of the mandible fragments (LS-359/80) has been gnawed by a carnivore; a second (LS-358/219) has been gnawed by both carnivores and rodents.

Family Bovidae—Bovids
Bos taurus—Domestic Cow

Material: 577 specimens (table 41).
Remarks: I have referred all specimens listed in table 41 to the Bovidae using the criteria provided by Brown and Gustafson (1979) and Olsen (1959, 1960). Some of the fragmentary ribs and vertebrae may represent equids, but have been assigned to the Bovidae because of the large number of specimens that are clearly bovid, compared to the small number that are clearly equid. At least six individuals are represented in the collection.

I have used criteria provided by Olsen (1959, 1960) to assign bovid specimens to *Bos*. In particular, the Last Supper Cave bovid specimens are less robust than those of *Bison*, and the flat to slightly concave frontals, anteriorly projecting horn cores, and nonprojecting orbits of the Last Supper Cave bovid skulls allow certain assignment to *Bos*.

Two innominates were sufficiently complete and mature to allow determination of

sex following the criteria presented by Grigson (1982). Both of these specimens appear to be from females. Although one is a right, the other a left, the lack of bilateral symmetry shown by these specimens suggests that they represent different individuals.

I assessed bovid age using two sets of data. First, I used mandibular tooth eruption stages, following criteria presented by Brown et al. (1960). Of the five mandibles that could be assessed in this fashion, two (LS-199/75, both from the same individual) indicate an age at death of 32 months, two others (LS-197/75 and LS-505/159, perhaps not from the same individual) indicate an age at death of 30 months, and the fifth (LS-503/45) indicates an age at death of 28 months. Brown et al. (1960) found no difference in the chronology of tooth development and eruption across five dairy and three beef breeds of cattle (including Hereford and Shorthorn), suggesting that the age assessments provided here are highly likely to be accurate.

Second, I used stage of epiphyseal fusion of major long bones to assess age at death. I recorded three such stages: unfused, fused with visible suture, and fused with no visible suture. Age assessments (table 42) follow criteria specified by Silver (1969) and Grigson (1982). Sixteen bones have not been included in table 42: these bones (axis, cervicals 3–7, left scapula, left and right humerus, left radius and ulna, left and right innominate, left and right femur, right tibia) represent a six-month-old calf.

Both sets of age data indicate that the five adult cows in the assemblage would have been about 2.5 years old at death, and thus would have been in the prime-of-life. However, the first, and to a lesser extent the second, permanent incisors of these animals were virtually worn out (LS-199/75; see fig. 20). The lower cheek teeth, particularly the molars, also appear relatively heavily worn (LS-199/75; see fig. 21), though the lack of comparative data prevents the utilization of crown height measurements (cf. Klein and Cruz-Uribe, 1984). The upper molars of at least one individual are clearly excessively worn, particularly M2 (LS-200/38; see fig. 22). This heavy tooth wear suggests that the cows in Last Supper Cave were consuming a large amount of very coarse forage and/or sedi-

TABLE 41
Inventory of Bovid Bones from Last
Supper Cave

Element	cf. *Bos*	*Bos*	Bovid
Horn sheath		4	
Horn sheath fragments			10
Skull		4	
Skull fragments			20
Molariform fragments		6	6
Left dp4		1	
Left m3		1	
Left Premaxilla		1	
Left Maxilla		1	
Maxilla fragment	1		
Mandible		7	
Mandible fragments	20		
Atlas		3	
Atlas fragments	2		
Axis		3	
Axis fragments	1		
Cervical 3–7 (13 complete)	22		
Thoracic (35 complete)	57		
Lumbar (25 complete)	34		
Sacral (4 complete)	11		
Caudal (5 complete)	5		
Indeterminate vertebra fragments	4		
Rib (54 complete)	73		
Costal cartilage fragments	9		
Sternabra	2		
Scapula (8 complete)	4	8	
Humerus (1 complete)		15	
Radius (3 complete)		13	
Ulna (1 complete)		5	
Carpals		22	
Metacarpal (2 complete)		10	
Innominate			
Complete		3	
Ilium fragment		5	
Ischium fragment		1	
Acetabulum fragments		6	
Femur (2 complete)		20	
Patella	4		
Tibia (4 complete)		17	
Calcaneus (8 complete)		10	
Astragalus (5 complete)		6	
Distal fibula		7	
Tarsals		11	
Metatarsal (4 complete)		7	
Metapodial fragments		10	
Phalanx 1		20	
Phalanx 2		15	
Phalanx 3		17	
Hoof Sheath		4	
Proximal sesamoid	15		
Distal sesamoid	14		
Totals	278	263	36

TABLE 42
Epiphyseal Fusion Data for Five Last Supper Cave Cows

Element	Age at fusion (months)	Unfused	Stage of fusion	
			Fused, suture	
			Visible	Not visible
Proximal humerus	42–48	4	3	0
Distal humerus	12–18	0	0	6
Proximal radius	12–18	0	0	6
Distal radius	42–48	8	0	0
Distal metacarpal	24–30	1	2	1
Proximal femur	42	2	2	0
Distal femur	42–48	7	0	0
Proximal tibia	42–48	10	0	0
Distal tibia	24–30	4	3	2
Distal metatarsal	27–30	1	3	1
Distal metapodial	24–30	4	0	0

Age class in months	NISP per age class
>12–18	12
<24–30	10
ca. 24–30	12
<42–48	31
ca. 42–48	5
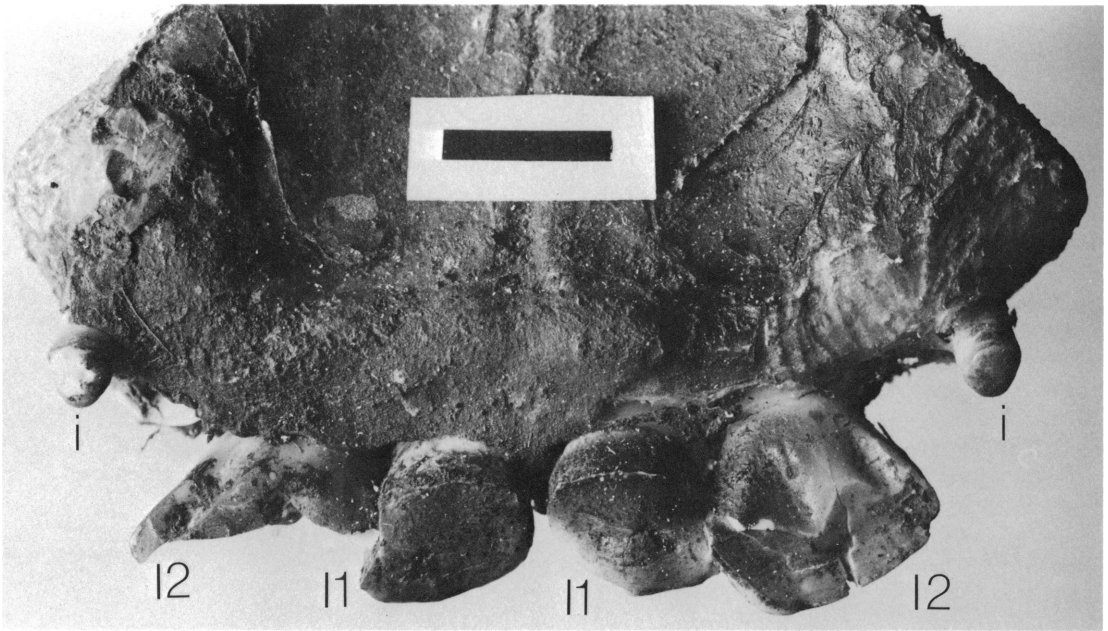
Fig. 20. Worn permanent incisors of Last Supper Cave cow mandible LS-199/75. Upper case letters denote permanent incisors; lower case letters denote deciduous incisors. See figure 21 for the lower molariforms associated with these incisors. Scale bar is 1 cm.
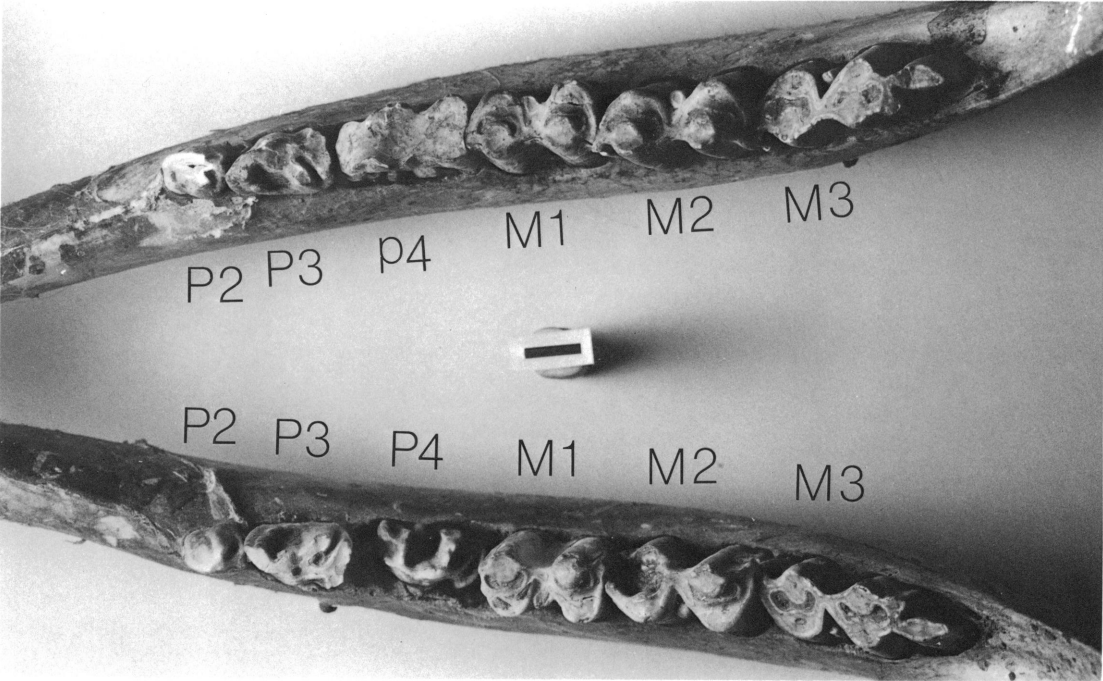
Fig. 21.   Lower molariforms of Last Supper Cave cow mandible LS-199/75; note the degree of wear on the molars. Permanent premolars are denoted by P, deciduous premolars by p, molars by M. Based on dental eruption, this individual was about 32 months of age at death. See figure 20 for associated incisors. Scale bar is 1 cm.
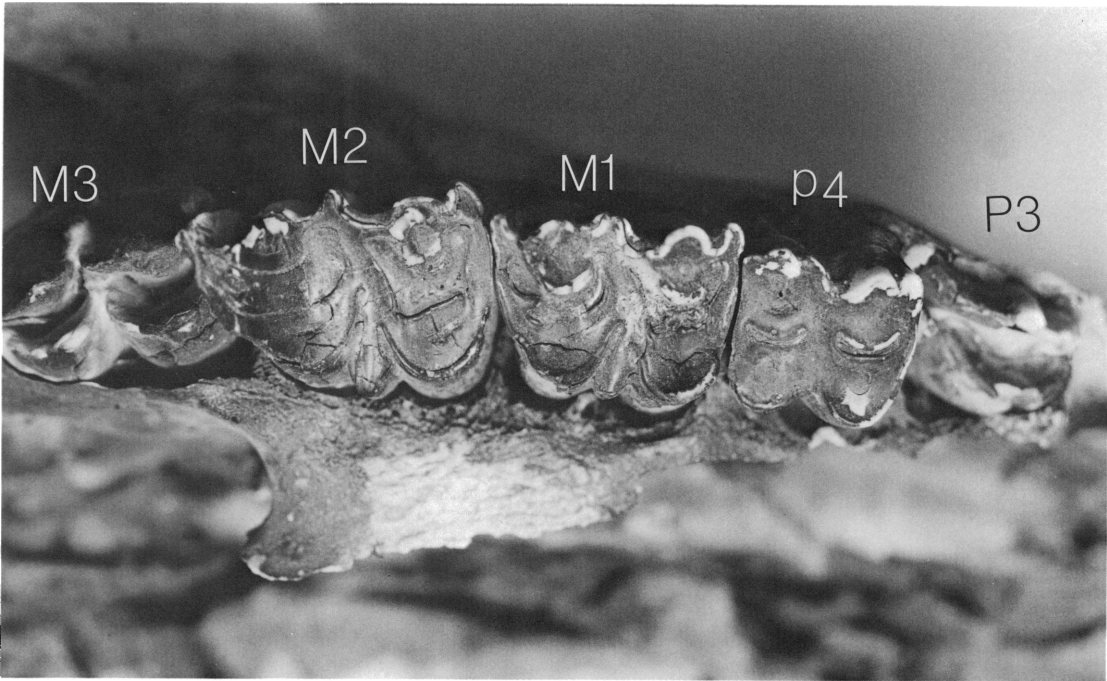
Fig. 22.   Upper right molariform tooth row of Last Supper Cave cow skull LS-200/38, occlusal view. See figure 21 for key to abbreviations.

Fig. 23.   Basal view of posterior aspect of Last Supper Cave cow skull LS-206/170; note that the opening in the occipital region is bordered by sutures.

carnivores, two display flake scars. One of these, a left distal humerus (LS-148/174), has a flake scar in the posterolateral area of the distal diaphysis. The second specimen consists of the medial portion of the proximal diaphysis of the humerus (LS-358/150), and displays one flake scar on the anterior edge, another on the posterior edge. These scars thus appear similar to the bipolar flaking of lithic material, and suggest the diaphysis was supported directly under the point at which force was applied.

These two specimens do not appear to have been broken by carnivores (cf. Binford, 1981; Haynes, 1980, 1983) and there is no evidence of carnivore gnawing on either bone. Although people may have created these flake scars, Dixon (1984) has shown that rooffall in caves can result in the fracturing, flaking, and scratching of bones on cave floors. Had people broken the Last Supper Cave cow bones in order to extract marrow, I would expect large numbers of specimens to show flake scars, suggesting that rooffall may well

account for the two specimens that actually do show such scars.

The third specimen displaying marks that cannot be confidently attributed to carnivores or rodents is the right ascending ramus of a mandible with several longitudinal grooves on the lateral surface. Marks of similar orientation and location have often been interpreted as dismembering marks associated with cutting through the masseter muscle in order to disarticulate the mandible from the skull (cf. Binford, 1981: 136, mark M-2). The marks on the Last Supper Cave specimen, however, are rather broad and U-shaped in cross-section, a morphology that is more characteristic of carnivore gnawing marks than of cuts made with either metal or stone tools (e.g., Haynes, 1980, 1983). While I cannot be sure of the origin of these marks, carnivores seem much more likely than people to have made them.

The fourth specimen is a right ascending ramus fragment (LS-354). As with the specimen just discussed, the location of this mark
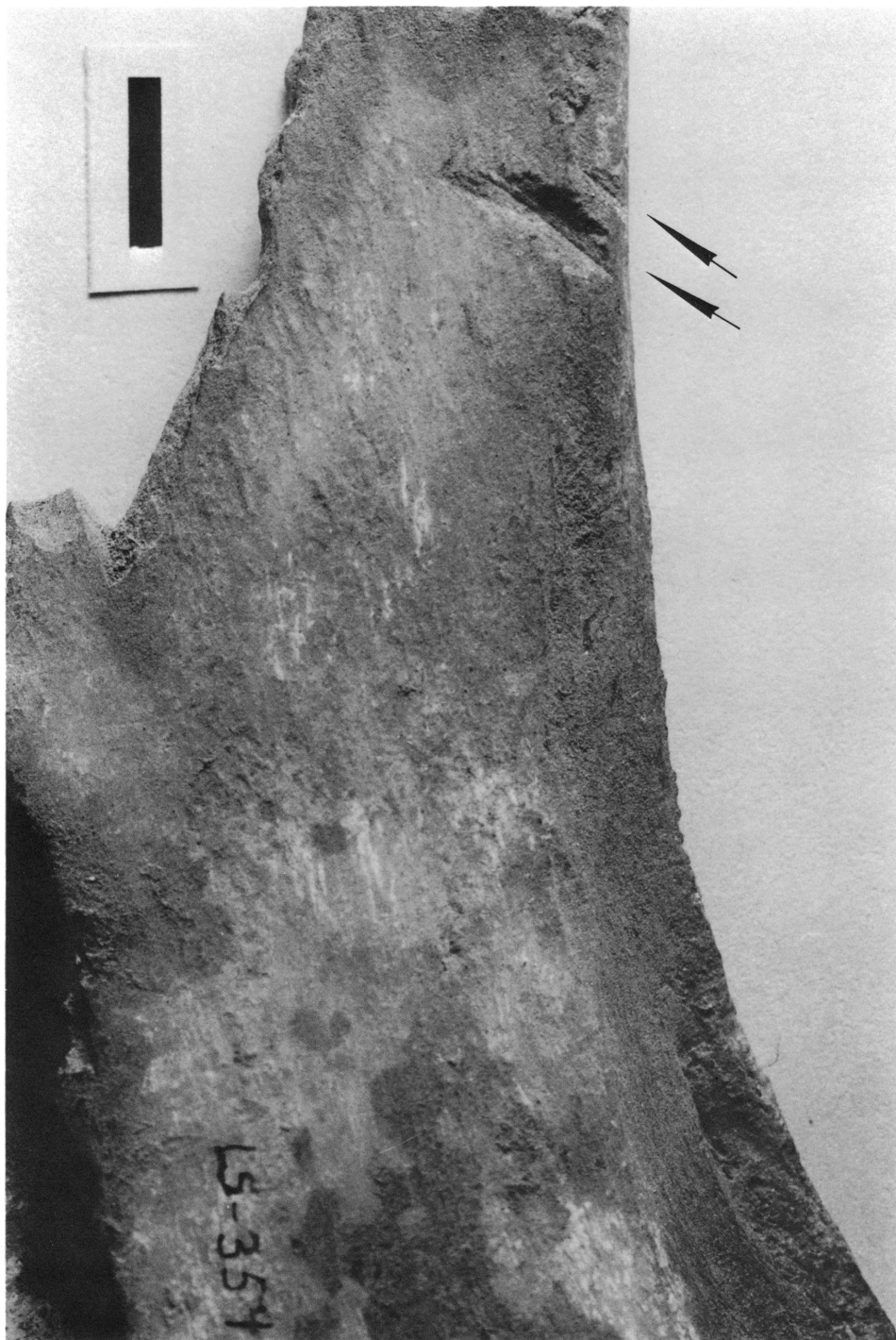
Fig. 24. Right ascending ramus fragment of Last Supper Cave cow mandible LS-354 with a linear groove on the anterolateral surface (arrows); note the microstriae within the major groove. This may represent a butchering mark. Scale bar is 1 cm.

is similar to those made to dismember the mandible (fig. 24). However, the morphology of this mark is more similar to those made by stone knives: it is broad and V-shaped in cross-section and has visible microstriae inside the main striation (cf. Shipman, 1981; Shipman and Rose, 1983). It is quite possible that this specimen has been butchered. I note, however, that the bone involved is greasier and appears fresher than all but about six other specimens in the collection, and may not represent the same population of specimens as the other surficial cow bones. I also note that recent evidence suggests that microstriae in grooves of this sort may, in fact, be produced by carnivores (Eickhoff and Herrmann, 1985; see also Haynes and Stanford, 1984: 226, fig. 6, left) and by trampling (Behrensmeyer et al., 1986).

On the assemblage level, it is important to note that of the 597 equid and bovid specimens I have examined, only four (0.7% of the collection) display marks that might liberally be interpreted as reflecting human processing activities. While it is certainly possible that the Last Supper Cave cows were butchered in such a manner as to leave little to no trace of this activity on the bones, ethnoarchaeological data suggest that the number of marked bones in butchered assemblages range from 1 to 30 percent of those assemblages, with modes near 15 to 20 percent (Lyman, 1987). We still have much to learn about frequencies of butchering marks in such assemblages, but the numbers of possible marks on the Last Supper Cave cow bones are so low as to provide no secure indication of human intervention.

3. Bones have been cooked

Layton (1970, 1977) does not note why he felt the Last Supper Cave cow bones were cooked, but he probably reached this conclusion because many of the bones are burned. However, as with the subsurface burned bones at Last Supper Cave (chap. 3), there is substantial evidence that at least some of these bones were burned well after the death of the animals involved. Approximately 12 burned specimens have charred carapaces of dermestid beetle larvae attached. The presence of these specimens suggests that the burning occurred after the cows had died, their flesh had dried, and the beetles had fed on that dried flesh. While the beetles may well have been exploiting butchering refuse at the time, the presence of these burned carapaces clearly removes the burning, and hence the evidence for cooking, as evidence for a human role in the deposition of the specimens.

Burning causes microstructural weakening of bone because of the loss of collagen fibers (Shipman, 1981). The Last Supper Cave burned cow bones are much more brittle than those that were not burned. I mention this because the Nevada State Museum catalog lists two specimens, a fragmentary tibia (surface specimen no. 102; LS-115) and a fragmentary femur (surface specimen no. 106; LS-112) as having been "cracked for marrow." Both are burned, but neither displays flake scars, signs of battering, or other indications of human modification. I suspect both to have cracked simply as a direct or indirect result of burning.

4. Most bones are in the rear of the cave behind a low rock wall

The bones found in the rear of the cave are too large to have been moved there by wood rats (the vertebral column consisting of 11 articulated thoracic and 6 lumbar vertebrae, with 7 attached ribs, for instance, is far heavier and more cumbersome than the *Ovis* skull discussed in chap. 3). Rodents may have moved some of the smaller bones to this position, and carnivores may have contributed as well, but there simply is not sufficient evidence to explain conclusively how the bones came to be distributed the way they were found. An important issue that cannot be addressed is when the bones reached the back of the cave. Layton's suggestion that they were deposited here by rustlers who hoped to avoid detection is certainly reasonable, but it is very possible that they were placed here, by Indians or others, long after the animals died. The wooden stakes, discussed below, do not help resolve this issue. We simply do not know how or precisely when the cow bones in Last Supper Cave came to be deposited where Layton found them in 1968.
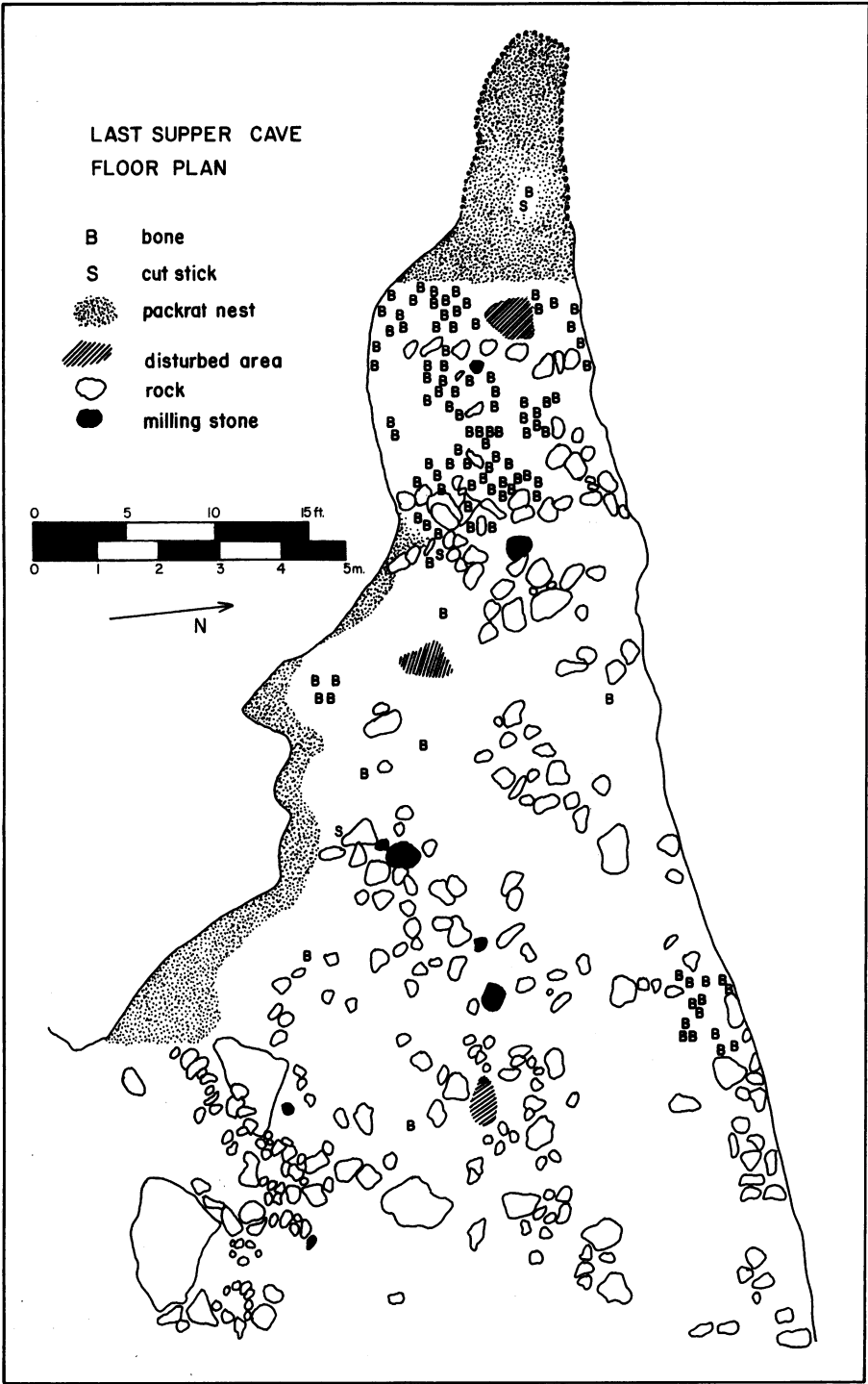
Fig. 25.   The distribution of mapped objects on the floor of Last Supper Cave (from original on file at the Nevada State Museum).

5. Bloodstained, metal-sharpened tools were used to process cow hides

I have not been able to examine these 13 objects, so am unable to comment directly on the two key attributes: sharpening by metal tools and bloodstaining. Nonetheless, any detailed analysis of these objects must address a number of taphonomic issues, and I wish to note those issues here.

As discussed in chapter 3, the south and rear walls of Last Supper Cave were lined with wood rat middens, and wood rats are very active in the area today. Of the 13 sharpened sticks found by Layton, the location of three is given on the floor plan of the site on file at the Nevada State Museum (redrawn as fig. 25). All three are in the vicinity of pack rat middens, and, given the level of activity of those animals in the cave, it seems highly unlikely that the position of these objects on the surface reflects their original position. Porcupines (*Erethizon dorsatum*) also transport sticks to their dens, which are not infrequently located in caves (Dixon, 1984). This large rodent is active in the area today (chap. 3), its remains occur in the deposits of Last Supper Cave, and it may have altered the location of the 13 sharpened sticks in the site.

The possible blood marking on the stakes must be analyzed in detail before it can be concluded that it is, in fact, blood. Urine staining by pack rats is common on the Last Supper Cave bones, while Dixon (1984) has observed dark stains on wood that appear to have resulted from scent-marking by porcupines. Reddish stains on specimens from caves may be blood, but they may also be something else, and detailed analysis may be needed before the true origin can be known.

People may have brought the sharp sticks into the cave and people may have used them precisely as Layton suggested. No detailed analysis of these objects has been conducted, however, and until that is done, they can shed little light on the taphonomic history of the cow bones.

6. Evidence for gnawing

I have used the criteria discussed by Bonnichsen and Will (1980), Haynes (1980, 1983), Shipman (1981), and Shipman and Rose

(1983) to distinguish carnivore and rodent gnawing marks, and to distinguish these from other marks on the bones (see the discussion of possibly butchered bones, above). Bovid specimens displaying carnivore and/or rodent gnawing marks are listed in table 43; an example of both is shown in figure 26.

The amount of gnawed bones in the collection as a whole is minimal (24 of 577 bovid specimens, or 4%). There are approximately six specimens that have been intensively gnawed (e.g., fig. 26), and these specimens appear greasier and fresher than the majority of the specimens in the collection. As with the possibly butchered mandible discussed above, these may have been introduced into the cave more recently than the other, drier specimens, although this cannot be known with certainty. The relative lack of gnawing displayed by these bones suggests that carnivores and rodents played only minimal roles in the taphonomic history of the collection.

7. Skeletal completeness and bone survivorship

Analyses of skeletal completeness and bone survivorship (see Lyman, 1984, 1985 and references therein) are conducted in order to assess how many of the bones of an animal's skeleton are represented in a collection, and whether the same skeletal elements are present or absent across individual skeletons. Explanations of the patterns that emerge from such analyses usually concern differential destruction and/or transport of skeletal parts by natural processes and human activities (cf. Lyman, 1985 and chap. 3). If the Last Supper Cave cow bones represent animals rustled by Indians, and if subsequent processing of those animals led to differential transport of body parts from the site, such transport may be revealed by analysis of relative skeletal completeness.

An analysis of this sort requires counting skeletal units, deriving a minimum number of individuals (MNI) from those counts, calculating the expected frequency of each skeletal unit on the basis of the MNI, and then calculating percent survivorship of each unit by dividing its observed by its expected value. Decisions concerning precisely how to

Fig. 26. Thoracic vertebra neural arch fragment with a carnivore-generated puncture and linear grooves created by rodent gnawing. Scale bar is 1 cm.

count skeletal units and how to aggregate faunal material in order to derive minimum numbers may strongly affect the resultant analysis (Grayson, 1984). As a result, such decisions must be appropriate to the goals of the analysis.

Although there is no certainty that all of the cow bones in Last Supper Cave represent a single depositional event, I will treat the entire bovid assemblage (table 41) as a single aggregate. Given the surficial nature of this collection, there is, in fact, little choice but to take this approach.

To assess relative skeletal completeness within this aggregate, I derived the minimum number of each skeletal element (MNE) for the five adult cows. Table 44 shows that the average survivorship per element is rather high ($\bar{x} = 64.7\%$), and that those elements whose survivorship is 40 percent or less are also among the smallest skeletal units analyzed. The correlation between relative survivorship and size suggests that some of the variation in survivorship may well be due to collection bias, the smallest bones having escaped detection (Watson, 1972). However,

the smallest bones are also the most likely to have been removed by wood rats, and this may have played a role in producing the pattern seen in table 44.

To assess differential destruction in the assemblage, I counted the minimum number of the proximal and distal ends of long bones and correlated their survival percentages with their bulk density (see Lyman, 1984 and chap. 3). The results suggest that little or no differential destruction has taken place (table 45). I also plotted the ratio of proximal to distal humeri and proximal to distal tibiae on a "destruction detection graph" (Binford, 1981), and the results again indicate that little destruction has taken place (fig. 27). Both of these analyses are in agreement with the minimal amount of carnivore damage on the bones themselves. The Last Supper Cave cow bones have not been ravaged by carnivores.

The degree of relative skeletal completeness suggests that smaller elements are underrepresented in the collection, perhaps because of collection bias or because of the activities of wood rats. I have shown that differential destruction cannot have played a

TABLE 43

Catalog of Last Supper Cave Bovid Bones Displaying Evidence of Carnivore and/or Rodent Gnawing Marks

Location	Rodent gnawed	Carni- vore gnawed
Skull fragment	+	
Mandible, ascending ramus	+	
Mandible, angular process	+	
Third cervical, transverse process		+
Fourth cervical, transverse process		+
Sixth cervical, body and transverse		+
Indet. cervical, transverse and arch		+
First thoracic, transverse process		+
Indet. thoracic, body and transverse: 2		+
Indet. thoracic, arch	+	+
Caudal		+
Rib fragment, shaft: 2	+	
Rib fragment, dorsal: 2		+
Rib fragment, ventral		+
Rib fragment, dorsal and ventral		+
Scapula, blade		+
Radius, proximal	+	
Metacarpal, shaft: 2		+
Ilium, ventral		+
Femur, lesser trochanter	+	

TABLE 44

Minimum Number of Elements for Five Adult Cows, Last Supper Cave; Minimum Number of Left (L) and Right (R) Elements for Paired Bones are Given in Parentheses

Element	MNE_{obs}	MNE_{exp}	% sur- vivor- ship
Skull	4	5	80
Mandible (5L, 5R)	10	10	100
Atlas	4	5	80
Axis	3	5	60
Cervical 3–7	13	25	52
Thoracic	54	65	83
Lumbar	30	35	86
Sacrum	5	5	100
Caudal	5	—	—
Rib	69	130	53
Sternabra	2	35	6
Scapula (5L, 3R)	8	10	80
Humerus (5L, 5R)	10	10	100
Radius (3L, 5R)	8	10	80
Carpals	22	60	37
Metacarpal (3L, 3R)	6	10	60
Innominate (3L, 3R)	6	10	60
Femur (2L, 5R)	7	10	70
Patella (1L, 3R)	4	10	40
Tibia (4L, 5R)	9	10	90
Calcaneus (3L, 5R)	8	10	80
Astragalus (3L, 3R)	6	10	60
Fibula (2L, 5R)	7	10	70
Naiculocuboid (2L, 3R)	5	10	50
Metatarsal (3L, 3R)	6	10	60
Phalanx 1	20	40	50
Phalanx 2	14	40	35
Phalanx 3	14	40	35

significant role in producing the percent survivorship values provided in table 44. Can differential transport have done so?

In addressing questions involving potential differential transport of bones by people, it is important to consider not only monitoring perspective (Thomas and Mayer, 1983; chap. 3), but also the adaptive strategy involved in the formation of the faunal record (Binford, 1984). In turn-of-the-century Nevada, there seem to have been two adaptive strategies followed by Native Americans. The first of these resulted from acculturation (Ambro, 1972; Rosen, 1978; Schulz, 1979), but Indians acculturated to turn-of-the-century Euro-American lifeways would either have obtained their beef from Euro-Americans, in which case the bones would have been cut by metal tools, or, if they were so

acculturated as to raise their own cattle, would have had access to metal tools. The complete lack of metal-cut bones in the Last Supper Cave collection eliminates the possibility that these bones were deposited by such people.

The second adaptive strategy seems to have been a more-or-less traditional one modified to include cattle rustling (Gould et al., 1972). If the Last Supper Cave cow bones represent this strategy, then the frequencies should reflect one of two alternatives. The cows may have been killed near the cave and complete carcasses brought into it, there to be butchered and consumed with minimal transport of meat away from the site. Alternatively, complete carcasses may have been brought
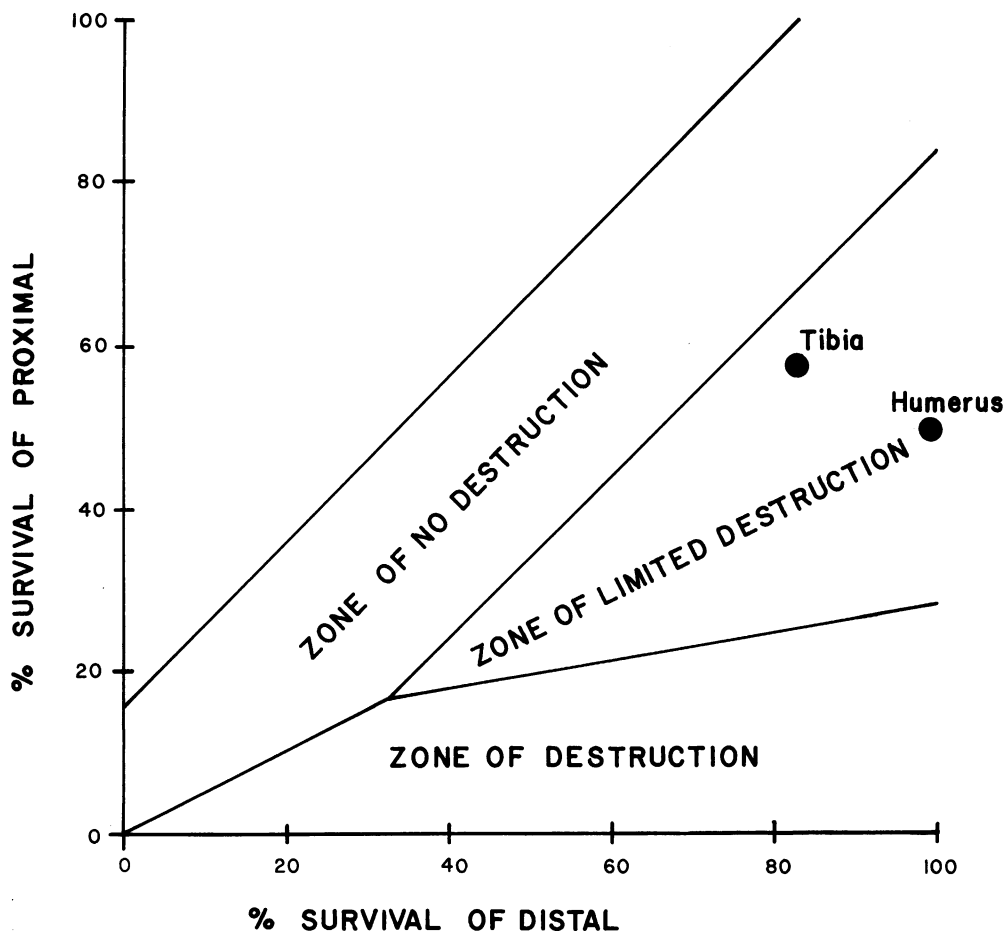
Fig. 27.   Relative frequencies of proximal and distal humeri and tibiae of the Last Supper Cave *Bos* plotted on Binford's (1981) destruction graph.

into the cave with differential transport of bones and meat from the site after butchering, or differential transport of body parts to the cave may have occurred, the meat being consumed on the spot.

The second of these alternatives is easy to eliminate through the construction of utility curves (Binford, 1978; Thomas and Mayer, 1983; see chap. 3). In the absence of MGUI values for cow, I have used the MGUI values for sheep (table 46), but note that the use of the only other available set of MGUI values, for caribou, provides results very similar to those presented here (fig. 28). Because a motivated reader might find a bulk utility strategy (Thomas and Mayer, 1983: fig. 188a) lurking in this plot, I note that the correlation (Pearson's *r*) between logarithmically transformed MGUI values and logarithmically

transformed %MAU values is 0.06. There is no differential bone transport to be seen in this plot.

This plot is, however, consistent with the first rustling strategy I discussed above: introduction of complete carcasses with minimal to no transport of bones away from the cave. It is also consistent with the alternative hypothesis I have presented: that the Last Supper Cave cows died a natural death in the site, where they remained until 1968. Of these two choices, the virtual lack of human modification of the cow bones in the collection suggests that it is the second that must be selected.

DENTON'S CAVE

Layton (1977: 371) mentioned that Denton's Cave (26HU312), located 5 km north-

TABLE 45
Survivorship Percentages and Bulk Densities of Long Bone Ends, Last Supper Cave Cows
(Observed frequencies derived from an MNI of 6)

Element	N observed	% survivorship	Rank	Bulk density	Rank
Proximal humerus	6	50	2	0.24	1
Distal humerus	12	100	8	0.39	4
Proximal radius	7	58	4.5	0.42	6
Distal radius	6	50	2	0.43	7
Proximal femur	6	50	2	0.41	5
Distal femur	8	67	6	0.28	2
Proximal tibia	7	58	4.5	0.30	3
Distal tibia	10	83	7	0.50	8

Kendall's tau, survivorship—bulk density, 0.08; $p > 0.20$

west of Last Supper Cave, also contained a surface scatter of "butchered and cooked remains of domestic cattle," and suggested that the two sites were used by the same group of Indian rustlers prior to 1913. Layton discovered this site by reading a description of it in the published diaries of S. W. Denton, who both described the cave and noted that the entrance to the site was covered by "the skeletons of cattle, horses, sheep and so forth by the dozens" (Denton, 1949: 152).

In 1974, Layton collected a sample of these "dozens of skeletons." His fieldnotes indicate that most loose, large bones were collected and their provenience recorded. Small bone fragments were not collected, nor was an articulated vertebral column with attached rib and innominate and an associated cow skull. The latter material was not collected because it was not believed to have been butchered by Indians. That Indians had used the cave was indicated by the recovery of approximately 30 lithic flakes and five other lithic artifacts from the surface of the interior and mouth of the cave. Concentrations of burned material were mapped, as were areas where wood rats appear to have been active. Apparently, the association of lithic artifacts with the disarticulated cow bones in Denton's Cave led Layton (1977) to argue that the cattle had been rustled.

DESCRIPTIVE SUMMARY

All identified vertebrates retrieved by Layton from Denton's Cave are described in this section; all are mammals. Information on the local distribution of the mammals repre-

TABLE 46
Sheep MGUI (from Binford, 1978), Minimum Numbers of Skeletal Parts (MNE) and Minimal Animal Units (MAU; see Binford, 1984) for the Last Supper Cave Cows

Skeletal part	Sheep MGUI	MNE	MAU	%MAU
Mandible	30	10	5	83
Atlas	19	4	4	67
Axis	19	3	3	50
Cervical	55	18	3.6	60
Thoracic	46	54	4.2	70
Lumbar	39	30	4.3	72
Innominate	82	8	4	67
Sacrum	60	5	5	83
Rib	100	69	2.7	45
Sternabra	91	2	0.3	5
Scapula	45	9	4.5	75
Proximal humerus	37	6	3	50
Distal humerus	33	12	6	100
Proximal radius	24	7	3.5	58
Distal radius	20	6	3	50
Proximal metacarpal	10	5	2.5	42
Distal metacarpal	8	6	3	50
Proximal femur	80	6	3	50
Distal femur	80	8	4	67
Proximal tibia	52	7	3.5	58
Distal tibia	38	10	5	83
Tarsals	23	5	2.5	42
Astragalus	23	6	3	50
Calcaneus	23	8	4	67
Proximal metatarsal	16	6	3	50
Distal metatarsal	12	6	3	50
Phalanx 1	8	20	2.5	42
Phalanx 2	8	14	1.75	29
Phalanx 3	8	14	1.75	29
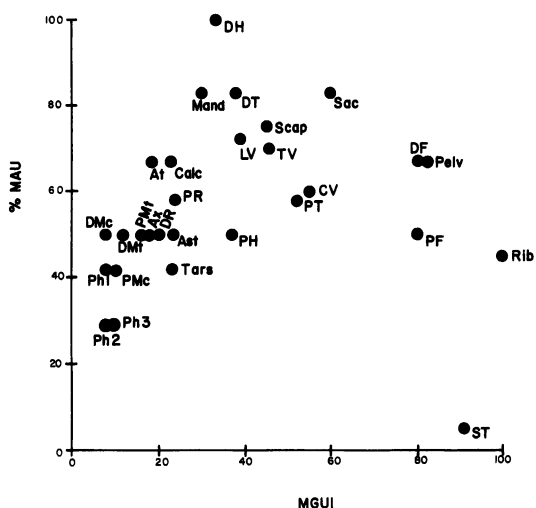
Fig. 28. Economic utility graph for the Last Supper Cave cow bones, based on the modified general utility index for sheep (see table 35 for key to abbreviations); plotted values from table 46.

sented in this collection is presented in chapter 3.

Order Lagomorpha—Rabbits, Hares, and Pikas
Family Leporidae—Rabbits and Hares
Lepus sp.—Hares

Material: Articulated thoracic and lumbar vertebrae, articulated right rear foot (astragalus, calcaneus, 4 metatarsals, 4 first phalanges, 4 second phalanges, 1 third phalanx): 2 specimens.

Remarks: These specimens are relatively fresh and retain much tendinous material. The vertebrae appear to have been gnawed by rodents and the foot is similar to remains deposited by carnivores (Juell and Schmitt, 1985).

Order Rodentia—Rodents
Family Sciuridae—Squirrels
Marmota flaviventris—Yellow-bellied Marmot

Material: Left mandible retaining incisor, p4-m3, proximal left femur: 2 specimens.

Family Erethizontidae—New World Porcupines
Erethizon dorsatum—Porcupine

Material: Left distal tibia: 1 specimen.

Remarks: This specimen has much dried tendinous material adhering to it, and appears to have been gnawed by rodents.

Order Carnivora—Carnivores
Family Felidae—Cats
Lynx sp.—Bobcat or Lynx

Material: Right mandible retaining i1-m1 and attached left mandible fragment retaining i1-i3 and canine fragment, right radius and articulated ulna: 2 specimens.

Remarks: Both specimens have tendinous material and periosteal tissue attached.

Order Artiodactyla—Artiodactyls
Genus and species indet.—Deer or Sheep

Material: Right mandibular articular condyle, 3 thoracic vertebra fragments, 1 lumbar vertebra fragment, 5 rib fragments, proximal right ulna, first phalanx fragment: 12 specimens.

Family Cervidae—Cervids
cf. Odocoileus sp.—Deer

Material: Left humerus (missing proximal epiphysis): 1 specimen.

Odocoileus sp.—Deer

Material: Right front foot (metacarpal, 2 first phalanges, 2 second phalanges, 2 third phalanges, 2 hoof sheaths, vestigial phalanges of dew claws): 1 specimen.

Remarks: The front foot bones are still articulated, are attached to one another by dried connective tissue, and are neither gnawed nor butchered.

Family Bovidae—Bovids
Ovis aries—Domestic Sheep

Material: Left mandible fragment retaining p4 fragment and m1-m2, left radius and articulated proximal ulna, left scapula glenoid, left tibia (missing distal end), right astragalus, left astragalus, right calcaneus: 7 specimens.

Remarks: These specimens are morphologically similar to, but much less robust than, the corresponding elements of bighorn sheep (Ovis canadensis). The scapula and radius show punctures and furrows from carnivore gnawing, and thus may have been transport-

ed into the site by carnivores. The scapula, calcaneus, and both astragali are burned to a gray-black color, suggesting they were heated to at least 500°C (Shipman et al., 1984).

Bos taurus — Domestic Cow

Material: 163 specimens (see table 47).

Remarks: These specimens were identified using the same procedures as those used to identify the Last Supper Cave bovids. However, the Denton's Cave material can all be more securely referred to *Bos* because there are no other taxa of equivalent size represented in the collection. At least three individuals are represented in this assemblage, as compared to the minimum of six individuals represented at Last Supper Cave. As shown by standard measurements (von den Driesch, 1976) provided in table 48, the Denton's Cave cows average 20 percent larger than those from Last Supper Cave. Age, sex, or breed of cattle represented could all, either singly or in combination, account for this difference. I will consider each of these factors in turn.

Only one incomplete maxillary dentition was recovered from Denton's Cave. The eruption and wear of M1 of this specimen suggest an individual older than those represented by specimens retaining M1 at Last Supper Cave. In addition, the suture between the lateral occipitals and the supraoccipital is not fused in any of the Last Supper Cave cow skulls, yet is fused and only slightly visible on the Denton's Cave skull.

The epiphyseal fusion data for Denton's Cave (table 49) show that some of the cow remains from Denton's Cave are ontogenetically older than those at Last Supper Cave. The Denton's Cave collection provided eight specimens suggesting an age greater than four years, while Last Supper Cave contained no specimens reaching this age. Since the Last Supper Cave collection is twice as large as that from Denton's Cave, it seems unlikely that the absence of older animals in the former collection can be attributed to differing sample sizes. It would appear, then, that age differences can account for some of the size differences that distinguish the cow bones from the two sites. Two pubic fragments from Denton's Cave appear to represent males; the two pubic fragments from Last Supper Cave that allowed sex determination represent fe-

TABLE 47
Identified *Bos* Specimens from Denton's Cave

Element	NISP
Skull	1
Horn sheath	2
Premaxilla	1
Mandible, ascending ramus	2
Mandible, body	1
Atlas	3
Axis	1
Cervical 3–7	8
Thoracic	18
Lumbar	9
Sacrum	1
Rib	3
Rib, dorsal	17
Rib, shaft	7
Rib, ventral	8
Costal cartilage fragments	2
Sternabra	2
Scapula	2
Scapula, blade	1
Scapula, glenoid	1
Humerus	4
Humerus, proximal	1
Humerus, distal	2
Radius	2
Radius, proximal	2
Radius, shaft	1
Radius, distal	2
Ulna	1
Ulna, proximal	1
Carpals	3
Metacarpal	4
Metacarpal, proximal	1
Ilium	3
Pubis	2
Femur, proximal	2
Femur, shaft	1
Femur, distal	4
Tibia	3
Tibia, proximal	3
Tibia, shaft	2
Tibia, distal	2
Patella	1
Naviculocuboid	1
Calcaneus	4
Astragalus	3
Metatarsal	1
Metatarsal, distal	1
Metapodial, shaft	1
Metapodial, distal	2
Sesamoid	1
Phalanx 1	4
Phalanx 2	1
Phalanx 3	3
Hoof sheath	4
Total	163

TABLE 48
Selected Measurements (in centimeters) of *Bos* Specimens from Denton's and Last Supper Caves
(Measurement definitions from von den Driesch, 1976)

Measurement	Denton's Cave	Last Supper Cave	% difference[a]
Least occipital breadth (von den Driesch, 1976: 27, no. 30)	14.5	10.8	26
Least frontal breadth (von den Driesch, 1976: 27, no. 32)	17.4	15.2	13
Least diameter of horncore base (von den Driesch, 1976: 28, no. 46)	19.0	12.0 12.5 11.0	38
Greatest breadth, Facies articularis proximalis of radius (von den Driesch, 1976: 79, BFp)	7.73 9.58	7.58 7.52	13
Greatest breadth, Facies articularis distalis of radius (von den Driesch, 1976: 79, BFd)	8.34 7.60 8.30	6.48 6.34	19
Greatest breadth, distal tibia (von den Driesch, 1976: 87, Bd)	8.10 7.55	6.61 6.21	18

[a] The % difference (C) was calculated as C = 100 − B/A where A is the average of measurements on Denton's Cave specimens and B is the average of measurements on Last Supper Cave specimens.

males. Assuming, as seems reasonable, that the cattle represented in these two collections were sexually dimorphic in size, these data suggest that sexual differences between the two collections may also help account for the size differences.

There are no known osteological criteria that allow breeds of American cattle to be distinguished from one another (Gust, 1982). The horn cores from the Denton's Cave and Last Supper Cave collections differ markedly but even single breeds of modern North American domestic cattle display a great deal of variation in horn and horn core morphology (R. Miller, personal commun.). Given the variety of cattle breeds present in northwestern Nevada during the last 150 years, these collections may well represent different breeds. Unfortunately, because we lack characters which would allow such breeds to be distinguished, this issue simply cannot be addressed here. In sum, the substantial size differences between the Denton's Cave and Last Supper Cave cattle can be attributed to differences in age, sex, and, perhaps, breed. It is possible that the Last Supper Cave individuals represent a group of winter-killed cows, while the Denton's Cave cattle represent several bulls.

TAPHONOMY OF THE DENTON'S CAVE *BOS* BONES

1. Carnivore damage

Only 12 *Bos* specimens display damage due to carnivore gnawing (table 50). Most damage consists of two or three punctures and/or one or two furrows per gnawed specimen. Remarkably, none display evidence of rodent gnawing. The frequency and distribution of gnawing marks on the Denton's Cave cow bones are similar to that seen on the Last Supper Cave collection (compare tables 43 and 50). This similarity suggests that carnivores played similar roles in the taphonomic history of both assemblages.

2. Burned bones

Table 51 provides the percentages of burned bone by skeletal element in the Denton's Cave *Bos* collection. As with the Last Supper Cave bones, several of the Denton's Cave specimens have burned dermestid beetle carapaces attached. In addition, three of these specimens are partially coated with burned cow manure. These facts suggest that a fire burned at least some of these bones well after they were deposited in the cave. There is no

TABLE 49
Epiphyseal Fusion Data for the Denton's Cave *Bos* Specimens

Element	Age at fusion (months)	Stage of fusion		
		Unfused	Fused, suture	
			Visible	Not visible
Proximal humerus	42–48	1	2	2
Distal humerus	12–18	0	0	4
Proximal radius	12–18	0	0	4
Distal radius	42–48	1	1	2
Distal metacarpal	24–30	1	2	1
Proximal femur	42	0	1	1
Distal femur	42–48	2	1	1
Proximal tibia	42–48	3	0	3
Distal tibia	24–30	2	0	3
Distal metatarsal	27–30	1	0	1
Distal metapodial	24–30	2	0	0

Age class in months	NISP per age class	
	Denton's Cave	Last Supper Cave
>12–18	8	12
<24–30	5	10
ca. 24–30	2	12
<42–48	7	31
ca. 42–48	4	5
>42–48	8	0
Totals	34	70

clear patterning in the skeletal elements that are burned. Some bones are burned black, others gray, a few reddish-yellow, and a few white. These facts suggest little overall patterned burning as well as varied heating temperatures (Shipman et al., 1984). As with the Last Supper Cave bovid bones, the Denton's Cave cattle specimens are routinely broken in areas where they are burned. Structural weakening resulting from loss of the organic component of the bones again appears to be a major factor in controlling their breakage.

TABLE 50
Carnivore Damaged Bones, Denton's Cave *Bos*

Element	Number damaged
Ilium	2 of 3
Proximal tibia	1 of 6
Dorsal rib	3 of 20
Ventral rib	3 of 11
Atlas	1 of 3
Thoracic vertebra	2 of 18
Total	12 of 163 (7.4%)

3. Skeletal representation

The low incidence of carnivore damage suggests little carnivore-induced destruction. Plotting the ratio of proximal to distal humeri

TABLE 51
Percentages of Burned *Bos* Skeletal Element Fragments at Denton's Cave

Element	% Burned
Mandible	67
Cervical	50
Thoracic	39
Lumbar	50
Rib	47
Scapula	25
Humerus	67
Radius/ulna	62
Carpals	0
Metacarpal	60
Pelvis	0
Femur	100
Tibia	50
Tarsals	38
Metatarsal	50
Phalanges	25
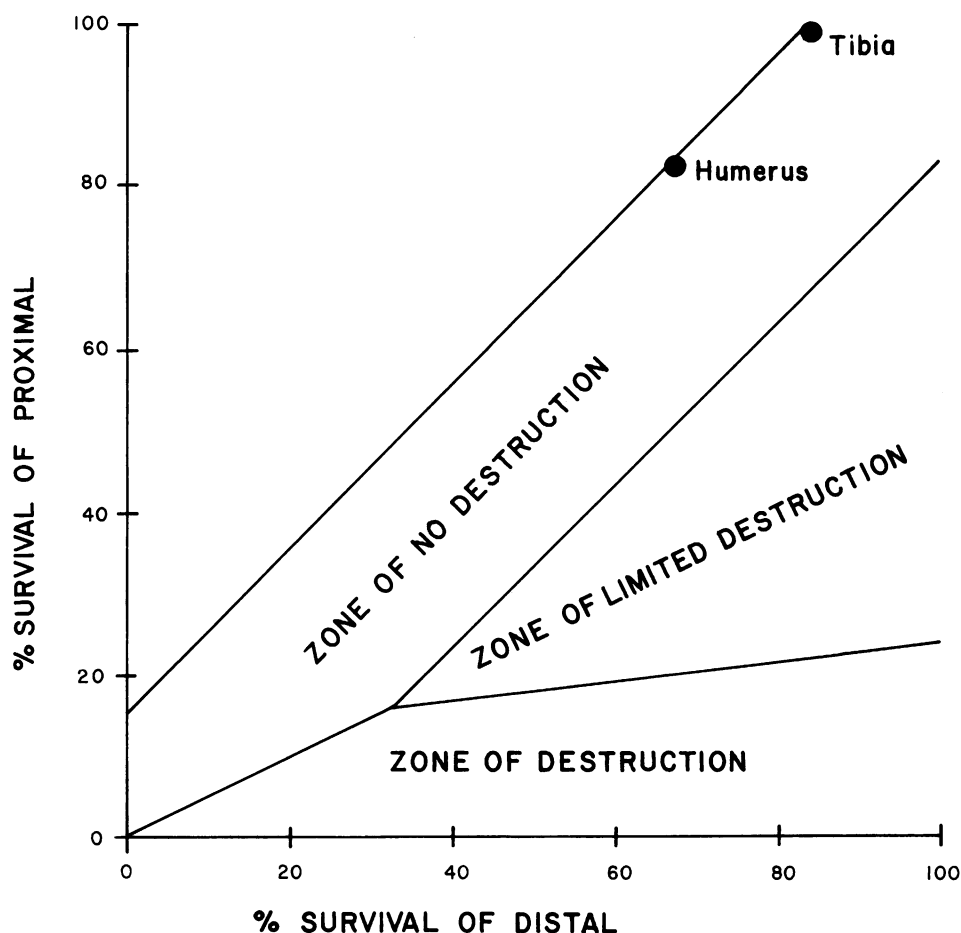
Fig. 29.   Relative frequencies of proximal and distal humeri and tibiae of the Denton's Cave *Bos* plotted on Binford's (1981) destruction graph.

and tibiae on Binford's (1981) "destruction graph" supports this conclusion (fig. 29). As a result, possible selective transport of skeletal parts can be addressed through the construction of a utility curve.

Using the methods discussed above, I derived the relative frequencies of animal units (table 52), and plotted the results against the MGUI values for sheep. There is no pattern in the resultant scatterplot (fig. 30), suggesting that little to no transport related to the economic value of body parts has occurred.

4. Other modifications

The cow skull retrieved from Denton's Cave is broken in the occipital region. The left temporal is missing, and part of the border of the resultant hole consists of the pa-

rietal-temporal suture. However, unlike the Last Supper Cave cow skulls, the sutures between the basisphenoid and basiocciput and between the lateral occipitals and supraoccipital are tightly fused. The basilar and left lateral occipital of the Denton's Cave skull are clearly broken, although both display burning on and around part (ca. 15%) of the break surfaces. This opening in the braincase might be interpreted as evidence of brain extraction by people (cf. Layton, 1977), but there is no evidence of battering near the break margins, such as might be expected if a hammerstone had been used to enter the braincase. Although I would not suggest that burning alone could have produced this break, there is little to support the argument that people were involved.

One other specimen, the distal diaphysis
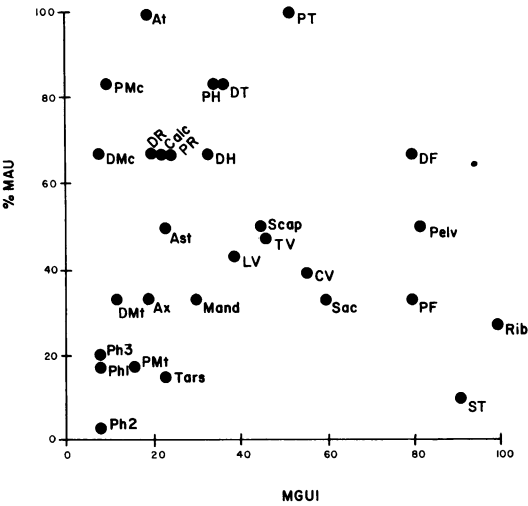
Fig. 30. Economic utility graph for the Denton's Cave cow bones, based on the modified general utility index for sheep (see table 35 for key to abbreviations); plotted values from table 52.

TABLE 52
Numbers of Skeletal Parts and Minimal Animal Units for the Denton's Cave Cows

Skeletal part	Number	MAU	%MAU
Mandible	2	1	33
Atlas	3	3	100
Axis	1	1	33
Cervical	8	1.6	53
Thoracic	18	1.4	47
Lumbar	9	1.3	43
Innominate	3	1.5	50
Sacrum	1	1	33
Rib	20	0.8	27
Sternabra	2	0.3	10
Scapula	3	1.5	50
Proximal humerus	5	2.5	83
Distal humerus	6	3	100
Proximal radius	4	2	67
Distal radius	4	2	67
Proximal metacarpal	5	2.5	83
Distal metacarpal	4	2	67
Proximal femur	2	1	33
Distal femur	4	2	67
Proximal tibia	6	3	100
Distal tibia	5	2.5	83
Tarsals	1	0.5	17
Astragalus	3	1.5	50
Calcaneus	4	2	67
Proximal metatarsal	1	0.5	17
Distal metatarsal	2	1	33
Phalanx 1	4	0.5	17
Phalanx 2	1	0.1	3
Phalanx 3	3	0.4	13

of a left radius, displays attributes of breakage that are unusual. On the anterior surface of this specimen, a portion of the periosteal bone, measuring 6.5 cm proximodistally and 3.5 cm lateromedially, has been removed, exposing the interior trabecular bone. There are three small flake scars on the lateral edge of this break (fig. 31a), as well as two on the exterior and one on the interior of the fracture surface, suggesting forces pushing in and out, respectively. There is also a flake scar on the posterior part of the diaphysis (fig. 31b). The bone displays a spiral fracture, perhaps as a result of the posterior flake scar. This fracture, however, occurred sometime after the bone was fresh. Just distal to the posterior flake scar, the fracture front follows a split line crack for approximately 2 cm prior to continuing to spiral around the bone. In addition, the surface of the fracture is rough and jagged, and is thus a Type II spiral fracture (Shipman, 1981). Shipman (1981: 372) suggests such fractures cannot be produced by trampling or weathering, but only by "agents capable of exerting torsional strength sufficient to overcome the structural strength of the bone." Johnson (1985) notes that dry bone breakage is characterized by the presence of fracture surfaces that exhibit a rough texture and that are at right angles to the exterior cortical surface. In addition, she notes that fracture fronts will "jump" at split line cracks.

All of these features are exhibited by the Denton's Cave specimen.

Rooffall may well have been the agent that fractured this radius, creating the posterior flake scar and the spiral fracture. The anterior removal of periosteal bone, however, cannot be so readily explained. This feature does not appear to have been produced by carnivores, nor is it clearly the result of human activities. I cannot explain it.

Four specimens in the assemblage, three ribs and a first phalanx, display single scratches. Attributes of these scratches were examined under a 40× light microscope, and are presented in table 53. All four follow the bone surface and all four possess microstriae. As I have noted, Shipman and Rose (1983) argue that this attribute indicates that the marks were made by tools, but Eickhoff and Herrmann (1985) have recently shown that
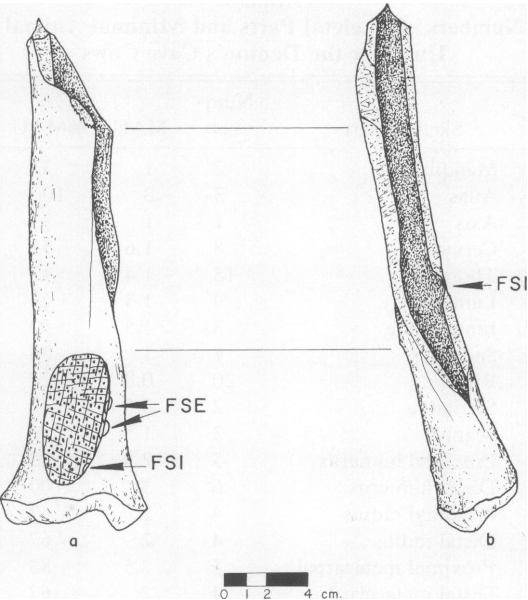
Fig. 31. Damaged *Bos* radius from Denton's Cave (from a drawing by R. L. Lyman): **a,** anterior view; **b,** lateral view; FSI, flake scar on interior of medullary cavity; FSE, flake scar on exterior surface. Note the missing periosteal bone on the distal portion of the anterior surface.

such marks can be created by carnivores, and Behrensmeyer et al. (1986) have shown that they can be created by trampling. In addition, the other attributes of three of these scratches weigh heavily against human involvement.

The scratch on specimen 117 penetrates through the heat-blackening to lighter bone, and was clearly made after the bone was burned. The scratch on specimen 88 is also relatively recent: it is not stained as dark as

adjacent surfaces of the bone. Minute linear marks in, and precisely perpendicular to the long axis of, this scratch may have been produced by a sand-size particle. The scratch on specimen 10 bends abruptly, at an angle of approximately 15 percent, and has a location and orientation inconsistent with interpretation as a butchering mark (Lyman, 1987). The scratch on specimen 69 cannot be readily explained, and may or may not reflect butchering. It is important to note that because a number of the Denton's Cave cow bones are coated by manure, it is clear that live cattle were in the cave after some of the bones were deposited. As a result, all of the scratches described in table 53 could have been produced by trampling (cf. Boaz, 1982; Fiorillo, 1984; Behrensmeyer et al., 1986).

Of the 163 *Bos* specimens, all but 10 (two horn sheaths, four third phalanx sheaths, three third phalanges, one second phalanx) might be expected to show butchering marks. Only one of these specimens, however, displays what might be such a mark (0.7%). While it is unclear just how many bones should display marks of this sort (see above), the virtual lack of butchering marks on the Denton's Cave cow bones is not consistent with Layton's argument that these animals were rustled and butchered.

Finally, one midrib fragment that appears too small to be *Bos* was cut perpendicular to its long axis with a saw; the end opposite the cut has been gnawed by carnivores. This specimen is greasy, and was found approximately 4 m inside the drip line of the cave. The pitch of the teeth of the saw used to cut the bone was apparently fine, as the striae on

TABLE 53
Scratches on the Denton's Cave Cow Bones

Element	Location/length	Surface color	Scratch long axis orientation	Microstriae	Cross-section
Left rib (117)	Dorsal, postero-lateral/7.3 mm	Lighter than adjacent	Down posterior to anterior	Parallel to major scratch	Shallow U
Left rib (69)	Dorsal, postero-lateral/4.1 mm	Same as adjacent	Down posterior to anterior	Parallel to major scratch	Shallow U
Left rib (88)	Dorsal, anteromedial/5.0 mm	Lighter than adjacent	Up posterior to anterior	Perpendicular to major scratch	Shallow U
Phalanx 1 (10)	Lateral/6.1 mm	Same as adjacent	Perpendicular to long axis of bone (bends)	Parallel to major scratch	Shallow V
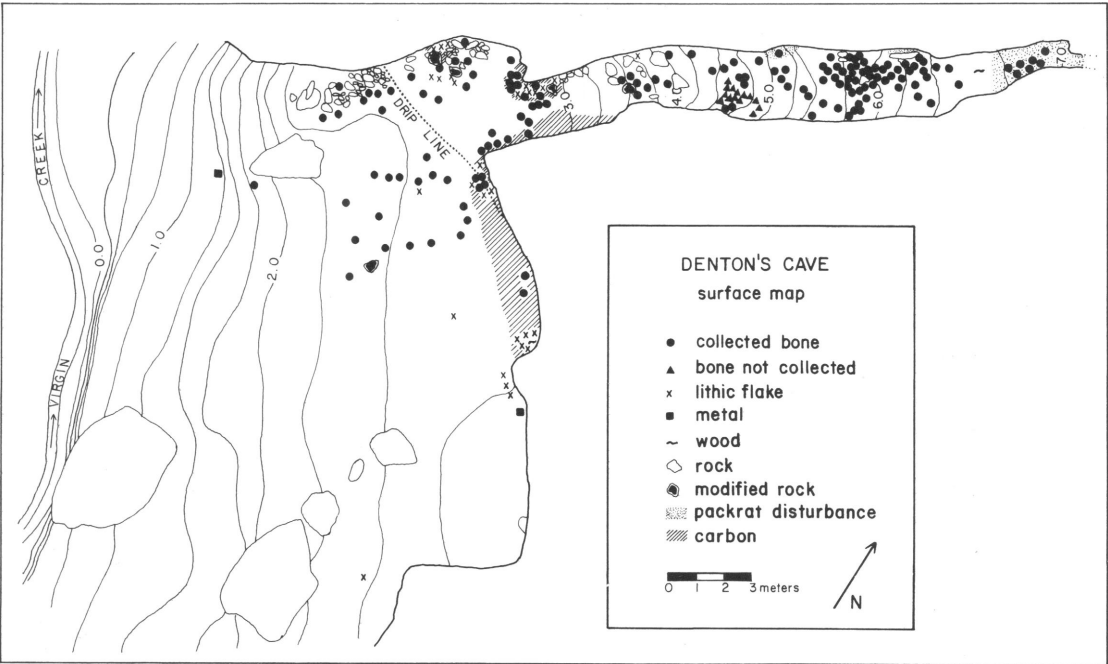
Fig. 32.   The distribution of mapped objects on the floor of Denton's Cave (from original on file at the Nevada State Museum).

the cut surface are shallow and closely spaced. It seems likely that this specimen—the only one from the site that has been clearly modified by people—was deposited by a carnivorous occupant of the cave.

HORIZONTAL DISTRIBUTION OF THE BONES

Cattle bones were scattered throughout the length of Denton's Cave, and many were on the slope leading to, and in front of, the cave's entrance (fig. 32). There was no accumulation at the back of the cave, as occurred at Last Supper Cave. There are a few suggestions that some of these bones were moved subsequent to their initial deposition. Table 54 provides weathering stage data (Behrensmeyer, 1978) for those Denton's Cave *Bos* specimens that could be so analyzed. If the bones were not moved after deposition, then I would expect the most-weathered bones to be outside of the cave, the least-weathered inside, assuming all bones were deposited at roughly the same time. With rare exceptions, this is the case. Those bones that are most weathered (Stages 3 and 4, N = 11) were, with one exception, outside of the drip line of the cave;

the single exception is a lumbar vertebra centrum located 1 m inside the drip line. One of the least-weathered bones (Stage 0), a complete *Bos* rib, was located approximately 3 m outside the drip line, and displays carnivore tooth punctures. These few exceptions suggest some, but not much, movement of bones subsequent to their initial deposition.

Postdepositional movement may be suggested by the distribution of burned bones. Beyond the bones themselves, the only evidence for burning on the surface of the cave is provided by the charcoal and carbon con-

TABLE 54
Frequencies of Denton's Cave Cow Bones by
Behrensmeyer (1978) Weathering Stage

Weathering stage	Number of specimens	% of total
0	1	1
1	113	84
2	10	7
3	3	2
4	8	6
Totals	135	100

centrations mapped by Layton (fig. 32). Assuming that these concentrations imply burning, and that the bones were burned after initial deposition, the fact that only 11 of 19 bones from the burned areas are themselves burned, and that 53 (64%) of the 83 identifiable bones comprising the bone concentration in the back part of the cave are not associated with burned areas but are nonetheless burned, may imply postdepositional movement of bones.

DISCUSSION AND CONCLUSIONS

In describing the 1911 conflict between Indians and Euro-American stockmen at issue here, Layton (1977: 366) reported that "four wealthy California ranchers were found murdered and mutilated in the rugged High Rock country of northwestern Nevada. [These were] respected stockmen." Jones (1980: 64), on the other hand, noted that "in 1911, four Basque shepherds were slain by a group of Bannock Indians camping in the area [of the entrance to Little High Rock Canyon]. Their mutilated bodies were found frozen in the streambed one month later." These differences in how the historic record has been reported indicate that some care is needed when interpreting and discussing that record, and the same is certainly true of the historic faunal assemblages I have described and analyzed here. In this concluding section, I discuss the implications of the analyses I have presented.

WAS THERE A LAST SUPPER?

Layton felt that the best evidence for cattle rustling came from Last Supper Cave and Hanging Rock Shelter. As I have noted, we were unable to locate the cow bones from Hanging Rock Shelter (see chap. 6). At this site, however, Layton (1970: 83) reported "hearths including the broken bones of cooked domestic cattle. In one hearth, a Desert-side Notched projectile point was found in association with cooked cowbone." Such an association would provide strong evidence for rustling, but my analysis of the cow bones from Last Supper and Denton's caves suggests caution here. Certainly, it should be clear that burned bones from such settings do not necessarily imply cooking by people, and the spatial association of burned bone with the

projectile point does not necessarily imply association in a systemic, behavioral context. If the Hanging Rock Shelter cow bones are located, they should be examined with a critical eye.

Layton (1970, 1977) notes that a flaked glass fragment from a liquor bottle dating to between 1911 and 1917 also came from Hanging Rock Shelter. He suggests this dated artifact provides strong support for Indian use of the cave at the time of the rustling incident, and he certainly may be correct about this. However, two facts make me hesitant to accept Layton's argument. First, the site was occupied by a government trapper in 1918, and that individual could well have been the source of the bottle. Second, as Layton (1970) notes, cattle occupied the cave after 1918. As a result, the flaking on the glass object could well be due to trampling (cf. Knudson, 1979; Miller, 1982).

Without a reanalysis of the Hanging Rock Shelter cow bones, there is little more that can be said about the support that this site might provide for early historic rustling by Indians in this area. I can, however, say that neither Last Supper Cave nor Denton's Cave provides evidence for such rustling.

During the last decade, archaeologists have made tremendous strides in understanding the taphonomic history of bone assemblages. Many of the analyses I have presented here simply would not have been possible at the time Layton (1970, 1977) presented his arguments for early historic Indian cattle rustling. Indeed, at the time he offered those interpretations, they were reasonable ones, made so because of our general ignorance of taphonomic processes. Although that ignorance is now substantially decreased, we remain sufficiently ignorant that I see no way to test my hypothesis that the remains of cattle in Last Supper and Denton's caves are to be explained by the fact that the animals took shelter in those sites and simply died there. Nonetheless, we appear to have learned enough to be able to document that the bones themselves suggest that no human agents played a role in their deposition. To a certain extent, the differences between the conclusions presented by Layton (1970, 1977) and those I have presented here measure the increase in our understanding of taphonomic processes during the past decade.

6. HANGING ROCK SHELTER

DONALD K. GRAYSON AND PAUL W. PARMALEE

Hanging Rock Canyon is located just northwest of the northern edge of the Calico Mountains, some 40 km southeast of Vya, Nevada (fig. 8). The rhyolite walls of the upper reaches of this canyon have been deeply incised by a spring-fed stream that ultimately joins Wall Canyon Creek some 10 air-km downstream. Hanging Rock Shelter sits on the north wall of this gorge, just west of its eastern terminus, at an elevation of ca. 1725 m, about 4.3 m above the current stream bed.

The vegetation facing the shelter is typical of streamside vegetation in this portion of the Great Basin. Cottonwoods (*Populus* sp.) and currants (*Ribes* sp.) are fairly dense on both sides of Hanging Rock Creek, while large willows (*Salix* sp.) occur at the mouth of the gorge itself. The dominant shrub between the canyon walls and the stream is big sage (*Artemisia tridentata*), but rabbitbrush (*Chrysothamnus* sp.) is also common. The understory consists of grasses, and dense, low grasses form small meadowlike areas in the flats immediately adjacent to the stream.

Hanging Rock Shelter was excavated under the direction of Thomas N. Layton in 1967 and 1968. Excavation proceeded according to natural stratigraphic units; when the thickness of those units exceeded 4 in. (10 cm), materials were collected by 4 in. (10 cm) levels within each stratum. All excavated sediments were passed through both ¼ in. (0.64 cm) and ⅛ in. (0.32 cm) screens. Layton's work here provided a substantial artifact collection, including 378 projectile points that ranged from the stemmed and concave-based forms characteristic of late Pleistocene and earliest Holocene archaeological assemblages in the Great Basin to the smaller arrowpoints characteristic of late prehistoric and early historic occupations (see Layton, 1970, for a full discussion of these materials).

In addition, Layton retrieved a sizable faunal collection from Hanging Rock Shelter. The mammals in this collection formed part of the basis for David H. Thomas' Master's thesis (Thomas, 1970b), as well as for two innovative methodological articles on faunal analysis by him (Thomas, 1969, 1971). Here, we report the results of a more intensive ex-

amination of the Hanging Rock vertebrates, one that incorporates identifications of the amphibians, reptiles, and birds within the collection, and one that succeeded in identifying a larger fraction of the mammalian component of the assemblage than has previously been identified (6422 specimens, as opposed to the 2315 specimens discussed by Thomas [1970b]).

THE HANGING ROCK SHELTER DEPOSITS

Layton (1970) described five strata for this site, the cultural sequence beginning, he suggested, at about 10,000 B.P. The basal stratigraphic unit within Hanging Rock Shelter he termed the Yellow Stratum. This unit was largely composed of densely packed, highly weathered rooffall, with only the uppermost sections containing artifacts. Basing his argument primarily on the presence of both large, stemmed Parman and Cougar Mountain projectile points and edge-ground Black Rock concave-based points, Layton (1970) suggested that the upper sections of the Yellow Stratum accumulated between about 10,000 and 8000 B.P. Because the artifact content of this stratum was confined to its upper limits, the typologically determined dates strongly suggest that the lower levels of the Yellow Stratum are of late Pleistocene age. We felt that a detailed examination of the vertebrate fauna of this stratum might shed significant light on the nature of late Pleistocene and early Holocene vertebrate faunas in this region, and on the nature of the transition to faunas characteristic of later times. As will be seen, these hopes were, unfortunately, frustrated.

Overlying the Yellow Stratum was a gray-brown midden, termed the Suborganic Stratum by Layton (1970). This unit contained abundant rooffall as well as artifacts throughout, including 130 projectile points. Layton (1970) noted that this unit had been riddled by rodent burrows in places, and the presence of five objects of European manufacture in the otherwise prehistoric deposits of this unit most certainly documents disturbance. The

only radiocarbon date available for Hanging Rock Shelter was obtained from the Suborganic Stratum: 3140 ± 120 B.P. (Gx-1629). Based on projectile point content, however, Layton (1970) estimated that this unit had accumulated between about 8000 B.P. and A.D. 1. That is, he estimated that this single stratigraphic unit spans much of the Holocene. Unfortunately, he was unable to detect any stratigraphic divisions within the Suborganic Stratum, and concluded that "because it represents such a vast period of time, it is particularly difficult to say very much about it" (Layton 1970: 77–78).

In addition to obtaining a radiocarbon date for the Suborganic Stratum, and to assigning ages to all Hanging Rock Shelter strata on the basis of the projectile points each contained, Layton (1970) analyzed hydration rim thicknesses on a series of 104 projectile points from the site. Within the Suborganic Stratum, he found that most of those measurements fell between 6.6 and 2.1 microns. However, he also noted that no specimens had rims between 4.5 and 6.1 microns thick. This he interpreted as an episode of human abandonment of the site, caused by the harsh climatic conditions of the Altithermal (ca. 7000–5000 B.P.). In retrospect, it is easy to question the direct equation of a gap in obsidian hydration measurements with human abandonment of the site, but such equations were common in the early 1970s, as was the explanation of possible abandonments through correlation with hypothesized climatic events in the Great Basin (e.g., Bedwell, 1973; Fagan, 1974). However, it is important to note that even if Layton was correct in suggesting a hiatus in human occupation of the site, there is little convincing reason to associate it with the Altithermal. At Dirty Shame Rockshelter in southeastern Oregon, for instance, an occupational gap of much the same sort fell not between 7000 and 5000 B.P., but between 5900 and 2700 B.P. (Aikens et al., 1977). In addition, while a break in human occupation might alter the nature of the faunal collection within the Suborganic Stratum, there is no stratigraphic suggestion that deposition of faunal material in the cave ceased during the accumulation of this stratum. However, given current information, it is true that it is difficult to deal with this

stratum in any way other than as a stratigraphically indivisible unit.

The Suborganic Stratum was capped by a layer of evaporites called the White Fleck Zone. Perched on top of this layer was an archaeologically rich unit termed the Organic Stratum, the name taken from the fact that it contained abundant plant macrofossils, coprolites, and perishable artifacts. In addition, this stratum provided 112 projectile points, of which 70 (63%) were either Desert Side-notched or Cottonwood. Layton (1970) estimated the time of accumulation of the Organic Stratum as A.D. 1 to A.D. 1920. However, his obsidian hydration work provided a gap in hydration measurements between 2.7 and 1.7 microns. Layton (1970) correlated this gap with proposed low levels of Pyramid Lake during the same time period and suggested that drought once again caused human abandonment of the area. (For a discussion of late Holocene lake levels in the Pyramid and Winnemucca lake basins, see Hattori, 1982.) In support of this suggested occupational gap, Layton (1970) noted that *Olivella* and clam shell beads recovered from the Organic Stratum clearly postdated A.D. 700. Again, however, even if Hanging Rock Shelter had been abandoned by people during this time period, there is no indication that deposition of noncultural materials ceased, so we will treat the Organic Stratum as having accumulated between A.D. 1 and A.D. 1920.

The Organic Stratum was covered by a layer of dung deposited by cattle. This unit, termed the Manure Stratum, contained items of Euro-American manufacture. In 1918, a government trapper began to live in Hanging Rock Shelter, providing a precise date for the definite end of aboriginal use of the site and for the termination of deposition of the Organic Stratum. Layton (1970) thus reasonably argued that the Manure Stratum had been deposited between ca. 1920 and contemporary times.

This stratigraphic framework, consisting of five depositional units, will form the basis of our analysis of the Hanging Rock fauna. However, because the great majority of identifiable faunal specimens came from the Suborganic Stratum (for instance, 4335 [68%] of the 6422 identified mammalian specimens), our analysis cannot be detailed. This situa-

TABLE 55
Number of Identified Specimens per Avian Taxon by Stratum at Hanging Rock Shelter
(Stratum 5 = Yellow Stratum; 4 = Suborganic; 3 = White Fleck; 2 = Organic;
1 = Manure and Surface)

Taxon	Stratum				NP	Totals
	2	3	4	5		
Anatinae, gen. and sp. indet.	—	—	1	—	—	1
Falco sparverius	—	—	1	—	—	1
cf. *Dendragapus obscurus*	1	—	3	—	—	4
Centrocercus urophasianus	—	—	14	1	3	18
cf. *Tympanuchus phasianellus*	—	—	1	—	—	1
Tetraoninae, gen. and sp. indet.	1	—	6	1	1	9
cf. *Bubo virginianus*	—	—	1	—	—	1
Pica pica	2	—	—	—	—	2
Corvus corax	—	—	—	1	—	1
Lanius sp.	—	—	1	—	—	1
Passerines, gen. and sp. indet.	1	—	14	7	2	24
Totals	5	—	42	10	6	63
Indet. bird bone specimens	10	2	27	3	12	54

tion is aggravated by the fact that a large number of specimens (for instance, 809 [13%] of the identified mammalian specimens) cannot be assigned to a single stratum within the site.

DESCRIPTIVE SUMMARY AND ANALYSIS

In this section, we provide basic descriptive data for the Hanging Rock Shelter mammals and birds (tables 55 and 56). These comments include the results of a very brief small mammal survey (112 trap nights) conducted by Grayson in Hanging Rock Canyon in September 1983. Since basic distributional information on wide-ranging species has been presented in earlier chapters, we have not repeated that information here, nor have we repeated discussions of characters used to identify specimens. Because of the lack of stratigraphic resolution available for the Suborganic unit, which provided the bulk of the fauna, we have conducted few detailed analyses of the vertebrate remains from this site. Those analyses that we have conducted are incorporated into this section as well.

CLASS AVES

Order Anseriformes—Swans,
Geese, and Ducks
Family Anatidae—Swans, Geese,
and Ducks
Anatinae, genus and sp. indet.

Material: Right coracoid shaft: 1 specimen.

Remarks: This incomplete coracoid, missing the head and neck as well as the sternal facet and sternocoracoidal facet, is from a duck the size of a Northern Shoveler (*Anas clypeata*), but is too fragmentary to be identified to genus. Small spring-fed streams, such as that in Hanging Rock Canyon, would not have provided a major attraction to waterbirds; the paucity of such birds in the collection would appear to reflect that fact.

Order Falconiformes—Diurnal
Birds of Prey
Family Falconidae—Caracaras and Falcons
Falco sparverius—American Kestrel

Material: Anterior sternal fragment: 1 specimen.

Order Galliformes—Gallinaceous Birds
Family Phasianidae—Partridges, Grouse,
Turkeys, and Quail
cf. *Dendragapus obscurus*—Blue Grouse

Material: Proximal right humerus, complete right coracoid, proximal right femur, distal left femur: 4 specimens.

Centrocercus urophasianus—Sage Grouse

Material: 3 proximal right humeri, right humerus (missing proximal end), distal right humerus, proximal left radius, 3 right ulna

TABLE 56
Number of Identified Specimens per Mammalian Taxon: Hanging Rock Shelter
(See table 55 for key to stratum designations)

Taxon	Stratum									NP	Totals
	1	2	2/3	3	2/4	3/4	4	4/5	5		
Ochotona princeps	—	—	—	—	1	—	1	—	2	—	4
Sylvilagus sp.	9	17	2	9	9	2	310	26	65	7	456
Sylvilagus idahoensis	2	28	5	6	28	15	379	21	58	7	549
Sylvilagus cf. *nuttallii*	20	179	8	37	90	56	1910	155	339	79	2873
Sylvilagus nuttallii	—	33	—	6	14	4	406	21	55	17	556
Lepus sp.	15	72	2	19	30	16	808	83	135	45	1225
Tamias sp.	—	—	—	—	—	—	1	—	—	—	1
Marmota flaviventris	2	27	—	5	9	2	181	8	19	4	257
Spermophilus sp.	—	3	—	—	2	—	32	3	9	1	50
Spermophilus cf. *townsendii*	—	3	—	—	—	—	9	2	—	—	14
Spermophilus townsendii	—	—	—	—	5	—	27	3	3	4	42
Spermophilus cf. *beldingi*	—	2	—	—	—	—	7	—	—	—	9
Spermophilus beldingi	—	—	—	—	—	—	8	—	1	—	9
Spermophilus cf. *lateralis*	—	1	—	—	—	—	—	—	—	—	1
Spermophilus lateralis	—	—	—	—	—	—	5	—	1	—	6
Thomomys sp.	—	—	—	—	1	—	13	4	1	—	19
Thomomys cf. *talpoides*	—	—	—	—	—	—	6	—	1	—	7
Thomomys talpoides	—	—	—	—	—	—	4	—	1	1	6
Perognathus sp.	—	—	—	—	—	—	20	1	3	—	24
Reithrodontomys sp.	—	—	—	—	—	—	1	—	—	—	1
Peromyscus sp.	—	—	—	—	—	—	5	—	—	—	5
Peromyscus maniculatus	—	—	—	—	—	—	4	—	1	—	5
Peromyscus crinitus	—	—	—	—	—	—	2	—	—	—	2
Neotoma sp.	—	—	—	—	—	—	7	—	3	—	10
Neotoma cf. *cinerea*	1	1	—	1	3	—	32	4	7	1	50
Neotoma cinerea	—	2	—	—	1	—	19	2	7	2	33
Microtus sp.	—	—	—	—	—	—	41	—	8	—	49
Lagurus curtatus	—	2	—	—	—	—	30	—	1	—	33
Erethizon dorsatum	—	—	—	—	—	—	6	—	1	—	7
Canis cf. *latrans*	—	—	—	—	1	—	—	—	1	—	2
Canis latrans	—	—	—	—	—	—	1	—	—	—	1
Mustela frenata	—	1	—	—	—	—	2	—	—	—	3
Taxidea taxus	—	—	—	5	—	—	—	—	—	—	5
Lynx cf. *rufus*	—	2	—	—	2	—	4	—	—	—	8
Lynx rufus	—	—	—	—	—	—	5	—	—	—	5
Cervus elaphus	—	—	—	—	2	—	18	—	14	—	34
Odocoileus sp.	—	—	—	—	1	—	2	—	—	—	3
Antilocapra americana	—	3	—	—	1	—	4	—	—	—	8
Bison bison	—	—	—	—	1	—	—	1	—	—	2
Ovis canadensis	—	4	—	5	8	5	25	—	1	—	48
Totals	49	380	17	93	209	100	4335	334	737	168	6422

shafts, left ulna shaft, proximal right coracoid, 2 proximal halves left coracoid, proximal left scapula, 2 sternal fragments, distal left femur, proximal right tarsometatarsus: 18 specimens.

Remarks: The distal right humerus bears a series of cut marks at the edge of the impression of the brachialis anticus.

cf. *Tympanuchus phasianellus* —
Sharp-tailed Grouse

Material: Complete left coracoid: 1 specimen.

Tetraoninae — Grouse, genus and
sp. indet.

Material: Proximal right humerus, distal

left humerus, distal left radius, distal half left ulna, 2 proximal right coracoids, proximal left scapula, fragmentary sternum, fragmentary synsacrum: 9 specimens.

Remarks: Although the coracoid is not the best diagnostic element to use in separating such similarly sized birds as Blue Grouse, Spruce Grouse, female Sage Grouse, and Sharp-tailed Grouse, this specimen compares closely with Sharp-tailed Grouse.

Sage Grouse were once very widespread in northern Nevada and their presence in the deposits of Hanging Rock Shelter occasions no surprise. However, there are no historic records for either Sharp-tailed Grouse or Blue Grouse from northwestern Nevada (Gullion and Christensen, 1957). We stress, however, the tentative nature of the identification of both birds in the collection.

Order Strigiformes—Owls
Family Strigidae—Typical Owls
cf. *Bubo virginianus*—Great Horned Owl

Material: Fragmentary premaxilla: 1 specimen.

Remarks: The identification of this specimen is tentative because it is both fragmentary and weathered.

Order Passeriformes—Passerine Birds
Family Corvidae—Jays,
Magpies, and Crows
Pica pica—Black-billed Magpie

Material: Left femur, proximal right tarsometatarsus: 2 specimens.

Corvus corax—Common Raven

Material: Distal left tarsometatarsus: 1 specimen.

Remarks: Both Black-billed Magpies and Common Ravens are common residents in northern Nevada.

Family Laniidae—Shrikes
Lanius sp.—Shrike

Material: Left humerus (missing pneumatic fossa and bicipital crest): 1 specimen.

Remarks: The Northern Shrike (*L. excubitor*) is occasionally found in the Great Basin in the winter, while the Loggerhead Shrike

(*L. ludovicianus*) is common here during the summer (Ryser, 1985).

CLASS MAMMALIA

Order Lagomorpha—Rabbits,
Hares, and Pikas
Family Ochotonidae—Pikas
Ochotona princeps—Pika

Material: 1 mandible, 2 isolated teeth, 1 humerus: 4 specimens.

Remarks: Today, pikas are discontinuously distributed across the Great Basin, with known populations confined to the high-elevation settings provided by a subset of Great Basin mountain ranges. Pikas were one of the mammals used by Brown (1971, 1978) in his analysis of the distribution of boreal mammals across Great Basin mountains. Although patches of talus suitable for pikas would appear to exist along the canyon walls upstream from Hanging Rock Shelter, these patches contain no suggestion that pikas exist here today. Indeed, the closest modern records for pikas of which we are aware come from approximately 45 km to the northwest, east of Fort Bidwell at an elevation of 1740 km, and from 55 km to the east in the Pine Forest Range at an elevation of ca. 2590 km (Hall, 1946).

Brown's hypothesis that boreal mammals occupied the Great Basin during the Pleistocene, only to become confined to, and ultimately differentially extinct across, the mountaintops of the region after the close of the Pleistocene, predicts, as was discussed in chapter 1, that such boreal mammals as pikas existed in Great Basin low-elevation settings at some time in the past. There is ample evidence that this was, in fact, the case, and pikas are currently the best-documented example of this phenomenon, although the record for marmots (*Marmota flaviventris*) is now beginning to provide yet another detailed example. There are Holocene records for pikas from a number of low-elevation settings in the northern half of the Great Basin, with the most recent of these records falling at about 6500 B.P. (Grayson, 1987). It now appears that pikas became isolated on Great Basin mountain ranges between about 6500 and 5100 B.P., the older date taken from the low-elevation records provided by such sites as

the Connley Caves in southcentral Oregon (Grayson, 1979) and Streamview Rockshelter in the Snake Range (Thompson, 1984), and the younger date from the Gatecliff Shelter record for pika movement to higher elevations on the Toquima Range (Grayson, 1983).

The presence of pikas in Hanging Rock Shelter provides yet another extralimital low-elevation record for this animal in the Great Basin. Unfortunately, the stratigraphic placement of these specimens (one in either the Suborganic or Organic stratum, one in the Suborganic Stratum, and two in the Yellow Stratum: see table 56) does not provide much information on the timing of the local extinction of these animals here. Clearly, they were present in terminal Pleistocene/early Holocene times, since the Yellow Stratum seems to have stopped accumulating by 8000 B.P. However, the remaining specimens could have been deposited any time between ca. 2000 and 8000 B.P. and it is, of course, quite possible that all were deposited prior to 5000 B.P. Such a date would be consistent with other dates available for low-elevation extinctions of this mammal in the northern reaches of the Great Basin, although, as one of us has pointed out elsewhere (Grayson, 1987), there is little reason to think that the process of local extinction and subsequent isolation for any given taxon was synchronous across the Great Basin.

Family Leporidae—Rabbits and Hares
Sylvilagus sp.—Rabbits

Material: 49 skull fragments, 19 mandibles, 111 isolated teeth, 56 scapulae, 20 humeri, 14 radii, 14 ulnae, 5 metacarpals, 32 vertebrae, 1 sacrum, 16 innominates, 16 femora, 14 tibiae, 4 calcanea, 12 metatarsals, 3 metapodials, 70 phalanges: 456 specimens.

Sylvilagus idahoensis—Pygmy Rabbit

Material: 105 skull fragments, 93 mandibles, 135 isolated teeth, 16 scapulae, 28 humeri, 17 radii, 9 ulnae, 3 metacarpals, 5 vertebrae, 1 sacrum, 16 innominates, 35 femora, 58 tibiae, 12 calcanea, 4 astragali, 1 navicular, 11 metatarsals: 549 specimens.

Sylvilagus cf. *nuttallii*—Nuttall's Cottontail

Material: 336 skull fragments, 281 mandibles, 461 isolated teeth, 181 scapulae, 179 humeri, 99 radii, 79 ulnae, 29 metacarpals, 1 carpal, 56 vertebrae, 3 sacra, 131 innominates, 241 femora, 472 tibiae, 75 calcanea, 31 astragali, 6 miscellaneous tarsals, 104 metatarsals, 108 phalanges: 2873 specimens.

Sylvilagus nuttallii—Nuttall's Cottontail

Material: 180 skull fragments, 122 mandibles, 254 isolated teeth: 556 specimens.

Lepus sp.—Hares

Material: 122 skull fragments, 88 mandibles, 173 isolated teeth, 59 scapulae, 112 humeri, 89 radii, 51 ulnae, 13 metacarpals, 21 vertebrae, 1 sacrum, 29 innominates, 142 femora, 3 patellae, 157 tibiae, 17 astragali, 35 calcanea, 10 miscellaneous tarsals, 50 metatarsals, 53 phalanges: 1225 specimens.

Remarks: Nuttall's cottontails, pygmy rabbits, and black-tailed jackrabbits are common inhabitants of the Sagebrush Vegetation Zone (Cronquist et al., 1972) of the Great Basin.

Order Rodentia—Rodents
Family Sciuridae—Squirrels
Tamias sp.—Chipmunks

Material: 1 tibia: 1 specimen.

Marmota flaviventris—Yellow-bellied Marmot

Material: 80 skull fragments, 33 mandibles, 62 isolated teeth, 3 clavicles, 6 scapulae, 13 humeri, 9 radii, 9 ulnae, 2 innominates, 11 femora, 4 tibiae, 2 fibulae, 3 astragali, 5 calcanea, 1 cuboid, 8 metatarsals, 6 phalanges: 257 specimens.

Spermophilus sp.—Ground Squirrels

Material: 9 skull fragments, 7 mandibles, 3 isolated teeth, 4 scapulae, 5 humeri, 1 radius, 5 ulnae, 4 innominates, 4 femora, 6 tibiae, 1 fibula, 1 calcaneus: 50 specimens.

Spermophilus cf. *townsendii* — Townsend's
Ground Squirrel

Material: 6 skull fragments, 8 mandibles:
14 specimens.

Spermophilus townsendii — Townsend's
Ground Squirrel

Material: 10 skull fragments, 6 mandibles,
26 isolated teeth: 42 specimens.

Spermophilus cf. *beldingi* — Belding's
Ground Squirrel

Material: 6 skull fragments, 3 mandibles:
9 specimens.

Spermophilus beldingi — Belding's
Ground Squirrel

Material: 4 skull fragments, 2 mandibles,
3 isolated teeth: 9 specimens.

Spermophilus cf. *lateralis* — Golden-mantled
Ground Squirrel

Material: 1 mandible: 1 specimen.

Spermophilus lateralis — Golden-mantled
Ground Squirrel

Material: 2 skull fragments, 2 mandibles,
2 isolated teeth: 6 specimens.
Remarks: Although no active marmots
were seen during the brief September visit to
Hanging Rock Shelter, a recent marmot skull,
with soft tissues still present, was found in
the vicinity of the site itself, strongly sug-
gesting that marmots are present here today.
All of the other sciurids identified from the
site are common inhabitants of this part of
Nevada (Hall, 1946).

In chapter 3, it was noted that Last Supper
Cave contains a number of marmot mandi-
bles that display butchering marks on the
buccal wall of the ascending ramus, and that
these marks are identical to those shown by
two marmot mandibles from Alta Toquima
(Mt. Jefferson, Toquima Range) and one from
Hanging Rock Shelter (see fig. 19). The Hang-
ing Rock specimen shows two very small
(maximum length, 0.9 mm) parallel cuts, sep-
arated by 0.20 mm, at right angles to the
anterior edge of the buccal wall of the as-
cending ramus of the right mandible, almost

exactly at the level of the m3 alveolus. Both
cuts are deepest at their anterior ends, and
both have V-shaped cross-sections. Because
this specimen (HR-26) came from the Sub-
organic Stratum, little can be said about its
age, other than it is likely to have been de-
posited between 8000 and 2000 B.P.

Family Geomyidae — Pocket Gophers
Thomomys sp. — Smooth-toothed
Pocket Gophers

Material: 2 skull fragments, 1 mandible, 2
scapulae, 3 humeri, 1 ulna, 5 innominates, 1
femur, 3 tibiae, 1 astragalus: 19 specimens.

Thomomys cf. *talpoides* — Northern
Pocket Gopher

Material: 1 skull fragment, 6 mandibles: 7
specimens.

Thomomys talpoides — Northern
Pocket Gopher

Material: 4 skull fragments, 2 isolated teeth:
6 specimens.
Remarks: Three measurable edentulous
Thomomys mandibles were retrieved from
Hanging Rock Shelter; the p4–m2 alveolar
lengths of all three (5.0, 5.3, and 5.4 mm) are
consistent with identification as either *T. tal-
poides* or *T. bottae* (see Grayson, 1983, and
chap. 3). Edentulous *Thomomys* mandibles
were assigned to *T.* cf. *talpoides* on the basis
of the presence of relatively elongate p4 al-
veoli. *T. talpoides* is the only pocket gopher
known from the Hanging Rock Canyon area
(Hall, 1946).

Family Heteromyidae — Pocket Mice,
Kangaroo Mice, and Kangaroo Rats
Perognathus sp. — Pocket Mice

Material: 2 skull fragments, 2 mandibles,
4 isolated teeth, 2 scapulae, 7 humeri, 1 in-
nominate, 2 femora, 2 tibiae, 2 calcanea: 24
specimens.
Remarks: The fragmentary *Perognathus*
material from Hanging Rock Shelter could
not be identified to species. The Great Basin
pocket mouse, *Perognathus parvus,* is the only
member of the genus known from the Hang-
ing Rock area; during the small mammal sur-
vey conducted in the canyon, a single *P. par-*

TABLE 57
Alveolar and Occlusal Lengths (in millimeters) for Hanging Rock Shelter *Peromyscus*
Mandibles Retaining at Least One Molar
(See table 55 for key to stratum designations)

Specimen number	Alveolar length	Occlusal length			Identification	Stratum
		m1	m2	m3		
HR-24	3.51	1.45	1.19	—	*P. maniculatus*	5
HR-25	3.68	1.58	1.14	—	*P. maniculatus*	5
HR-18	3.11	—	—	0.95	*P. crinitus*	5

vus was taken adjacent to the stream bank just east of Hanging Rock Shelter.

Family Muridae—Murids
Reithrodontomys sp.—Harvest Mice

Material: 1 isolated tooth: 1 specimen.

Peromyscus sp.—Deer Mice

Material: 3 skull fragments, 1 mandible, 1 isolated tooth: 5 specimens.

Peromyscus maniculatus—Deer Mouse

Material: 2 skull fragments, 2 mandibles, 1 isolated tooth: 5 specimens.

Peromyscus crinitus—Canyon Mouse

Material: 1 skull fragment, 1 mandible: 2 specimens.

Neotoma sp.—Wood Rats

Material: 4 skull fragments, 1 mandible, 3 isolated teeth, 1 humerus, 1 tibia: 10 specimens.

Neotoma cf. *cinerea*—Bushy-tailed Wood Rat

Material: 11 skull fragments, 10 mandibles, 3 isolated teeth, 1 scapula, 5 humeri, 3 radii, 5 ulnae, 2 innominates, 7 femora, 3 tibiae: 50 specimens.

Neotoma cinerea—Bushy-tailed Wood Rat

Material: 11 skull fragments, 10 mandibles, 12 isolated teeth: 33 specimens.

Microtus sp.—Meadow Voles

Material: 8 mandibles, 41 isolated teeth: 49 specimens.

Lagurus curtatus—Sage Vole

Material: 2 skull fragments, 31 isolated teeth: 33 specimens.

Remarks: Table 57 provides measurements of the Hanging Rock Shelter *Peromyscus* mandibles, and of the teeth in those mandibles (see Grayson, 1985). Table 58 presents mandibular and maxillary alveolar lengths for the measurable Hanging Rock *Neotoma* specimens; occlusal lengths for isolated *Neotoma* teeth in this collection, as well as for single teeth within otherwise unidentifiable *Neotoma* mandibles or maxillae, are provided in table 59 (tables 4 and 5, chap. 1 provide comparative measurements of modern *Neotoma* mandibles, maxillae, and teeth).

All of the Hanging Rock murids are common in this part of Nevada. During the brief mammal survey conducted in Hanging Rock Canyon, eight *Peromyscus maniculatus* were taken immediately adjacent to the stream bank just east of Hanging Rock Shelter; an additional four individuals were taken in a dense stand of big sage (*A. tridentata*) just east of the mouth of the canyon gorge. In addition, a single *P. crinitus* was taken from along the rear wall of the shelter itself, and a single *Neotoma lepida* (unrepresented in the Hanging Rock fauna) from an isolated boulder between the shelter and the stream. Finally, four *Microtus longicaudus* were taken along the stream bank immediately south of the site.

Family Erethizontidae—New World Porcupines
Erethizon dorsatum—Porcupine

Material: 1 skull fragment, 1 mandible, 5 isolated teeth: 7 specimens.

Remarks: Porcupines are found throughout Nevada (Hall, 1946).

TABLE 58

Mandibular and Maxillary Alveolar Lengths (in millimeters): Hanging Rock Shelter *Neotoma*
(See table 55 for key to stratum designations)

Specimen number	Alveolar length	Identification	Stratum
A. Mandibles (m1-m3)			
HR-56	9.8	*N. cinerea*	5
HR-78	10.3	*N. cinerea*	5
HR-104	10.3	*N. cinerea*	6
HR-49	10.4	*N. cinerea*	5
HR-52	10.5	*N. cinerea*	5
HR-87	10.7	*N. cinerea*	5/6
B. Maxillae (M1-M3)			
HR-39	9.3	*Neotoma* sp.	5
HR-96	9.6	*N. cinerea*	5
HR-104	9.9	*N. cinerea*	6
HR-48	10.0	*N. cinerea*	NP
HR-93	10.2	*N. cinerea*	5
HR-52	10.3	*N. cinerea*	5

TABLE 59

Occlusal Lengths (in millimeters) of *Neotoma* Molars from Hanging Rock Shelter: Isolated Specimens or Those from Mandibles or Maxillae with Unmeasurable Alveolar Lengths
(See table 55 for key to stratum designations)

Tooth	Specimen number	Occlusal length	Identification	Stratum
M1	HR-22	3.36	*N. cinerea*	5
	HR-104	3.59	*N. cinerea*	6
	HR-5	3.66	*N. cinerea*	6
	HR-41	3.73	*N. cinerea*	6
M2	HR-6	2.92	*N. cinerea*	3/5
	HR-1	3.01	*N. cinerea*	5
M3	HR-39	2.68	*N. cinerea*	5
m1	HR-27	3.60	*N. cinerea*	5
	HR-5	3.67	*N. cinerea*	6
	HR-51	3.74	*N. cinerea*	5
m2	HR-1	3.05	*N. cinerea*	5
	HR-87	3.21	*N. cinerea*	5/6
m3	HR-18	2.19	*N. cinerea*	5
	HR-21	2.24	*N. cinerea*	6

Order Carnivora—Carnivores
Family Canidae—Coyote, Wolves, Foxes, and Dogs
Canis cf. *latrans*—Coyote

Material: 1 isolated tooth, 1 femur: 2 specimens.

Canis latrans—Coyote

Material: 1 tarsal: 1 specimen.

Family Mustelidae—Mustelids
Mustela frenata—Long-tailed Weasel

Material: 1 skull fragment, 1 mandible, 1 isolated tooth: 3 specimens.

Taxidea taxus—Badger

Material: 1 mandible, 4 isolated teeth: 5 specimens.

Family Felidae—Cats and Allies
Lynx cf. *rufus*—Bobcat

Material: 2 humeri, 1 radius, 1 metatarsal, 4 phalanges: 8 specimens.

Lynx rufus—Bobcat

Material: 2 mandibles, 3 isolated teeth: 5 specimens.
Remarks: All of the carnivores present in

the Hanging Rock fauna are common in northern Nevada (Hall, 1946).

Order Artiodactyla—Artiodactyls
Family Cervidae—Cervids
Cervus elaphus—Wapiti

Material: 33 isolated teeth, 1 metacarpal: 34 specimens.

Odocoileus sp.—New World Deer

Material: 1 scapula, 1 ulna, 1 astragalus: 3 specimens.

Family Antilocapridae—Pronghorn
Antilocapra americana—Pronghorn

Material: 2 mandibles, 3 isolated teeth, 1 carpal, 1 tibia, 1 phalanx: 8 specimens.

Family Bovidae—Bovids
Bison bison—Bison

Material: 1 metatarsal, 1 phalanx: 2 specimens.

Ovis canadensis—Mountain Sheep

Material: 10 mandibles, 21 isolated teeth, 1 ulna, 5 radii, 3 metacarpals, 2 carpals, 1

tibia, 1 fibula, 1 astragalus, 3 phalanges: 48 specimens.

Remarks: It is problematic whether white-tailed deer (*Odocoileus virginianus*) have ever occurred in northwestern Nevada and adjacent northeastern California (Adams, 1963). One of the goals of this project was to clarify this issue through the application of discriminant function analysis to deer mandibles (Livingston, 1987) recovered from Hanging Rock Shelter and Last Supper Cave. Unfortunately, those collections did not contain material in a sufficient state of preservation to allow such an analysis and the issue remains unresolved.

As I have noted (chap. 3), there are no historic records for wapiti in northwestern Nevada or adjacent Oregon (Bailey, 1936; Hall, 1946, 1981). However, they have been reported from the Connley Caves and from Fort Rock Cave in the Fort Rock Basin of southcentral Oregon. The single specimen from Fort Rock Cave is of ambiguous age, but 24 of the 25 Connley Caves specimens were deposited between 11,000 and 7000 B.P., the remaining specimen having been deposited between 4400 and 3400 B.P. (Grayson, 1979). The chronology of the Last Supper Cave wapiti material is anything but clear, but all eight provenienced specimens were deposited during the last 6000 years, and at least four may have been deposited during the last 2000 years. In Hanging Rock Shelter, 32 of the 34 *C. elaphus* specimens came from either the Suborganic (18) or the Yellow (14) stratum; the remaining two specimens came from mixed Organic/Suborganic deposits. As with the pikas here, all of the Hanging Rock Shelter wapiti materials could have been deposited during relatively early Holocene times, though there is, unfortunately, no way of knowing whether this was the case. In dealing with a similar problem, Thomas (1970b) divided the Suborganic deposits into upper and lower halves, explicitly recognizing that this provided little true control over time, but hopeful that it would provide at least some. If the same approach is taken with the Hanging Rock Shelter wapiti, 13 of those specimens can be assigned to the upper half of the Suborganic deposits, the remaining five to the lower half of that unit. Although deep placement of all Suborganic wapiti specimens

might have provided support for an earlier Holocene age for those specimens, their actual position does not clarify their temporal setting. With the exception of a single distal left metacarpal, all Hanging Rock wapiti materials were teeth: two incisor fragments and cheek teeth and cheek teeth fragments. Transport of this material from afar seems unlikely. The presence of wapiti in the Connley Caves, Fort Rock Cave, Last Supper Cave, and Hanging Rock Shelter suggests that small numbers of wapiti may have been widely scattered throughout northern Nevada and adjacent portions of Oregon during much of the Holocene.

Many large faunal collections from Holocene-age deposits in the northern half of the Great Basin contain small numbers of bison, suggesting that these animals were widespread, though apparently nowhere abundant, in this region during the past 10,000 years. The scanty available record suggests as well that these animals may have been more abundant during the first half of the Holocene than during the last 5000 years (see the discussions in Grayson, 1979, 1982b). The entire Hanging Rock bison collection consists of a distal phalanx fragment from mixed Organic/Suborganic stratum deposits, and a fragmentary distal bovid metatarsal from mixed Yellow/Suborganic deposits that has been assigned to bison solely on the basis of its age. Little can be said of the time of deposition of these specimens.

CONCLUSIONS

As we have noted, one of the prime reasons for our interest in the Hanging Rock fauna related to the presence of a late Pleistocene/early Holocene fauna in the Yellow Stratum. Known faunas of this age are quite rare in the northern reaches of the Great Basin and are completely unknown from northwestern Nevada and adjacent northeastern California. We were hopeful that the Yellow Stratum assemblage would allow us to clarify the nature of pre-8000 B.P. vertebrate faunas in this region and to assess the nature of the difference between faunas of this age and those of later Holocene times. We were also hopeful that the Yellow Stratum materials would shed further light on the history of boreal mam-

TABLE 60
Numbers of Identified Specimens (NISP) and Relative Abundances of the Hanging Rock Shelter Mammals: Yellow Stratum Compared to all Later Units
(All "cf." identifications have been merged with the corresponding species)

	Stratum			
	Manure–suborganic		Yellow	
Taxon	NISP	%	NISP	%
Ochotona princeps	2	00	2	01
Sylvilagus sp.	358	07	65	09
S. idahoensis	463	09	58	08
S. nuttallii	2763	53	394	54
Lepus sp.	962	19	135	18
Tamias sp.	1	00	0	00
Marmota flaviventris	226	04	19	03
Spermophilus sp.	37	01	9	01
Spermophilus townsendii	44	01	3	00
Spermophilus beldingi	17	00	1	01
Spermophilus lateralis	6	01	1	00
Thomomys (all)	24	01	3	00
Perognathus sp.	20	00	3	00
Reithrodontomys sp.	1	00	0	00
Peromyscus (all)	11	00	1	00
Neotoma sp.	7	00	3	00
Neotoma cinerea	60	01	14	02
Microtus sp.	41	01	8	01
Lagurus curtatus	32	01	1	00
Erethizon dorsatum	6	00	1	00
Canis latrans	2	00	1	00
Mustela frenata	3	00	0	00
Taxidea taxus	5	00	0	00
Lynx rufus	13	00	0	00
Cervus elaphus	20	00	14	02
Odocoileus sp.	3	00	0	00
Antilocapra americana	8	00	0	00
Bison bison	1	00	0	00
Ovis canadensis	47	01	1	00
Totals	5183	99	737	99

mals in low-elevation settings in the northern Great Basin.

We were largely frustrated in these hopes. The Yellow Stratum provided only four bird specimens that could be identified to at least the genus level, while the mammalian fauna consists of only 734 identified specimens (see table 60), of which 54 percent are Nuttall's cottontail. Even if now-extirpated boreal mammals other than pikas existed in the Hanging Rock area in late Pleistocene/early Holocene times, as we suspect was the case, they may well have been uncommon. The Yellow Stratum mammalian assemblage is sufficiently small that even if rare taxa did occur in this area, the chances that they would be represented in the recovered assemblage are slim. Thus, it is not surprising that neither the mammalian taxa present in the Yellow Stratum nor the abundances of those taxa distinguish this stratum from the fauna of the deposits above. Unfortunately, more detailed information on the history of the Suborganic Stratum would be needed to assess the nature of the differences between early and late Holocene faunas in this area.

Finally, we note that we have been unable to confirm Layton's argument that the Organic Stratum at Hanging Rock Shelter contained hearths "with the broken bones of cooked domestic cattle" (Layton, 1970: 83). Unlike the situation at Last Supper Cave (see chap. 6), where reanalysis of the cattle remains using contemporary analytic procedures failed to support the argument that those animals had been butchered, we have been unable to locate the remains of any large bovids from the Organic Stratum at Hanging Rock Shelter. The only large bovids in the collections we have located (and those collections include the material analyzed by Thomas [1969, 1970b, 1971]) are the two bison specimens discussed above, one from mixed Organic/Suborganic and one from mixed Suborganic/Yellow deposits. Given the results from the Last Supper Cave analysis, the Hanging Rock Organic Stratum large bovids will have to be located and reanalyzed before it can be assumed that they do, in fact, represent the aboriginal use of cattle.

7. HERPETOFAUNA FROM DANGER CAVE, LAST SUPPER CAVE, AND HANGING ROCK SHELTER

JIM I. MEAD

A total of 132 amphibian and reptilian bones were recovered during the excavations of Danger Cave, Last Supper Cave, and Hanging Rock Shelter. The Danger Cave herpetofauna is represented by only a single specimen, suggesting the use of large screens in the excavation of the deposits of this site (see chap. 1). The herpetofaunas from Last Supper Cave (69 specimens, of which 64 were identified) and Hanging Rock Shelter (62 specimens, 27 identified) are better represented because of the use of 3.2 mm screen in the excavations at these sites. It is probable that use of a 2.0 mm mesh screen at these sites would have provided remains of some of the smaller snakes and lizards absent from the retrieved collections (table 61).

DESCRIPTIVE SUMMARY

Characteristics used to identify the herpetofaunas from these sites are not presented here, with the exception of those of particular importance or not discussed elsewhere (see Mead, 1985; Mead et al., 1982; Mead et al., 1983). Previous fossil and subfossil occurrences of the species represented in these faunas can be found in the references provided below.

Class Amphibia—Amphibians
Order Salienta—Frogs and Toads
Family Bufonidae—True Toads
Bufo sp.—True Toad

Material: *Last Supper Cave:* 1 vertebral column with urostyle: 1 specimen.
Remarks: The entire shaft of the urostyle on *Bufo* is fairly thick; on *Rana* (frog), this shaft is narrow. The urostyle shaft on *Scaphiophus* (spadefoot toad) lacks the ventral flange (*spina ossis coccygeus*) that appears on *Rana, Bufo,* and the Last Supper Cave specimen. The combination of a thick shaft and ventral flange securely identifies this specimen as *Bufo.*
Although several species of *Bufo* occur in the Great Basin today, only the western toad,

B. boreas, lives in the general vicinity of Last Supper Cave.

Family Hylidae—Treefrogs
cf. *Pseudacris triseriata*—Chorus Frog

Material: *Hanging Rock Shelter:* 1 tibiofibula: 1 specimen.
Remarks: This subfossil specimen was very long and slender, identical to that of *Pseudacris* and unlike the shorter tibiofibula of *Hyla* (canyon treefrog) and the more robust elements of *Rana, Bufo,* and *Scaphiophus.*
Pseudacris triseriata is inadequately known from late Pleistocene and early/middle Holocene deposits (Lynch, 1966). This is the first specimen recovered from such a context in the Great Basin. Holman (1970) recorded a single ilium from late Pleistocene deposits in Dry Cave, New Mexico.
Today, the chorus frog occurs no closer to Hanging Rock Shelter than the Snake River valley, some 100 km to the northeast (Stebbins, 1966). The species is terrestrial, frequenting damp marshes, swamps, and lake and pond sides (Stebbins, 1962).

Class Reptilia—Reptiles
Order Squamata—Lizards and Snakes
Suborder Sauria—Lizards
Family Iguanidae—Iguanid Lizards
Sceloporus sp.—Spiny Lizard

Material: *Last Supper Cave:* 1 premaxilla, 4 maxillae, 2 dentaries: 7 specimens. *Hanging Rock Shelter:* 2 dentaries: 2 specimens.

Sceloporus graciosus—Sagebrush Lizard

Material: *Hanging Rock Shelter:* 3 maxillae, 1 dentary: 4 specimens.
Remarks: The maxilla and dentary of the sagebrush lizard are very small compared to those of most other spiny lizards of the arid west. Although these elements are similar in size to those of *Uta* (side-blotched lizard), the teeth of the latter species are more recurved and more sharply pointed.
The sagebrush lizard presently occurs

TABLE 61
Amphibian and Reptile Remains from Danger Cave, Last Supper Cave, and Hanging Rock Shelter
(See chaps. 1, 3, and 6 for stratigraphic information)

Taxon	Danger Cave	Last Supper Cave				Hanging Rock Shelter		
	V	R	3	4	NP	2	4	5
Bufo sp.	—	1	—	—	—	—	—	—
cf. *Pseudacris triseriata*	—	—	—	—	—	—	1	—
Sceloporus sp.	—	4	3	—	—	—	2	—
Sceloporus magister	—	—	—	—	—	1	1	—
Sceloporus graciosus	—	—	—	—	—	—	3	1
Sceloporus occidentalis	—	11	—	—	1	—	6	—
cf. *Charina bottae*	—	—	—	—	—	—	3	—
Hypsiglena torquata	—	—	—	—	2	—	—	—
Lampropeltis sp.	—	7	—	1	—	—	—	—
Lampropeltis getulus	—	4	—	—	—	—	—	—
Masticophis sp.	—	2	—	—	—	—	—	1
Pituophis melanoleucus	1	12	—	1	—	—	2	—
Thamnophis sp.	—	2	—	—	—	—	3	—
Crotalus cf. *viridis*	—	13	—	—	—	—	3	—
Totals	1	56	3	2	3	1	24	2

throughout most of the Great Basin, including the Hanging Rock Shelter area.

Sceloporus magister—Desert Spiny Lizard

Material: *Hanging Rock Shelter:* 1 maxilla, 1 quadrate: 2 specimens.

Remarks: The teeth of the desert spiny lizard are relatively large, wide at the base, taper rapidly to a point, and occur on robust maxillae and dentaries. These features distinguish *S. magister* from the eastern (*S. undulatus*) and western (*S. occidentalis*) fence lizards at all stages of growth.

The quadrates of sceloprines are easily distinguished from those of other iguanid lizards that inhabit the Great Basin (fig. 33). The quadrates of the collared (*Crotaphytus collaris*), leopard (*C.* [=*Gambelia*] *wislizenii*), and short-horned (*Phrynosoma douglassi*) lizards
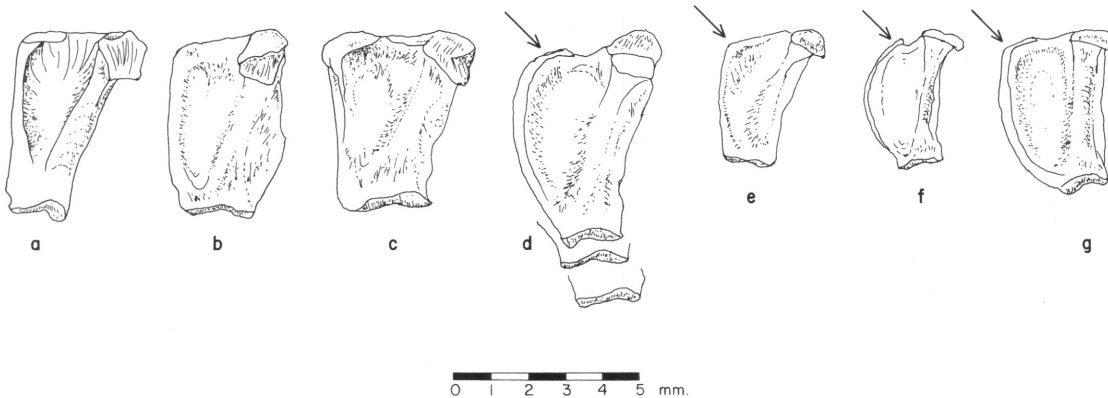
Fig. 33.   Left quadrates of some iguanid lizards currently found in the Great Basin, and the Hanging Rock specimen identified as *Sceloporus magister* (**a,** *Phrynosoma douglassi*; **b,** *Crotaphytus wislizenii*; **c,** *Crotaphytus collaris*; **d,** *Sceloporus magister* adult; **e,** *Sceloporus magister* juvenile; **f,** *Sceloporus occidentalis*; **g,** Hanging Rock Specimen HR-18). Top of figured bone is dorsal; left edge is anterior. Arrows point to the dorsal corner of the tympanic crest, as discussed in the text (from a drawing by J. I. Mead).

have straight-sided anterior edges; sceloprine quadrates have curved anterior edges (tympanic crests). The dorsal side of the quadrate of the fence lizard is rounded and short anteroposteriorly. In contrast, the dorsal side of the desert spiny lizard quadrate is longer and has a distinct corner at the dorsal edge of the tympanic crest. Juvenile desert spiny lizard quadrates are similar in size to those of adult fence lizards, although desert spiny lizards from the more northern parts of their distribution tend to be somewhat smaller. These characters allow the Hanging Rock Shelter specimen to be identified as an adult desert spiny lizard.

The desert spiny lizard presently lives in the southern and far western portions of the Great Basin, occurring no further north than Pyramid Lake, Nevada (Parker, 1982). Its present northern limit may correspond to the 120 minimum days-per-year 32°F isogram (Houghton et al., 1975) and it may thus be a possible cold-sensitive species. It is unlikely that the species occurs near Hanging Rock Shelter today. The late Pleistocene sediments of Smith Creek Cave, eastern Nevada, have also provided an extralocal Great Basin record for this species (Mead et al., 1982).

Sceloporus occidentalis—Western Fence Lizard

Material: *Last Supper Cave:* 2 premaxillae, 4 maxillae, 3 dentaries, 1 frontal, 1 humerus, 1 pelvis/hind legs, tail, and scales: 12 specimens. *Hanging Rock Shelter:* 2 maxillae, 2 dentaries, 1 frontal, 1 supraoccipital: 6 specimens.

Remarks: Size and dental characters distinguish fence from spiny lizards (see above). The western fence lizard is skeletally indistinguishable from *S. undulatus,* the eastern fence lizard. The specimens referred to *S. occidentalis* here are so referred because the single partial individual retained colored scales that allowed easy identification to species, and because only the western fence lizard occurs in the area today.

Suborder Serpentes—Snakes Family Boidae—Boas cf. *Charina bottae*—Rubber Boa

Material: *Hanging Rock Shelter:* 3 vertebrae: 3 specimens.

Remarks: These specimens are indistinguishable from the vertebrae of modern *Charina,* including the absence of a haemal keel. Rubber boas currently occur in the Hanging Rock Shelter area.

Family Colubridae—Colubrid Snakes *Hypsiglena torquata*—Night Snake

Material: *Last Supper Cave:* 2 vertebral columns of 8 and 32 vertebrae: 2 specimens.

Remarks: Night snakes currently live in the Last Supper Cave area.

Lampropeltis sp.—Kingsnake

Material: *Last Supper Cave:* 1 isolated vertebra and 7 vertebral columns of 2 (3 specimens), 7 (2 specimens), 4, and 9 vertebrae: 8 specimens.

Lampropeltis getulus—Common Kingsnake

Material: *Last Supper Cave:* 4 vertebrae: 4 specimens.

Remarks: The vertebrae have heavy subcentrum ridges and a low, well-flattened neural spine (fig. 34). These characters are typical of most kingsnakes. Overall morphology (Van Devender and Mead, 1978) indicates that only four kingsnake vertebrae from the cave are from *L. getulus.* Measurements of four of the Last Supper Cave specimens support identification as *L. getulus* and not as either *L. zonata* (California mountain kingsnake) or *L. pyromelana* (Sonora mountain kingsnake; see table 62).

No kingsnakes are now known to live in the Last Supper Cave area. Of the various species of kingsnakes, the common kingsnake probably lives the closest to Last Supper Cave today, being known from the Pyramid Lake area. The California kingsnake lives no closer than the Sierra Nevada. The Sonoran mountain kingsnake is primarily a Colorado Plateau and southern Arizona species, inhabiting only the Snake Range of eastern Nevada in the Great Basin. A specimen referred to *L. pyromelana* was reported from Holocene age deposits at Hidden Cave (Mead, 1985). A number of late glacial and Holocene deposits in the Great Basin are known to contain the remains of kingsnakes; all are in need of more detailed examination.
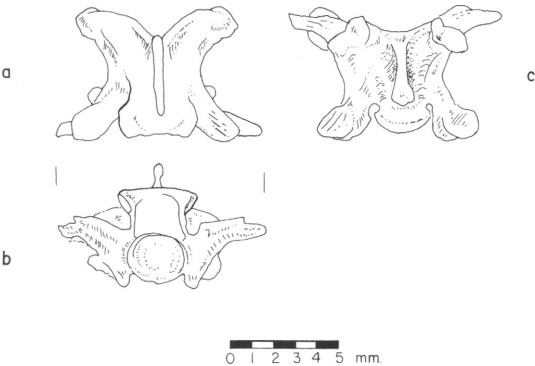
Fig. 34. A mid-column vertebra of *Lampropeltus getulus* from Last Supper Cave (LS-369): **a,** dorsal; **b,** anterior; **c,** ventral (from a drawing by J. I. Mead).

Masticophis sp.—Coachwhip or Racer

Material: *Last Supper Cave:* 2 vertebrae: 2 specimens. *Hanging Rock Shelter:* 1 vertebra: 1 specimen.

Remarks: The vertebrae of *Masticophis* and *Coluber* are very similar. The former have a PR-PR/PO-PR ratio of 0.87:1.00, the latter of 0.98:1.25 (Auffenberg, 1963; Rogers, 1976). The Last Supper Cave specimen assigned to *Masticophis* has a ratio of 0.93.

Masticophis taeniatus (striped whipsnake) and *Coluber constrictor* (racer) presently live in the area of both Last Supper Cave and Hanging Rock Shelter.

Pituophis melanoleucus—Gopher Snake

Material: *Danger Cave:* 1 vertebral column of 6 vertebrae: 1 specimen. *Last Supper Cave:* 10 isolated vertebrae, and 3 vertebral columns of 4, 6, and 10 vertebrae: 13 specimens.

Hanging Rock Shelter: 2 vertebrae: 2 specimens.

Remarks: These specimens were identified using the criteria discussed by Auffenberg (1963). Gopher snakes are currently common near all three sites.

Thamnophis sp.—Garter Snake

Material: *Last Supper Cave:* 2 vertebral columns of 2 and 8 vertebrae: 2 specimens. *Hanging Rock Shelter:* 3 vertebrae: 3 specimens.

Remarks: These heavily chewed specimens could not be identified to species.

Family Viperidae—Vipers
Crotalus cf. *viridis*—Western Rattlesnake

Material: *Last Supper Cave:* 10 isolated vertebrae; 3 vertebral columns of 2, 4, and 17 vertebrae: 13 specimens. *Hanging Rock Shelter:* 3 vertebrae: 3 specimens.

Remarks: These specimens are referred to *C. viridis* on geographic grounds, since only this rattlesnake currently occurs near these sites.

CONCLUSIONS

Of the 64 identifiable amphibian and reptile elements from Last Supper Cave, 56 came from the wood rat middens (see chap. 3). These could have been introduced to the midden by wood rats scavenging either inside or outside of the cave, but it is also possible that some of the species may have been commensals, living within the midden itself. Although some of the amphibians and reptiles

TABLE 62
Vertebral Measurements (in millimeters) for Three Species of Kingsnakes and Four Last Supper Cave Specimens
(See Auffenberg, 1963, for measurement definitions)

	Measurement				
	C1/NAW	PR-PR/PR-PO	C1/ZW	ZW/NAW	N
Lampropeltis getulus	0.85–1.36	1.10–1.45	1.05–1.50	0.67–0.95	56
Lampropeltis zonata	1.00–1.03	1.19–1.24	1.19–1.24	0.94–0.98	18
Lampropeltis triangulum	1.04	1.24	1.32	0.78	1
LS-369	1.04	1.23	1.25	0.83	
LS-369	1.07	1.25	1.24	0.86	
LS-372	1.16	1.23	1.40	0.83	
LS-372	0.97	1.29	1.39	0.70	

may have been procured by the human occupants of the cave and tossed onto the midden, there is no indication of human modification of any of the herpetofaunal specimens.

Few Quaternary herpetofaunas have been described for the Great Basin as a whole, and none for northern Nevada. For this reason alone, the Last Supper Cave and Hanging Rock Shelter faunas are important. Although the chronology of these two sites is poorly controlled (see chaps. 3 and 6), all the amphibian and reptile material provided by them is of middle and upper Holocene age.

The recovery of cf. *Pseudacris triseriata* in the northwestern Great Basin is biogeographically significant, since the closest known extant population is in the Snake River area of western Idaho. The same stratum of Hanging Rock Shelter that provided the chorus frog specimen (4, or Suborganic) also provided *Sceloporus magister* and *Ochotona princeps*, also presently extralocal. Assuming that this unit is not bioturbated and that these species actually coexisted, *Pseudacris* and *Ochotona* suggest a climatic regime with more available moisture, perhaps with summers cooler than at present. In contrast, the presence of *S. magister* suggests winters that were at least no colder than those of today. If the associations are valid, the Hanging Rock Shelter fauna may suggest that the lower/middle Holocene was a period of more equable climate. The middle Holocene may have been a time of greater aridity and colder winters, thus causing the breakup of lower Holocene vertebrate communities.

8. CONCLUSIONS

Archaeologists have yet to fully master the excavation of the sediments that fill caves and rockshelters. State-of-the-art excavations of such sites in the Great Basin proceed with great care paid to stratigraphy and to horizontal provenience, with the use of fine screens—routinely no greater than 0.32 cm mesh—and with the help of scientists drawn from many different disciplines (e.g., Thomas, 1983). The resulting work proceeds slowly, but the purpose of scientific archaeology (as distinguished from business archaeology) is not to reach the bottom as fast as you can, but to reach the bottom as well as you can. The reports that issue from such work are collaborative efforts, each contributor generally having available the developing results of every other contributor as he or she proceeds.

It is, of course, true that none of the faunas reported in this volume came from sites excavated in a way that would meet contemporary state-of-the-art standards. Danger Cave comes closest, given the close attention paid to chronology, stratigraphy, and the thorough documentation and analysis of the artifact content of the site. Nonetheless, the excavation techniques used at Danger Cave followed from a particular set of general questions; extracting the answers to those questions did not appear to require detailed attention to microstratigraphy or the use of fine screens, and the control now available over the faunal contents of the deposits of that site is correspondingly blurred. More severe problems confront the analysis of the faunas from Last Supper Cave and Hanging Rock Shelter. The artifacts from Last Supper Cave have never been analyzed, and virtually nothing is known about the chronology and composition of the wood rat middens that provided not only the bulk of the perishable artifacts from this site, but also the bulk of the fauna. While the contents of Hanging Rock Shelter are more fully reported, the depositional chronology of this site is also poorly controlled, limiting our understanding of the meaning of the extralimital taxa that appear in the fauna.

Even though these problems exist, the faunas from all three sites have significantly contributed to our understanding of the historic biogeography of vertebrates in the Great Basin, the nature of western Lake Bonneville Basin environments during the waning centuries of the Pleistocene, and (though perhaps obliquely) human prehistory in the Great Basin.

Both Danger Cave and Hanging Rock Shelter add further support to Brown's argument that boreal mammals currently confined to Great Basin mountains reached this area during the Pleistocene, only to become extinct in the lowlands and isolated on the mountains after the Pleistocene ended (Brown 1971, 1978). The local extinction of marmots and bushy-tailed wood rats in at least the lower elevations of the Silver Island Mountains and of pikas in the area surrounding Hanging Rock Shelter joins an ever-growing body of data in meeting predictions drawn from Brown's model (see the review and analysis in Grayson, 1987). The support for this model seems so strong that it becomes appropriate to direct research questions to other issues. What, for instance, was the rate of extinction of boreal mammals on given mountainous islands, how did the rates differ between islands, and do differential rates meet the requirement of island biogeographic theory? When did particular species become extinct in the lowlands, and what is the relationship between genotypic and phenotypic divergence on the one hand, and the timing of isolation of given species on mountains caused by these lowland extinctions on the other?

The Danger Cave fauna also provides a deeper glimpse at the history of pygmy rabbits in the Great Basin. It has been clear for some time that these animals underwent a decline at about 7000 B.P. in the Great Basin and adjacent Plateau (Butler, 1972; Grayson, 1982b). Chronologically, this decline appears correlated with both a decrease in effective precipitation (e.g., Thompson, 1984) and the extinction of pikas in lowland habitats in the northern Great Basin (Grayson, 1987). Danger Cave suggests that pygmy rabbits in the Great Basin also decreased in number at the end of the Pleistocene, ca. 10,000 B.P., a decrease that may have occurred at the same time as pygmy rabbits became extinct in the

Southwest. These animals appear to require healthy stands of big sagebrush, and both declines may be related to the loss of sagebrush habitat. The correlated decrease of Sage Grouse at Danger Cave lends support to this suggestion, as does the correlated decline of pygmy rabbits and Sage Grouse at the Connley Caves (Grayson, 1979) and the presence of both Sage Grouse and an undated pygmy rabbit specimen at Hidden Cave (Grayson, 1985). These facts have implications for the management of small mammal habitat in the Great Basin. Clearly, many small mammals are isolated on Great Basin mountains, and have probably been so for 7000 years or more. Under current conditions, local extinction of these animals on a given Great Basin mountain will not be followed by recolonization. Were pikas to become extinct on the Toquima Range, for instance, a population that has probably been genetically isolated for 7000 years would be lost. Alpine habitats in the Great Basin must be managed with this thought in mind. The welfare of pygmy rabbit populations is a subject of increasing concern (e.g., Weiss and Verts, 1984). The paleontological record strongly suggests that pygmy rabbits have undergone at least two major population decreases in the Great Basin during the past 11,000 years, and such independent evidence as apparently correlated declines in Sage Grouse implies that these decreases were correlated with losses of sagebrush habitat. Paleontological data are thus fully consistent with modern ecological information: preservation of pygmy rabbits will require careful management of sagebrush steppe.

Although we seem to know much about the biogeographic history of selected small mammals in the Great Basin, we know much less about the history of the larger ones. This differential knowledge has resulted from some very simple facts of life history. Larger mammals tend to be far less abundant than smaller ones, which makes the remains of individual larger mammals scarcer than the remains of smaller ones. In addition, the large samples of small mammal remains in caves and rockshelters have routinely been accumulated as a result of the activities of such agents as wood rats and raptors. No agent that routinely collects equivalent numbers of large

mammal bones exists, although people at times fill the role, as Gatecliff Shelter and Last Supper Cave attest. Even though we know less about the history of large mammals in the Great Basin, some basic distributional facts are becoming clear, above and beyond the now-routine observation that deer were once uncommon and mountain sheep abundant throughout much of the area (e.g., Thomas, 1970a; Grayson, 1982b). Bison were once widespread throughout much of the Great Basin, as a number of faunas, including that from Danger Cave, demonstrate. Wapiti ("elk") are unknown historically from the northwestern quarter of Nevada and adjacent Oregon, but the faunas from Fort Rock Cave, the Connley Caves, Last Supper Cave, and Hanging Rock Shelter provide compelling evidence that these animals were once found throughout much of the Great Basin north of the hydrologic rim of Pleistocene Lake Lahonton. When they became extinct in this area is not yet known.

We know less of the history of other vertebrates in the Great Basin. Last Supper Cave and Hanging Rock Shelter both provided tentatively identified avian extralimitals: Blue Grouse at both sites, Sharp-tailed Grouse at the latter. As discussed in earlier chapters, the tentative nature of these identifications stems from the fact that fragmentary grouse bones are notoriously difficult to identify. Discriminant function analysis might provide an appropriate means by which to explore further these important specimens. Last Supper Cave provided a record for common kingsnake; Hanging Rock Shelter, for desert spiny lizard and, tentatively, chorus frog. These extralimital records suggest that surprises may be in store as our knowledge of the history of amphibians and reptiles in the Great Basin improves.

The information provided by Danger Cave is important not only because it increases our understanding of the history of mammals and birds in the Great Basin, but also because it seems to shed light on general environmental history in the western Bonneville Basin. At about 10,000 B.P., the mesic-adapted taxa that characterized the DI faunal assemblage— marmots, pygmy rabbits, and Sage Grouse— appear to have become locally extinct. A decrease in abundance of mesic habitats in the

area immediately surrounding Danger Cave is clearly implied. Such a decrease fits well with the chronology suggested by D. R. Currey and his colleagues (e.g., Currey et al., 1984; Currey and Oviatt, 1985) for the retreat of Lake Bonneville from the Gilbert shoreline at about 10,000 B.P. It does not fit well with the suggestion of Spencer et al. (1984) that Lake Bonneville had retreated to essentially historic levels by ca. 14,500 B.P., and did not exceed those levels between 14,500 and 3500 B.P.

There are fewer strictly archaeological implications of the Danger Cave, Last Supper Cave, and Hanging Rock Shelter faunas. The main archaeological implication is, in fact, oblique, though nonetheless important. The analysis of "utility" curves in archaeology has become increasingly popular. These curves assume that people optimally forage across the body of an animal, as some believe people optimally forage across larger landscapes. The assumption gains support from limited ethnoarchaeological observations, but that support is largely provided by the same observations that led to the development of the curves in the first place. That these curves have been so readily adopted by archaeologists is in large part a function of our thirst for analytical techniques that will validly inform on past human behavior. Thirsty, we drink.

Analysis of the Last Supper Cave mountain sheep collection, however, suggests that the waters are not always pure. Plotting relative skeletal abundance against the optimal foraging MGUI values for this assemblage provides a "reverse utility" curve remarkably similar to that derived by Thomas and Mayer (1983) for the Gatecliff Shelter Horizon 2 *Ovis*

assemblage. Work conducted by Lyman (1984, 1985) after the Gatecliff analysis appeared suggested that reverse utility curves could emerge for reasons that have little to do with human economic decisions, but that instead relate to density mediated bone destruction. Both the Last Supper Cave and Gatecliff Shelter mountain sheep assemblages have been heavily damaged by carnivores, and correlations between the relative abundances of skeletal parts and bone density are higher than they are between relative skeletal part abundance and MGUI values. This discovery strongly suggests that the "reverse utility" curves for both assemblages reflect bone destruction, presumably by carnivores, and not bone transport by people. Caution at every level is clearly needed in applying this kind of analysis, but it would have taken longer to discover that without Thomas and Mayer's (1983) detailed study of Gatecliff Shelter mountain sheep.

Although aspects of the analysis of these three faunas have been highly frustrating— the discovery, for instance, that the vast majority of the Last Supper Cave fauna came from undated wood rat middens—the archaeologists and museum curators who urge us to study the past by studying museum collections certainly cannot be faulted in this instance. Study of the long-archived Danger Cave, Last Supper Cave, and Hanging Rock Shelter collections has taught us much about the history of the northern half of the Great Basin. Credit for these opportunities must go not only to the original excavators of the material, but also to the museums, particularly the curators, who have cared for it over the years.

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