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

ANTHROPOLOGICAL PAPERS OF
THE AMERICAN MUSEUM OF NATURAL HISTORY
Volume 66, part 1, pages 1–130, figures 1–34, tables 1–62
Issued May 6, 1988
Price: $16.65 a copy

ISSN 0065-9452

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

Taxon	Stratum							
	I	II	III	IV	V	S	NP	Totals
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-

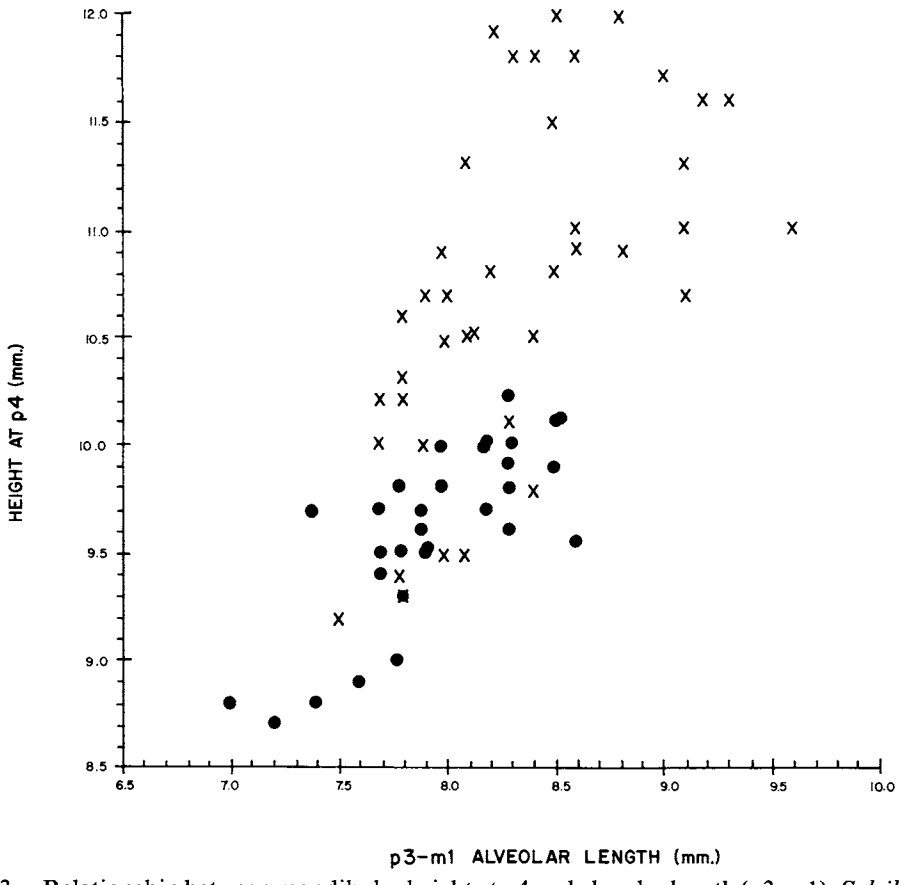

Fig. 3. Relationship between mandibular height at p4 and alveolar length (p3-m1): *Sylvilagus nuttallii* (solid circles) and *S. audubonii* (x).

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
		p3-m3	p3-m1	p4
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 evidence 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.

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

times (Grayson, 1983, 1987). I have also noted that the original observation made by Butler (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 Danger Cave. This decrease strongly suggests higher late Pleistocene than Holocene abundances 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 decrease 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 observed 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 decreases 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 become 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 supports this hypothesis). Brown's model predicts that the boreal mammals involved, including marmots and bushy-tailed wood rats, must once have been present in the intervening lowlands, since those lowlands provided access to the mountains during the Pleistocene. Several years ago (Grayson, 1982b), I noted that the only known extralimital record for marmots within their general distributional range was provided by Hidden Cave (Grayson, 1985), which documents 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 distribution, should be forthcoming" (Grayson, 1982b: 90–91). Danger Cave provides just such a record, documenting marmots in the vicinity of Danger Cave during late Pleistocene times, and suggesting that their extirpation 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, marmots 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 Hogup Cave marmots also provide a low elevation record for marmots in an area in which they no longer exist. The Hogup Cave data suggest that, if transport by people is not involved, 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 significant 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 between 11,000 and 10,000 years ago (e.g., Currey, 1980; Currey et al., 1984; Currey and Oviatt, 1985), and suggests that the alternative picture painted by Spencer et al. (1984) is not correct. In addition, the site has provided 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.

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												
	1	2	3	3/4	4	5	5/6	6	7	8	R	NP	Totals
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.

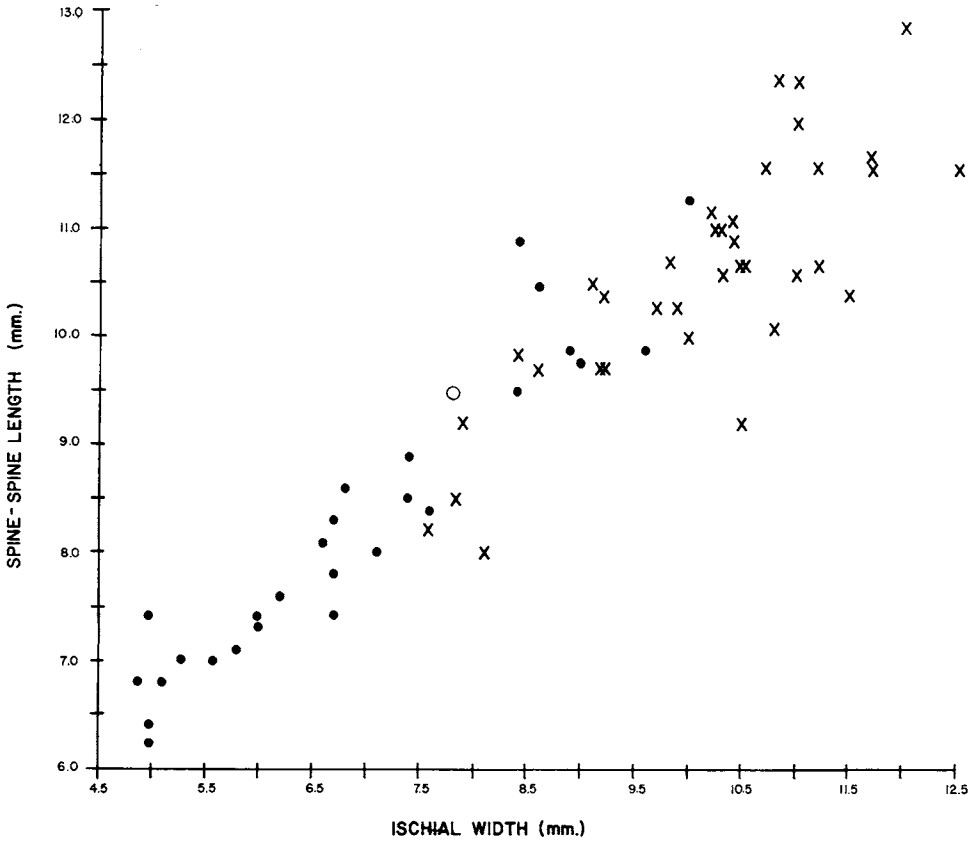

Fig. 10. Modern *Mustela erminea* (solid circles), *M. frenata* (x), and the Last Supper Cave *Mustela* sp. (open circle) innominates compared: ischial width and spine-spine length.

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-

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.

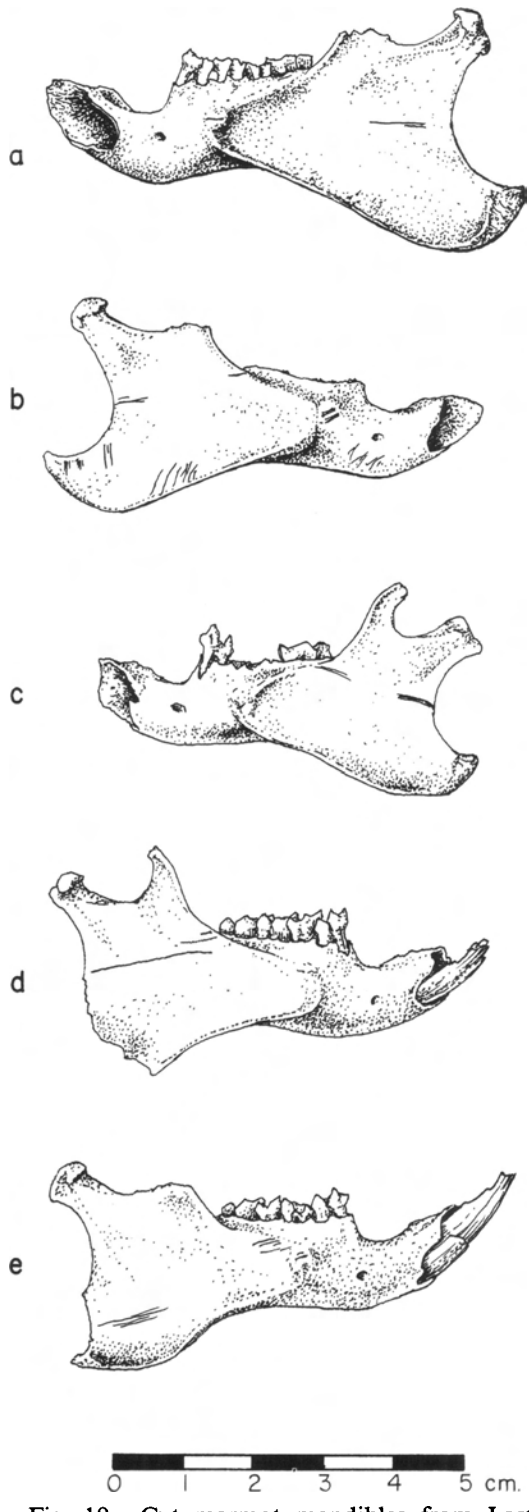

Fig. 19. Cut marmot mandibles from Last Supper Cave (**a,** LS-256/84; **b,** LS-333/70; **c,** LS-373/15; **d,** LS-256/40; **e,** LS-353/42).

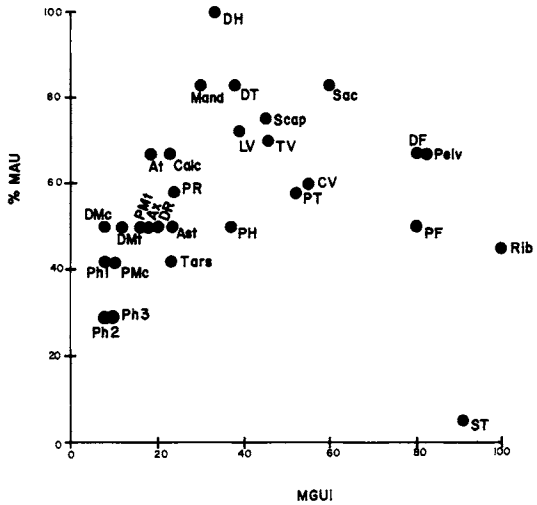

Fig. 28. Economic utility graph for the Last Supper Cave cow bones, based on the modified general utility index for sheep (see table 35 for key to abbreviations); plotted values from table 46.

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-

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

Taxon	Stratum										
	1	2	2/3	3	2/4	3/4	4	4/5	5	NP	Totals
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 suggesting 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 mandibles 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 Hanging Rock specimen shows two very small (maximum length, 0.9 mm) parallel cuts, separated by 0.20 mm, at right angles to the anterior edge of the buccal wall of the ascending 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 Suborganic Stratum, little can be said about its age, other than it is likely to have been deposited 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. talpoides* 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 alveoli. *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 innominate, 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 Hanging Rock area; during the small mammal survey conducted in the canyon, a single *P. par-*

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.

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.

REFERENCES CITED

Adams, L.
1963. Do white-tailed deer occur in northeastern California? J. Mammal., 44: 518–522.

Aikens, C. M.
1970. Hogup Cave. Univ. Utah Anthrop. Pap., 93: 286 pp.

Aikens, C. M., D. L. Cole, and R. Stuckenrath
1977. Excavations at Dirty Shame Rockshelter, southeastern Oregon. Tebiwa: Idaho State Univ. Mus. Misc. Pap. 4: 29 pp.

Alcorn, J. R.
1946. The birds of Lahontan Valley, Nevada. Condor, 48: 129–138.

Ambro, R. D.
1972. The Grass Valley Archaeological Project: preliminary observations on the surface archaeology of Ridge Valley North, an historic period Shoshone village. *In* C. W. Clewlow, Jr. and M. Rusco (eds.), The Grass Valley Archaeological Project: collected papers. Nevada Archaeol. Surv. Res. Pap. 3: 85–106.

Auffenberg, W.
1963. The fossil snakes of Florida. Tulane Stud. Zool., 10: 131–216.
Bailey, V.
1936. The mammals and life zones of Oregon. North Am. Fauna, 55: 416 pp.
Bedwell, S. F.
1973. Fort Rock Basin: prehistory and environment. Eugene: Univ. Oregon Books.
Behle, W. H.
1958. The bird life of Great Salt Lake. Salt Lake City: Univ. Utah Press.
Behle, W. H., and M. L. Perry
1975. Utah birds: checklist, seasonal and ecological occurrence charts, and guides to bird finding. Salt Lake City: Utah Museum of Natural History.
Behrensmeyer, A. K.
1978. Taphonomic and ecologic information from bone weathering. Paleobiology, 4: 150–162.
Behrensmeyer, A. K., K. D. Gordon, and G. T. Yanagi
1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. Nature, 319: 768–771.
Binford, L. R.
1978. Nunamiut ethnoarchaeology. New York: Academic Press.
1981. Bones: ancient men and modern myths. New York: Academic Press.
1984. Butchering, sharing, and the archaeological record. J. Anthrop. Archaeol., 3: 235–257.
Boaz, D. B.
1982. Modern riverine taphonomy: its relevance to the interpretation of Plio-Pleistocene hominid paleoecology in the Omo Basin, Ethiopia. Ph.D. Diss., Univ. Calif., Berkeley.
Bonham, H. F.
1969. Geology and mineral deposits of Washoe and Storey counties, Nevada. Nevada Bur. Mines Bull., 70: 140 pp.
Bonnichsen, R., and R. T. Will
1980. Cultural modification of bone: the experimental approach in faunal analysis. *In* B. M. Gilbert, Mammalian osteology, pp. 7–30. Laramie, Wyo.: B. M. Gilbert.
Bright, R. C.
1966. Pollen and seed stratigraphy of Swan Lake, southeastern Idaho: its relation to regional vegetational history and to Lake Bonneville history. Tebiwa, 9(2): 1–47.
Brown, C. L., and C. E. Gustafson
1979. A key to postcranial remains of cattle/bison, elk and horse. Washington State Univ. Lab. Anthrop. Repts. Invest., 57: 199 pp.
Brown, J. H.
1971. Mammals on mountaintops: nonequilibrium insular biogeography. Am. Naturalist, 105: 467–478.
1978. The theory of insular biogeography and the distribution of boreal birds and mammals. *In* K. T. Harper and J. L. Reveal (eds.), Intermountain biogeography, a symposium. Great Basin Naturalist Mem., 2: 209–227.
Brown, J. H., and A. C. Gibson
1983. Biogeography. New York: Mosby.
Brown, W. A. B., P. V. Christofferson, M. Massler, and M. B. Weiss
1960. Postnatal tooth development in cattle. Am. J. Vet. Res., 21(80): 7–34.
Burch, J. B.
1975. Freshwater unionacean clams (Mollusca: Pelecypoda) of North America. Hamburg, Mich.: Malacological Publications.
Butler, B. R.
1972. The Holocene or postglacial ecological crisis on the eastern Snake River plain. Tebiwa, 15(1): 49–63.
Crane, H. R.
1956. University of Michigan radiocarbon dates I. Science, 124: 664–672.
Cressman, L. S.
1942. Archaeological researches in the northern Great Basin. Carnegie Inst. Washington Publ., 538: 158 pp.
1956. Klamath prehistory: the prehistory of the culture of the Klamath Lake area, Oregon. Am. Philos. Soc. Trans., new ser., 46(4): 1–513.
Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal
1972. Intermountain flora: vascular plants of the intermountain West, U.S.A., vol. 1. New York: Hafner.
Currey, D. R.
1980. Coastal geomorphology of Great Salt Lake and vicinity. *In* J. D. Gwynn (ed.), Great Salt Lake: a scientific, historical, and economic overview. Utah Geological and Mineral Survey Bull., 116: 69–82.
Currey, D. R., G. Atwood, and D. R. Mabey
1984. Major levels of Great Salt Lake and Lake Bonneville. Utah Geological and Mineral Survey Map, no. 73.
Currey, D. R., and C. G. Oviatt
1985. Durations, average rates, and probable causes of Lake Bonneville expansions, stillstands, and contractions during the

last deep-lake cycle, 32,000 to 10,000 years ago. *In* P. A. Kay and H. F. Diaz (eds.), Problems of and prospects for predicting Great Salt Lake levels. Univ. Utah Center for Public Affairs and Administration Spec. Publ., pp. 9–24.

Davis, J. O.
1982. Bits and pieces: the last 35,000 years in the Lahontan area. *In* D. B. Madsen and J. F. O'Connell, Man and environment in the Great Basin. Soc. Am. Archaeol. Pap., 2: 53–75.

Davis, S. J. M.
1985. A preliminary report of the fauna from Hatoula: a Natufian-Khiamian (PPNA) site near Latroun, Israel. *In* M. Lechevallier and A. Ronen, Le site natoufien-khiamien de Hatoula près de Latroun, Israël: fouilles 1980–1982, rapport préliminaire. Centre de recherches françaises de Jérusalem: Jerusalem.

Denton, S. W.
1949. Pages from a naturalist's diary. Boston: privately published.

Dixon, E. J.
1984. Context and environment in taphonomic analysis: examples from Alaska's Porcupine River caves. Quat. Res., 22: 201–215.

Durrant, S. D.
1952. Mammals of Utah: taxonomy and distribution. Univ. Kansas Publ., Mus. Nat. Hist., 6: 1–549.
1970. Faunal remains as indicators of Neothermal climates at Hogup Cave. *In* C. M. Aikens, Hogup Cave. Univ. Utah Anthrop. Pap., 93: 241–245.

Durrant, S. D., M. R. Lee, and R. M. Hansen
1955. Additional records and extensions of known ranges of mammals from Utah. Univ. Kansas Publ., Mus. Nat. Hist., 9(2): 69–80.

Eardley, A. J., V. Gvosdetsky, and R. E. Marsell
1957. Hydrology of Lake Bonneville and sediments and soils of its basin. Geol. Soc. Am. Bull., 68: 1141–1201.

Echlin, D. R., P. J. Wilke, and L. E. Dawson
1981. Ord Shelter. J. California Great Basin Anthrop., 3: 49–68.

Egoscue, H. J.
1961. Small mammal records from western Utah. J. Mammal., 42: 122–124.
1965. Records of shrews, voles, chipmunks, cottontails and mountain sheep from Utah. J. Mammal., 46: 685–687.

Eickhoff, S., and B. Herrmann
1985. Surface marks on bones from a Neolithic collective grave (Odagsen, Lower Saxony): a study on differential diagnosis. J. Human Evol., 14: 263–274.

Emslie, S. D.
1981. Birds and prehistoric agriculture: the New Mexican pueblos. Human Ecol., 9: 305–329.
1982. Osteological identification of Long-eared and Short-eared owls. Am. Antiquity, 47: 155–157.

Everitt, B. S.
1977. The analysis of contingency tables. London: Chapman and Hall.

Fagan, J.
1974. Altithermal occupation of spring sites in the Northern Great Basin. Univ. Oregon Anthrop. Pap., 6: 146 pp.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones
1975. Mammals of New Mexico. Albuquerque: Univ. New Mexico Press.

Fiorillo, A. R.
1984. An introduction to the identification of trample marks. Current Res., 1: 47–48. Center for the Study of Early Man, Orono, Maine.

Fowler, D. D.
1980. History of Great Basin anthropological research, 1776–1979. J. California Great Basin Anthrop., 2: 8–36.

Fowler, D. D., and J. D. Jennings
1982. Great Basin archaeology: a historical overview. *In* D. B. Madsen and J. F. O'Connell (eds.), Man and environment in the Great Basin. Soc. Am. Archaeol. Pap., 2: 105–120.

Fowler, D. D., D. B. Madsen, and E. M. Hattori
1973. Prehistory of southeastern Nevada. Desert Res. Inst. Publ. Soc. Sci., 6: 145 pp.

Goodrich, C.
1944. Pleuroceridae of the Great Basin. Univ. Mich. Mus. Zool., Occas. Pap., 485: 1–11.

Gould, R. A., D. D. Fowler, and C. S. Fowler
1972. Diggers and doggers: parallel failures in economic acculturation. Southwestern J. Anthrop., 28: 265–281.

Grayson, D. K.
1979. Mt. Mazama, climatic change, and Fort Rock Basin archaeofaunas. *In* P. D. Sheets and D. K. Grayson (eds.), Volcanic activity and human ecology, pp. 427–458. New York: Academic Press.
1982a. (Review of) Bones: ancient men and modern myths, by L. R. Binford. Am. Anthrop., 84: 439–440.
1982b. Toward a history of Great Basin mam-

mals during the past 15,000 years. *In* D. B. Madsen and J. F. O'Connell (eds.), Man and environment in the Great Basin. Soc. Am. Archaeol. Pap., 2: 82–101.

1983. The paleontology of Gatecliff Shelter: small mammals. *In* D. H. Thomas, The archaeology of Monitor Valley: 2. Gatecliff Shelter. Anthrop. Pap. Am. Mus. Nat. Hist., 59(1): 99–126.

1984. Quantitative zooarchaeology. New York: Academic Press.

1985. The paleontology of Hidden Cave: birds and mammals. *In* D. H. Thomas (ed.), The archaeology of Hidden Cave. Anthrop. Pap. Am. Mus. Nat. Hist., 61(1): 125–161.

1987. The biogeographic history of small mammals in the Great Basin: observations on the last 20,000 years. J. Mammal., 68: 359–375.

In press. The James Creek Shelter mammals. *In* R. G. Elston and E. E. Budy, The archaeology of James Creek Shelter. Univ. Utah Anthrop. Pap.

Griffin, D. M.

1972. Ecology of soil fungi. Syracuse: Syracuse Univ. Press.

Grigson, C.

1982. Sex and age determination of some bones and teeth of domestic cattle. *In* B. Wilson, C. Grigson, and S. Payne, Ageing and sexing animal bones from archaeological sites. British Archaeol. Reports, 109: 7–23.

Gullion, G. W., and G. C. Christensen

1957. A review of the distribution of gallinaceous game birds in Nevada. Condor, 59: 128–138.

Gust, S. M.

1982. Faunal analysis and butchering. *In* J. Frierman, The Ontiveros Adobe: early rancho life in Alta California, pp. 101–180. Pacific Palisades, Calif.: Greenwood and Associates.

Haines, F.

1938. The northward spread of horses among the Plains Indians. Am. Anthrop., 40: 429–437.

Hall, E. R.

1946. Mammals of Nevada. Berkeley: Univ. California Press.

1981. The mammals of North America, 2nd ed. New York: Wiley.

Harper, K. T., and G. M. Alder

1970. The macroscopic plant remains of the deposits of Hogup Cave, Utah, and their paleoclimatic implications. *In* C. M. Aikens, Hogup Cave. Univ. Utah Anthrop. Pap., 93: 215–240.

1972. Paleoclimatic inferences concerning the last 10,000 years from a resampling of Danger Cave. *In* D. D. Fowler (ed.), Great Basin cultural ecology, a symposium. Desert Res. Inst. Publ. Soc. Sci., 8: 13–23.

Harris, A. H.

1985. Late Pleistocene vertebrate paleoecology of the West. Austin: Univ. Texas Press.

Hattori, E. M.

1975. Northern Paiutes on the Comstock: archaeology and ethnohistory of an American Indian population in Virginia City, Nevada. Nevada State Mus., Occas. Pap., 2: 82 pp.

1982. The archaeology of Falcon Hill, Winnemucca Lake, Washoe County, Nevada. Nevada State Mus. Anthrop. Papers, 18: 208 pp.

Haynes, G.

1980. Evidence of carnivore gnawing on Pleistocene and Recent mammalian bones. Paleobiology, 6: 341–351.

1983. A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb bones. Paleobiology, 9: 164–172.

Haynes, G., and D. Stanford

1984. On the possible utilization of *Camelops* by early man in North America. Quat. Res., 22: 216–230.

Hayward, C. L., C. Cottam, A. M. Woodbury, and H. H. Frost

1976. Birds of Utah. Great Basin Nat. Mem., 1: 1–229.

Hoffmeister, D. F., and M. R. Lee

1963. Revision of the desert cottontail, *Sylvilagus audubonii,* in the Southwest. J. Mammal., 501–518.

Holman, J. A.

1970. A Pleistocene herpetofauna from Eddy County, New Mexico. Texas J. Sci., 22: 29–39.

Houghton, J. G., C. M. Sakamoto, and R. O. Gifford

1975. Nevada's weather and climate. Nevada Bur. Mines Geol., Spec. Publ., 2: 78 pp.

Hunt, C. B., and R. B. Morrison

1957. Geology of Danger and Juke Box caves, near Wendover, Utah. *In* D. J. Jennings, Danger Cave. Univ. Utah Anthrop. Pap., 27: 298–301.

Jennings, J. D.

1953. Danger Cave: a progress summary. El Palacio, 60: 179–213.

1957. Danger Cave. Univ. Utah Anthrop. Pap., no. 27.

1973. The short useful life of a simple hypothesis. Tebiwa, 16(1): 1–9.
1974. Prehistory of North America, 2nd ed. New York: McGraw-Hill.

Johnson, E.
1985. Current developments in bone technology. Adv. Archaeol. Method Theory, 8: 157–235.

Jones, P. M.
1980. Emigrant trails in the Black Rock Desert. Contrib. to Study Cultural Resources, Tech. Rept., no. 6. Reno: Bur. Land Mgt.

Juell, K. E., and D. N. Schmitt
1985. Culturally versus naturally deposited bones: explorations in small animal taphonomy. Paper presented at the 50th Annual Meeting, Society for American Archaeology, Denver.

Klein, R. G., and K. Cruz-Uribe
1984. The analysis of animal bones from archaeological sites. Chicago: Univ. Chicago Press.

Knudsen, R. A.
1979. Inference and imposition in lithic analysis. *In* B. Hayden, Lithic use-wear analysis, pp. 169–181. New York: Academic Press.

Kurtén, B., and E. Anderson
1972. The sediments and fauna of Jaguar Cave: II. The fauna. Tebiwa, 15(1): 21–45.

Lawrence, B.
1968. The antiquity of large dogs in North America. Tebiwa, 11(2): 43–49.

Layton, T. N.
1970. High Rock archaeology: an interpretation of the prehistory of the northwestern Great Basin. Ph.D. diss., Harvard Univ., Cambridge.
1977. Indian rustlers of the High Rock. Archaeology, 30: 366–373.
1979. Archaeology and paleo-ecology of Pluvial Lake Parman, northwestern Great Basin. J. New World Archaeol., 3: 41–56.

Layton, T. N., and J. O. Davis
MS. Last Supper Cave: early post-Pleistocene culture history and paleoecology in the High Rock country of the northwestern Great Basin. Unpublished manuscript on file in the Department of Anthropology, American Museum of Natural History, 1977.

Linsdale, J. M.
1951. A list of the birds of Nevada. Condor, 53: 228–249.

Livingston, S. D.
1987. Prehistoric biogeography of white-tailed deer in Washington and Oregon. J. Wildl. Manage. 51(3): 649–654.

Loud, L. L., and M. R. Harrington
1929. Lovelock Cave. Univ. California Publ. Am. Archaeol. Ethnol., 25(1): 1–183.

Lyman, R. L.
1980. Freshwater bivalve molluscs and southern Plateau prehistory: a discussion and description of three genera. Northwest Sci., 54: 121–136.
1984. Bone density and differential survivorship of fossil classes. J. Anthrop. Archaeol., 3: 259–299.
1985. Bone frequencies: differential transport, *in situ* destruction, and the MGUI. J. Archaeol. Sci., 12: 221–236.
1987. Archaeofaunas and butchery studies: a taphonomic perspective. Adv. Archaeol. Method Theory, 10: 249–337.

Lynch, J. D.
1966. Additional treefrogs (Hylidae) from the North American Pleistocene. Ann. Carnegie Mus., 38(11): 265–271.

Martin, P. S., J. B. Rinaldo, E. Bluhm, H. C. Cutler, and R. Grange, Jr.
1952. Mogollon cultural continuity and change: the stratigraphic analysis of Tularosa and Cordova caves. Fieldiana: Anthrop., 40: 1–528.

Marwitt, J. P., and G. F. Fry
1973. Radiocarbon dates from Utah. Southwestern Lore, 38(4): 1–9.

Mead, J. I.
1985. Paleontology of Hidden Cave: amphibians and reptiles. *In* D. H. Thomas (ed.), The archaeology of Hidden Cave. Anthrop. Pap. Am. Mus. Nat. Hist., 61(1): 162–170.

Mead, J. I., D. K. Grayson, and R. W. Casteel
1983. Fish, amphibians, reptiles, and birds. *In* D. H. Thomas, The archaeology of Monitor Valley: 2. Gatecliff Shelter. Anthrop. Pap. Am. Mus. Nat. Hist., 59(1): 129–135.

Mead, J. I., R. S. Thompson, and T. R. Van Devender
1982. Late Wisconsinan and Holocene fauna from Smith Creek Canyon, Snake Range, Nevada. Trans. San Diego Soc. Nat. Hist., 20(1): 1–26.

Merriam, J. C.
1910. Tertiary mammal beds of Virgin Valley and Thousand Creek in northwestern Nevada. Univ. Calif. Publ., Bull. Dept. Geol., 6(2): 21–53.

Miller, R.
1982. Pseudo-tools created by livestock from Halawa, Syria. J. Field Archaeol., 9: 281–283.

Morris, P.
1972. A review of mammalian age determination methods. Mammal Rev., 2(3): 69–104.
Neusius, S. W., and P. R. Flint
1985. Cottontail species identification: zooarchaeological use of mandibular measurements. J. Ethnobiol., 5: 51–58.
Olsen, S. J.
1959. Similarity in the skulls of the Bison and the Brahman. Am. Antiquity, 24: 321–322.
1960. Post-cranial characters of *Bison* and *Bos*. Peabody Mus. Archaeol. Ethnol. Pap., 35(4): 1–15.
1978. Bones from Awatovi: the faunal analysis. Peabody Mus. Archaeol. Ethnol. Pap., 70(1): 1–34.
1985. Origins of the domestic dog. Tucson: Univ. Arizona Press.
Orr, R. T.
1940. The rabbits of California. California Acad. Sci. Occas. Pap., 19: 227 pp.
Parker, W. S.
1982. *Sceloporus magister*. Catalogue Am. Amphib. Reptiles, 290: 1–4.
Parmalee, P. W.
1970. Birds from Hogup Cave. *In* C. M. Aikens, Hogup Cave. Univ. Utah Anthrop. Pap., 93: 263–266.
1977. The avifauna from prehistoric Arikara sites in South Dakota. Plains Anthrop., 22: 189–222.
1979a. A preliminary report on the birds from the Levee and Knoll sites, Box Elder County, Utah. *In* G. F. Fry and G. F. Dalley, The Levee Site and the Knoll Site. Univ. Utah Anthrop. Pap., 100: 110–113.
1979b. Inferred Arikara subsistence patterns based on a selected faunal assemblage from the Mobridge site, South Dakota. The Kiva, 44(2–3): 191–218.
1980. Utilization of birds by the Archaic and Fremont cultural groups of Utah. *In* K. E. Campbell, Jr. (ed.), Papers in Avian Paleontology honoring Hildegarde Howard. Nat. Hist. Mus. Los Angeles Cty. Sci. Ser., 330: 237–250.
Parmalee, P. W., and W. E. Klippel
1974. Freshwater mussels as a prehistoric food resource. Am. Antiquity, 39: 421–434.
Peterson, V. V.
1946. Range cattle in Nevada. Am. Cattle Producer, 27(11): 8–10, 30–32.
Rogers, K. L.
1976. Herpetofauna of the Beck Ranch local fauna (Upper Pliocene:Blancan) of Texas. Publ. Mus. Michigan State Univ., Paleontol. Ser., 1(5): 167–200.
Roscoe, E. J.
1963. Some Goniobases in western United States. The Nautilus, 77(2): 43–47.
1967. Ethnomalacology and paleoecology of the Round Butte archaeological sites, Deschutes River Basin, Oregon. Mus. Nat. Hist. Univ. Oregon Bull., 6: 20 pp.
Rosen, M. D.
1978. Faunal remains as indicators of acculturation in the Great Basin. *In* C. W. Clewlow, Jr., H. F. Wells, and R. D. Ambro (eds.), History and prehistory at Grass Valley, Nevada. UCLA Inst. Archaeol. Monograph VII, pp. 35–82.
Russell, E. W.
1973. Soil conditions and plant growth, 10th ed. London: Longman.
Ryser, F. A., Jr.
1985. Birds of the Great Basin. Reno: Univ. Nevada Press.
Schiffer, M. B.
1986. Radiocarbon dating and the "old wood" problem: the case of the Hohokam chronology. J. Archaeol. Sci., 13: 13–30.
Schulz, P. D.
1979. Historical faunal remains from Panamint City: notes on diet and status in a California boom town. Pac. Coast Archaeol. Soc. Q., 15(4): 55–63.
Scott, W. E., W. D. McCoy, R. R. Shroba, and M. Rubin
1983. Reinterpretation of the exposed record of the last two cycles of Lake Bonneville, western United States. Quat. Res., 20: 261–285.
Shipman, P.
1981. Applications of scanning electron microscopy to taphonomic problems. *In* A. M. Cantwell, J. B. Griffin, and N. Rothschild (eds.), The research potential of anthropological museum collections. New York Acad. Sci. Ann., 376: 357–385.
Shipman, P., G. Foster, and M. Schoeninger
1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. J. Archaeol. Sci., 11: 307–325.
Shipman, P., and J. Rose
1983. Early hominid hunting, butchering and carcass-processing behaviors: approaches to the fossil record. J. Anthrop. Archaeol., 2: 57–98.
Shippee, E. A., and H. J. Egoscue
1958. Additional mammal records from the

Bonneville Basin, Utah. J. Mammal., 39: 275–277.

Silver, I. A.
1969. The ageing of domestic animals. *In* D. Brothwell and E. Higgs (eds.), Science in archaeology, 2nd ed., pp. 283–302. London: Thames and Hudson.

Smith, G. I., and F. A. Street-Perrott
1983. Pluvial lakes of the western United States. *In* S. C. Porter (ed.), Late-Quaternary environments of the United States. Volume 1: The Late Pleistocene, pp. 190–212. Minneapolis: Univ. Minnesota Press.

Smith, R. C., P. M. Jones, J. R. Roney, and K. E. Pedrick
1983. Prehistory and history of the Winnemucca District: a cultural resources overview. Cultural Resource Ser., Monograph 5. Reno: Bur. Land Mgt.

Spencer, R. J., M. J. Baedecker, H. P. Eugster, R. M. Forester, M. B. Goldhaber, B. F. Jones, K. Kelts, J. Mckenzie, D. B. Madsen, S. L. Rettig, M. Rubin, and C. J. Bowser
1984. Great Salt Lake, and precursors, Utah: the last 30,000 years. Contrib. Mineral. Petrol., 86: 321–334.

Sperry, C. C.
1957a. Feathers recovered from Danger Cave. *In* J. D. Jennings, Danger Cave. Univ. Utah Anthrop. Pap., 27: 305–306.
1957b. Mammal feces. *In* J. D. Jennings, Danger Cave. Univ. Utah Anthrop. Pap., 27: 302.

Speth, J. D.
1983. Bison kills and bone counts. Chicago: Univ. Chicago Press.

Spinage, C. A.
1973. A review of the age determination of mammals by means of teeth, with especial reference to Africa. East African Wildl. J., 11: 165–187.

States, J. S.
1978. Soil fungi of cool-desert plant communities in northern Arizona and southern Utah. J. Arizona-Nevada Acad. Sci., 13(1): 13–17.

Stebbins, R. C.
1962. Amphibians of western North America, 2nd ed. Berkeley: Univ. California Press.
1966. A field guide to western reptiles and amphibians. Boston: Houghton-Mifflin.

Steward, J. H.
1938. Basin-Plateau aboriginal socio-political groups. Bur. Am. Ethnol. Bull., no. 120: 346 pp.

Thaeler, C. S., Jr.
1980. Chromosome numbers and systematic relations in the genus *Thomomys* (Rodentia: Geomyidae). J. Mammal., 61: 414–422.

Thomas, D. H.
1969. Great Basin hunting patterns: a quantitative method for treating faunal remains. Am. Antiquity, 34: 392–401.
1970a. Artiodactyls and man in the prehistoric Great Basin. *In* E. W. Ritter, P. D. Schulz, and R. Kautz (eds.), Papers on California and Great Basin prehistory. Center for Archaeol. Res. Davis, Publ. no. 2, pp. 199–208.
1970b. Quantitative analysis of faunal remains from the High Rock Country. *In* T. N. Layton, High Rock archaeology: an interpretation of the prehistory of the northwestern Great Basin. Ph.D. diss., Harvard Univ., Cambridge, pp. 335–355.
1971. On distinguishing natural from cultural bone in archaeological sites. Am. Antiquity, 36: 366–371.
1981. How to classify the projectile points from Monitor Valley, Nevada. J. California Great Basin Anthrop., 3: 7–43.
1982. The 1981 Alta Toquima Village project: a preliminary report. Desert Research Institute Social Sciences Center Technical Report Series, 27: 1–101.
1983. Some theoretical and methodological considerations. *In* D. H. Thomas, The archaeology of Monitor Valley: 2. Gatecliff Shelter. Anthrop. Pap. Am. Mus. Nat. Hist., 59(1): 419–440.

Thomas, D. H., and D. Mayer
1983. Behavioral faunal analysis of selected horizons. *In* D. H. Thomas, The archaeology of Monitor Valley: 2. Gatecliff Shelter. Ibid., 59(1): 353–391.

Thompson, R. S.
1984. Late Pleistocene and Holocene environments in the Great Basin. Ph.D. diss., Univ. Arizona, Tucson.

Thompson, R. S., L. Benson, and E. M. Hattori
1986. A revised chronology for the last Pleistocene cycle in the central Lahontan Basin. Quat. Res., 25: 1–9.

Van Devender, T. R., and J. I. Mead
1978. Early Holocene and late Pleistocene amphibians and reptiles in Sonoran Desert packrat middens. Copeia, 1978: 464–475.

von den Driesch, A.
1976. A guide to the measurement of animal bones from archaeological sites. Peabody Mus. Archaeol. Ethnol. Bull., 1: 137 pp.

Watson, J. P. N.
1972. Fragmentation analysis of animal bone samples from archaeological sites. Archaeometry, 14: 221–228.
Weiss, N. T., and B. J. Verts
1984. Habitat and distribution of pygmy rabbits (*Sylvilagus idahoensis*) in Oregon. Great Basin Nat., 44: 563–571.
Willden, R.
1964. Geology and mineral deposits of Humboldt County, Nevada. Nevada Bureau of Mines Bull., 59: 154 pp.