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BACKGROUND OF SELECT PALEOZOOLOGICAL SAMPLES

The following chapters of this book (Chapters 5–10) summarize and illustrate the diverse suite of analytical techniques used to develop paleoenvironmental reconstructions from paleozoological assemblages. Though our discussion of those techniques draws upon a variety of assemblages from different times and places around the world, we illustrate our analyses using the same faunal assemblages as often as possible. We hope this commonality will allow the reader to focus on variability in the analytical techniques rather than on variability in the faunal assemblages.

The faunas we routinely turn to include the late Quaternary micromammals (rodents and assorted insectivores <0.15 kg adult body mass) and macromammals (mammals >0.75 kg adult body mass) from Boomplaas Cave in South Africa. These faunas are zooarchaeological in the sense that they were recovered from deposits that include abundant archaeological material, though as we outline below this does not mean that humans accumulated all of the faunal remains. We also consider the late Quaternary small mammals (rodents and lagomorphs) from Homestead Cave in Utah (western United States). The Homestead Cave faunas are paleontological; human occupation of the site was limited, there are very few artifacts, and there is no evidence to implicate people in the accumulation of the faunal remains. We selected these sites for several reasons. First, both provide stratified sequences that span long periods of time and encompass substantial environmental changes (based on associated non-faunal data). Second, they provide sufficiently large samples to reasonably illustrate

how various analytical techniques work. There is also substantial variability in sample sizes between assemblages, providing us with an opportunity to illustrate how to contend with sampling issues. And lastly, both sets of faunas come from sites associated with a large body of published literature concerning the stratigraphy, chronology, paleoenvironments, and archaeology.

Because we frequently turn to these sites in the remainder of this book, we provide a brief discussion of each below. We have included in this discussion a synopsis of their relevant paleoenvironmental histories, emphasizing previous inferences derived from the faunas. These brief summaries are not meant to represent the definitive paleoenvironmental histories of each site or the respective regions in which they are found. Rather we hope that highlighting a few key patterns that will emerge in our forthcoming paleoenvironmental analyses will make it easier for our readers to follow and critically engage with those analyses. For those readers interested in delving into the environmental history in more detail, we recommend Chase and Meadows (2007) and Marean et al. (2014) for reviews of environmental archives relevant to Boomplaas Cave. Grayson's (2011) *The Great Basin: A Natural Prehistory* is the definitive source for paleoenvironmental records relevant to Homestead Cave.

BOOMPLAAS CAVE

Boomplaas Cave is a key late Quaternary archaeological and paleoenvironmental archive for southern Africa's Cape Floristic Region. This region comprises an area of ~88,000 km² along the southern and western-most portion of southern Africa, including the mountains of the Cape Fold Belt and the coastal lowlands. The Cape Floristic Region is best known for its spectacular floristic diversity, including the world's highest frequency of endemic plant species (Goldblatt and Manning 2002; Linder 2003), but to archaeologists it is also well known for its Middle and Later Stone Age archaeological sites that feature prominently in our understanding of modern human origins, with some of the best-known sites including the Klasies River Mouth caves, Blombos Cave, and the Pinnacle Point caves.

Boomplaas Cave is situated at an elevation of ~700 m above sea level within the cliffs of a limestone seam on the southern foothills of the Swartberg mountain range, approximately 60 m above the Cango Valley. The east–west trending Swartberg range forms the northern boundary of the intermontane basin known as the Klein Karoo, with the Outeniqua range marking its southern boundary 50 km to the south. The lowlands of the Klein Karoo, which sit in the rain-shadow of the Outeniquas, are a semi-desert; rainfall is higher in the mountainous uplands and Boomplaas Cave receives around 400 mm annual precipitation. Compared with much of the Klein Karoo, the Cango Valley is well-watered by streams draining from the flanks of the Swartberg and into the

eastward-flowing Grobelaars River (at the foot of Boomplaas Cave) and the westward-flowing Matjes River (10 km west of Boomplaas Cave).

The vegetation in the immediate vicinity of Boomplaas Cave is part of a transitional shrubland whose component species vary in relation to temperature and rainfall gradients from the valley floor up the slopes of the Swartberg (see Vlok and Schutte-Vlok [2010] for a detailed summary). The transitional shrublands are dominated by single shrub species, though grasses and short-lived herbs flourish after fires. In the low-lying areas just south of Boomplaas Cave occurs a shrubby habitat known as renosterveld, characterized by the renosterbos (*Elytropappus rhinocerotis*) and a sparse understory of grasses. Along watercourses and ravines in the Cango Valley are more densely wooded habitats that include sweet thorn trees (*Acacia karroo*) and ironwood (*Olea* spp.) among others (Moffett and Deacon 1977). The transitional shrublands give way to fynbos habitats – hard-leaved evergreen shrublands typically dominated by restios, ericas, and proteas – as one moves up the slopes of the Swartberg. These include a grassy fynbos habitat known as waboomveld, indicated by the presence of *Protea nitida* (waboom or wagon tree) and relatively abundant grasses, just north of Boomplaas. The grasses that occur in the vicinity of Boomplaas include a mix of C_3 (cool-season) and C_4 (warm-season) species, reflecting the fact that rainfall is fairly evenly distributed through the year.

Excavations conducted by Hilary Deacon (University of Stellenbosch) from 1974 to 1979 uncovered a stratified sequence extending to 5 m in depth and spanning the past >65,000 years (H. J. Deacon 1979, 1995; H. J. Deacon and Brooker 1976; H. J. Deacon et al. 1984; see also J. Deacon 1984). Deacon (1979) organized the stratigraphy according to a hierarchical scheme of stratigraphic members, units, and sub-units. We use the coarser-scale members in our analyses primarily because these stratigraphic aggregates provide larger sample sizes. Our goal in these analyses is to illustrate the application of certain techniques, so finer-scale stratigraphic and temporal control – which might be important if our goal were to address particular paleoenvironmental questions – is not needed here.

The chronology of the Boomplaas Cave deposits is supported by radiocarbon dates (primarily on charcoal) for the middle to upper portions of the sequence and a combination of amino acid racemization (AAR) on ostrich eggshell (Miller et al. 1999) and U-series ages on speleothems (Vogel 2001) for the lower section. The Boomplaas Cave chronology is summarized in Table 4.1. The lowest dated member (OCH) is associated with a broad range of age estimates but it includes Middle Stone Age artifacts attributed to the Howieson's Poort industry, which has been dated elsewhere in southern Africa by optically stimulated luminescence to ~59 to 66 ka (Jacobs and Roberts 2017). The basal member (LOH) is estimated to date to 80 ka (H. J. Deacon 1979) but this is not supported by any radiometric age estimates.

TABLE 4.1 *The stratigraphy and chronology of Boomplaas Cave. Radiocarbon dates reported here are those obtained on charcoal. Age ranges represent calibrated Bayesian models from Sealy et al. (2016).*

Member	Age	Modeled age range (kcal BP)
DGL	1,630 ± 50 (^{14}C)	1.6 to 1.4
	1,700 ± 50 (^{14}C)	
	1,510 ± 75 (^{14}C)	
BLD	1,955 ± 65 (^{14}C)	2.3 to 1.6
BLA	6,400 ± 75 (^{14}C)	8.0 to 6.4
BRL	9,100 ± 135 (^{14}C)	12.3 to 10.1
	10,425 ± 125 (^{14}C)	
CL	12,060 ± 105 (^{14}C)	16.9 to 13.9
	12,480 ± 130 (^{14}C)	
	14,200 ± 240 (^{14}C)	
GWA	17,830 ± 180 (^{14}C)	22.5 to 20.6
LP	Undated	23.1 to 22.2
LPC	21,110 ± 420 (^{14}C)	25.8 to 25.1
	21,220 ± 195 (^{14}C)	
YOL	–	32.3 to 25.8
BP	32,400 ± 700 (^{14}C)	39.7 to 36.0
	33,920 ± 770 (^{14}C)	
OLP	37,400 ± 1370 (^{14}C)	42.9 to 40.3
	44,000 ± 4,000 (AAR)	
BOL	–	–
OCH	>49,000 (^{14}C)	–
	56,000 ± 6,000 or	
	65,000 ± 6,000 (AAR)	
	59,000 ± 2,000 (U-Series)	
	64,000 ± 2,000 (U-Series)	
	66,000 ± 7,000 (U-Series)	
LOH	–	–

Boomplaas was excavated using 3 mm mesh screens, though select 1×1 m excavation squares were sieved through 2 mm mesh screens to enhance recovery of the microfauna (Avery 1982). The recovered material has been reported in numerous publications spanning the past several decades. These include reports on the cultural remains (H. J. Deacon et al. 1976; H. J. Deacon et al. 1978; J. Deacon 1984), the chronology (Miller et al. 1999; Vogel 2001), fossil charcoal and pollen (H. J. Deacon et al. 1983; Scholtz 1986), micromammals (Avery 1982, 2004; Thackeray 1987), macromammals (Brink 1999; Driesch and Deacon 1985; Faith 2013a; Klein 1978, 1983), and isotope geochemistry of ungulate tooth enamel (Sealy et al. 2016).

Table 4.2 reports Avery's (1982) taxonomic abundances (minimum number of individuals = MNI) for the rodents and insectivores (shrews, elephant shrews,

TABLE 4.2 *Taxonomic abundances (MNI) for the Boomplaas Cave microfauna (after Avery 1982).*

Family	Taxon	DGL	BLD	BLA	BRL	CL	GWA	LP	LPC	YOL	BP	OLP	BOL	OCH	LOH
Chrysochloridae	*Chlorotalpa duthieae*	2	11	1	11	40	60	61	5	16	58	447	53	10	3
Macroscelididae	*Elephantulus edwardii*	8	12	6	46	8	1	1	0	1	6	11	5	1	1
Soricidae	*Myosorex varius*	44	69	41	100	138	505	463	56	87	638	6443	657	128	33
	Suncus varilla	2	7	10	22	19	32	25	2	7	64	890	33	7	2
	Crocidura cyanea	24	37	10	44	34	0	0	0	0	30	277	13	7	2
	Crocidura flavescens	91	164	67	126	93	29	47	3	10	49	170	51	15	3
Bathyergidae	*Cryptomys hottentotus*	128	224	79	200	279	106	89	3	19	155	560	100	49	5
Gliridae	*Graphiurus ocularis*	1	1	0	3	4	4	4	0	0	8	37	10	4	0
Nesomyidae	*Dendromus melanotis*	1	3	2	8	7	18	26	2	5	48	464	47	4	1
	Dendromus mesomelas	0	0	0	5	2	0	1	0	0	2	25	1	1	0
	Mystromys albicaudatus	32	89	39	60	29	5	6	1	1	9	102	15	10	3
	Steatomys krebsii	6	27	10	10	0	0	0	0	0	0	0	0	0	0
	Saccostomus campestris	10	20	3	6	0	0	0	0	0	0	0	0	0	0
Muridae	*Acomys subspinosus*	4	9	4	16	9	5	4	1	1	16	131	20	2	1
	Aethomys namaquensis	73	99	55	275	124	33	37	3	4	91	387	60	13	3
	Dasymys incomtus	2	3	1	5	4	2	2	0	1	10	15	6	2	1
	Mus minutoides	3	8	6	6	3	6	7	1	1	18	313	18	1	1
	Myomyscus verreauxii	9	9	5	53	15	3	8	1	1	14	81	18	2	1
	Rhabdomys pumilio	17	39	6	27	19	8	13	3	1	18	117	20	7	1
	Gerbilliscus afra	0	5	3	11	1	0	0	0	0	3	9	0	0	1
	Gerbillurus paeba	0	2	1	4	1	0	0	0	0	0	3	1	0	1
	Otomys laminatus	5	6	3	17	14	3	1	0	2	4	32	5	2	0
	Otomys saundersiae	53	103	50	175	189	777	761	38	97	709	3113	588	170	35
	Otomys irroratus	233	362	191	504	411	128	203	10	44	297	1583	379	84	22
	Otomys unisulcatus	9	26	11	28	7	98	80	6	17	17	29	14	10	0

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and golden moles) from Boomplaas Cave. The sample includes more than 30,000 individuals distributed across twenty-five species. Based primarily on an assessment of the ecology of the prey species, most of which are nocturnal, Avery (1982) suggests that barn owls (*Tyto alba*) were the likely accumulators of the assemblage, an argument consistent with the presence of modern barn owl roosts in rockshelters adjacent to Boomplaas Cave. The micromammals are especially dense in deposits lacking archaeological remains (H. J. Deacon 1979), suggesting they were deposited when the cave was unoccupied by people.

The Boomplaas macromammal data are derived from specimen counts (typically referred to as number of identified specimens, or NISP) provided by Faith (2013a), reported here in Table 4.3. Note that Faith (2013a) did not examine the faunas from the uppermost pastoralist occupation (member DGL), which is dominated by sheep. The sample includes more than 6,400 specimens distributed across thirty-six non-overlapping taxa, though many of our analyses focus specifically on the ungulates (>2,600 specimens distributed across twenty-one non-overlapping taxa). Given the highly fragmentary nature of the Boomplaas Cave material, which rendered most specimens unidentifiable to lower taxonomic groups, the vast majority of taxonomic identifications for ungulates are based on dental remains. Analysis of bone surface modifications of those specimens corresponding in size to the ungulate taxa (>5 kg) at Boomplaas Cave indicates a complex taphonomic history of bone accumulation (Faith 2013a). The mammals from the bottom of the sequence were accumulated primarily by carnivores – leopards (*Panthera pardus*) being a likely candidate – with large raptors, probably the Cape eagle owl (*Bubo capensis*), also introducing remains belonging to the smallest bovids (*Oreotragus oreotragus* and *Raphicerus* spp.). From members BOL to GWA, there are variable amounts of bone accumulation related to people, carnivores, and raptors, with the anthropogenic component related mainly to the largest ungulate species. And in the upper members (CL and above), people accumulated most of the faunal remains. This complex taphonomic history poses some challenges for interpreting the environmental implications of the Boomplaas macromammals, and we discuss how this might be dealt with in subsequent chapters.

Paleoenvironmental Summary

Our task of providing a summary of the environmental history is complicated by the fact that some of the most basic details concerning the Cape Floristic Region's paleoenvironments – were glacial phases of the Pleistocene wetter or drier than the present? – are actively debated (e.g., Chase and Meadows 2007; Chase et al. 2018; Faith 2013b; Marean et al. 2014). The debate is not due to a lack of data – the Cape Floristic Region has been a focus of paleoenvironmental research for decades (e.g., J. Deacon and Lancaster 1988) – but instead

reflects a combination of seemingly contradictory lines of evidence coupled with a good measure of not yet well-understood regional variation. With this in mind, we focus below on what has been inferred from the Boomplaas mammals.

From the base of the sequence to the Last Glacial Maximum, the large mammals are interpreted as indicating a transition from shrubland habitats – perhaps not unlike the contemporary vegetation – to open grassland, with the grasslands replaced by shrubland at the onset of the Holocene (Faith 2013a; Klein 1978, 1983). Isotopic analysis of the Last Glacial Maximum grazers indicates a dominance of C_3 grasses in the diet, implying an intensification of winter rainfall systems in the region (Sealy et al. 2016). The vegetation history inferred from the microfauna complements this scenario, though Avery (1982) documents other subtle changes superimposed on this general trend. Avery (1982) and Thackeray (1987) provide independent analyses of the microfauna indicating a general decline in temperatures from the base of the sequence to the Last Glacial Maximum, with the Holocene characterized by the warmest temperatures in the sequence.

An important point of contention concerns the precipitation history. Previous interpretations of the Boomplaas faunas are in complete opposition, with the Last Glacial Maximum interpreted as either the driest portion of the sequence (Avery 1982; H. J. Deacon et al. 1984; Thackeray 1987) or the wettest (Faith 2013a, 2013b). These contradictions are worth keeping in mind, if only because they demonstrate that faunal-based paleoenvironmental reconstructions are neither infallible nor unambiguous – far from it! As is the case with all paleoenvironmental archives, confidence in interpretation is enhanced whenever multiple lines of evidence are in agreement. There are paleoenvironmental records not far from Boomplaas Cave (~70 km west) that indicate greater moisture availability during the Last Glacial Maximum compared with the Holocene (Chase et al. 2018), though the implications of environmental archives from elsewhere in the Cape Floristic Region are less clear.

HOMESTEAD CAVE

Homestead Cave provides perhaps the most detailed late Quaternary mammal sequence for the Great Basin (Grayson 2006, 2011), the vast region of internal drainage in the arid western United States. Homestead Cave is located at the northwestern-most spur of the Lakeside Mountains just west of the Great Salt Lake in north-central Utah. This low-lying spur, known as Homestead Knoll, is a rocky promontory lacking active springs or perennial streams and receiving very little rainfall throughout the year (~225 mm). The cave is formed within a small limestone ridge and sits at an elevation of 1,406 m, approximately 100

TABLE 4.3 *Taxonomic abundances (NISP) for the Boomplaas Cave macromammals (after Faith 2013a).*

Family	Taxon	BLD	BLA	BRL	CL	GWA	LP	LPC	YOL	BP	OLP	BOL	OCH	LOH
Lagomorpha	*Lepus capensis*	17	2	46	9	0	1	1	2	1	2	7	4	3
	Bunolagus monticularis	98	21	94	41	1	0	1	4	16	26	6	11	0
	Leporidae indet.	13	2	18	18	0	3	1	0	8	6	1	2	0
Rodentia	*Hystrix africaeaustralis*	8	3	14	4	0	0	0	0	0	0	4	0	0
Primates	*Papio ursinus*	215	34	78	19	0	2	4	13	6	16	16	101	12
Carnivora	*Canis* cf. *mesomelas*	1	1	0	1	0	0	0	1	0	1	0	0	0
	Lycaon pictus	0	0	0	0	0	0	0	0	0	0	0	4	0
	Mellivora capensis	2	0	0	0	0	0	0	0	0	0	0	0	0
	Genetta sp.	1	0	0	0	0	0	0	0	0	0	0	1	0
	Herpestes ichneumon	2	0	0	0	0	0	0	0	0	0	0	0	0
	Herpestes pulverulentus	0	0	3	1	0	0	0	0	0	1	0	0	0
	Herpestes sp.	2	0	0	0	0	0	0	0	0	0	0	0	0
	Hyaenidae indet.	0	0	0	0	0	0	0	0	0	0	2	0	0
	Caracal/Leptailurus	4	0	1	2	1	0	0	0	1	1	0	1	1
	Felis silvestris	21	1	0	0	0	0	0	0	0	0	0	0	0
	Panthera pardus	2	1	0	0	0	0	0	1	1	4	2	14	2
	Felidae indet.	0	0	1	0	0	0	0	0	0	0	0	0	0
Hyracoidea	*Procavia capensis*	1377	126	258	293	32	20	13	36	44	101	100	187	95
Equidae	*Equus capensis*	0	0	0	15	1	2	1	0	0	0	0	0	0
	Equus zebra/quagga	14	4	53	419	28	24	10	20	12	4	2	3	0
Suidae	*Potamochoerus larvatus*	0	0	1	0	0	0	0	0	0	0	0	0	0
Bovidae	*Taurotragus oryx*	1	0	9	55	5	0	2	0	2	0	0	7	0
	Tragelaphus strepsiceros	0	0	11	0	0	0	0	0	0	0	0	0	0

Taxon													
Tragelaphini indet.	1	0	8	15	0	0	0	0	2	0	0	1	0
Hippotragus leucophaeus	3	0	4	11	1	2	0	0	0	0	0	2	0
Hippotragus equinus	0	0	1	5	0	0	0	0	0	0	0	0	0
Hippotragus sp.	0	0	11	15	1	0	0	1	2	0	0	1	0
Redunca fulvorufula	21	1	2	4	0	0	0	0	2	7	5	27	1
Redunca arundinum	0	1	1	0	0	0	0	0	0	0	1	2	2
Redunca sp.	35	2	5	4	1	0	0	0	0	4	2	28	2
Alcelaphus buselaphus	12	0	1	0	0	1	0	0	2	0	0	0	0
Connochaetes cf. taurinus	0	0	0	0	0	0	0	0	6	0	0	0	0
Connochaetes cf. gnou	0	0	0	0	0	1	5	0	6	1	0	0	0
Connochaetes/Alcelaphus	0	0	4	11	11	5	13	2	46	1	0	1	0
Damaliscus cf. dorcas	0	0	4	0	1	1	0	0	11	3	0	8	2
Alcelaphini indet.	0	0	1	0	3	1	0	0	23	2	0	0	0
Extinct caprin	0	0	75	233	8	4	4	0	3	0	2	1	0
Pelea capreolus	17	10	31	17	3	2	5	12	13	22	24	80	21
Antidorcas cf. marsupialis	0	0	0	4	1	1	1	0	0	1	1	10	4
Oreotragus oreotragus	65	19	162	17	0	2	2	7	7	16	11	32	2
Raphicerus melanotis	2	1	2	0	0	0	0	0	0	1	1	1	1
Raphicerus campestris	0	0	1	0	0	0	0	0	0	0	0	0	0
Raphicerus sp.	63	16	83	14	0	1	2	1	6	11	28	49	8
Oreotragus/Raphicerus	42	8	126	17	0	0	0	1	2	4	13	19	7
Syncerus antiquus	0	0	0	4	0	5	0	0	0	0	1	0	0
Syncerus caffer	0	0	2	11	2	0	0	0	0	1	0	2	0
Syncerus sp.	0	0	0	2	0	0	0	0	0	0	0	0	0

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m above the valley floor. To the immediate west and northwest is the saline playa of Pleistocene Lake Bonneville, the pluvial lake that formerly covered much of western Utah until the Pleistocene came to an end. Although the playa is barren, the vegetation on the knoll itself is dominated by grasses and shrubs – the dominants being shadscale (*Atriplex confertifolia*) and horsebrushes (*Tetradymia* spp.) – with a few scattered junipers (*Juniperus osteosperma*). Greasewood (*Sarcobatus vermiculatus*) and big sagebrush (*Artemisia tridentata*) are common on the valley floor, along with invasive cheat grasses (*Bromus* spp.).

Excavations at Homestead Cave were directed by David Madsen (Utah Geological Survey) in 1993 (Madsen 2000). His team excavated a 1 × 1 m square down to bedrock – at a depth of ~2.7 m – providing a finely stratified sequence that begins ~13,000 years ago and continues into historic times. The stratigraphy is aggregated according to eighteen analytical units, from Stratum I at the base to Stratum XVIII at the top (Table 4.4). The original chronology reported by Madsen (2000) is provided by a series of twenty-one radiocarbon dates on various organic materials (e.g., fecal pellets, hackberry endocarps, charcoal), with an additional eighty radiocarbon dates obtained on kangaroo rat (*Dipodomys* spp.) femora more recently provided by Terry and Novak (2015). For the sake of simplicity, we report Madsen's (2000) chronology in Table 4.4.

Excavated deposits were passed through 1/4″ (6.4 mm), 1/8″ (3.2 mm), and 1/16″ (1.6 mm) mesh screens, from which organic and (rare) cultural remains were recovered. Madsen's (2000) monograph, which includes contributions from a variety of specialists, provides an excellent account of the excavated materials (see also Madsen et al. 2001). There are numerous other reports on Homestead Cave, including studies of the fecal pellets from woodrats (*Neotoma* spp.) (Smith and Betancourt 2003) and artiodactyls (Broughton et al. 2008), fishes (Broughton 2000; Broughton et al. 2000, 2006), mammals (Grayson 1998, 2000b; Grayson and Madsen 2000; Lyman and O'Brien 2005; Rowe and Terry 2014; Terry 2007, 2010a; Terry and Rowe 2015; Terry et al. 2011), and the chronology (Terry and Novak 2015).

The very limited evidence for human occupation of Homestead Cave, in contrast to sites elsewhere in the Bonneville Basin, is probably related to the lack of available water. But this did not detract from the suitability of the cave for owls. Roosting screech owls (*Megascops kennicottii*) and dense piles of owl pellets were observed in the cave when excavations began (Madsen 2000), and owl pellets in various states of decay were found throughout the sequence, with many of the recovered fossils having remains of pellets adhering to them (Grayson 2000a, 2000b). Like the micromammals from Boomplaas Cave, owls accumulated the vast majority of the Homestead faunal assemblage, which is dominated by rodents and lagomorphs. There are rare remains of large mammals, including artiodactyls and carnivores. These are represented

TABLE 4.4 *The stratigraphy and chronology of Homestead Cave (after Madsen 2000). Radiocarbon ages are calibrated (2σ range) using OxCal 4.3 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013).*

Stratum	¹⁴C age	Cal yrs BP
XVIII	–	
XVII	1,020 ± 40	799–1,051
XVI	1,200 ± 50	986–1,264
XV	–	
XIV	2,850 ± 50	2,848–3,143
XIII	3,480 ± 40	3,640–3,849
XII	3,400 ± 60	3,483–3,830
XI	–	
X	5,330 ± 65	5,946–6,278
IX	–	
VIII	–	
VII	6,160 ± 85	6,802–7,260
	6,185 ± 105	6,797–7,313
VI	7,120 ± 70	7,791–8,154
V	8,230 ± 69	9,022–9,406
IV	8,195 ± 85	8,996–9,425
III	–	
II	8,520 ± 80	9,320–9,682
	8,790 ± 80	9,561–10,154
	8,830 ± 240	9,241–10,564
I (upper 5 cm)	10,160 ± 85	11,396–12,127
	10,350 ± 80	11,836–12,527
I (general)	10,910 ± 60	12,696–12,942
I (lower 5 cm)	11,065 ± 105	12,729–13,096
	11,181 ± 85	12,811–13,213
	11,263 ± 83	12,975–13,303
	11,270 ± 135	13,796–14,892

primarily by small bones of the hands and feet (e.g., carpals, phalanges) and are thought to have been introduced by woodrats.

Our analyses of the Homestead Cave faunas make use of Grayson's (2000a) specimen counts (NISP) for rodents and lagomorphs (Table 4.5). Grayson's (2000a) data are based on identification of all mammals from the 1/4″ (6.4 mm) and 1/8″ (3.2 mm) sample fractions from fourteen of the eighteen stratigraphic units. Only the kangaroo rats (*Dipodomys* spp.) from Stratum X were identified so this stratum is not considered here. As is clear from Table 4.5, sample sizes are massive, with counts for individual assemblages ranging from 1,045 in Stratum XVIII – a solid figure by most paleozoological standards – to a whopping 28,525 in Stratum IV. These impressive samples are precisely why

TABLE 4.5 *Taxonomic abundances (NISP) for the Homestead Cave small mammals (after Grayson 2000a).*

Family	Taxon	I	II	III	IV	V	VI	VII	VIII	IX	XI	XII	XVI	XVII	XVIII
Sciuridae	*Ammospermophilus* sp.	0	0	0	0	0	0	0	3	8	0	0	0	0	0
	Ammospermophilus cf. *leucurus*	0	0	0	5	2	10	11	4	6	18	6	7	6	0
	Ammospermophilus leucurus	2	6	5	110	19	123	56	37	88	41	117	26	41	1
	Tamias sp.	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tamias minimus	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Marmota cf. *flaviventris*	30	4	0	7	0	1	2	0	0	0	0	0	0	0
	Marmota flaviventris	13	4	0	8	0	3	0	1	1	0	0	0	0	0
	Urocitellus sp.	0	1	2	3	0	0	10	23	32	0	0	0	0	0
	Urocitellus cf. *mollis*	0	0	1	8	1	39	18	0	89	183	306	52	119	10
	Urocitellus mollis	5	4	4	38	17	148	76	54	227	205	523	231	556	35
Geomyidae	*Thomomys* sp.	107	404	238	2952	506	2492	1153	665	1573	520	1144	393	1008	48
	Thomomys bottae	0	30	18	2158	35	129	86	44	141	42	79	57	87	4
	Thomomys talpoides	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Heteromyidae	*Chaetodipus formosus*	2	2	1	3	0	1	0	0	0	0	6	2	14	0
	Dipodomys sp.	310	1212	964	12629	2713	14016	9086	5286	14378	6343	15518	4048	9692	671
	Dipodomys microps	7	83	75	1033	245	1094	775	451	1075	467	1201	276	704	48
	Dipodomys ordii	43	34	17	50	7	63	7	5	24	10	34	11	22	1
	Microdipodops sp.	1	7	0	0	0	0	0	0	0	0	0	0	0	0
	Microdipodops megacephalus	6	10	0	0	0	0	0	0	0	0	0	0	0	0
	Perognathus longimembris	0	4	8	77	7	37	21	12	22	3	12	18	36	2
	Perognathus parvus	121	86	9	12	1	4	1	0	0	0	0	2	6	0

Cricetidae														
Lemmiscus curtatus	552	121	8	2	2	0	3	0	2	1	0	3	9	0
Microtus sp.	247	197	44	53	3	16	2	1	4	4	1	2	1	0
Neotoma sp.	50	150	59	258	43	182	147	53	180	57	56	26	50	48
Neotoma cf. *cinerea*	2310	1274	250	196	0	3	3	4	0	0	0	0	7	0
Neotoma cinerea	267	234	56	46	1	2	1	1	1	0	0	0	2	0
Neotoma cf. *lepida*	37	224	277	4281	786	2873	1340	807	2454	1257	2322	660	1810	118
Neotoma lepida	4	56	68	883	144	572	287	178	522	225	287	90	394	11
Ondatra zibethicus	0	0	0	1	0	3	0	0	2	0	0	0	1	0
Onychomys sp.	7	4	0	0	0	0	1	1	3	1	0	0	5	0
Onychomys leucogaster	8	4	1	5	0	2	1	1	4	1	5	5	10	0
Peromyscus sp.	1550	1124	205	531	52	178	88	52	147	49	187	61	205	17
Pitimys sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Reithrodontomys sp.	4	39	4	36	5	9	2	1	6	0	13	0	8	0
Reithrodontomys cf. *megalotis*	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Reithrodontomys megalotis	54	52	18	94	7	31	5	5	10	3	12	33	88	1
Leporidae														
Brachylagus idahoensis	192	32	3	4	1	4	1	1	0	1	0	0	0	0
Lepus sp.	2243	577	91	680	202	806	422	407	618	420	642	138	355	14
Lepus californicus	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Lepus townsendii	18	2	0	0	0	0	0	0	0	0	0	0	0	0
Sylvilagus sp.	2020	1832	450	2332	295	1443	278	181	424	221	349	109	294	15
Sylvilagus cf. *audubonii*	2	13	6	13	2	8	0	1	5	2	6	2	6	0
Sylvilagus cf. *nuttallii*	28	20	1	13	5	7	4	2	3	3	1	1	1	1

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the Homestead Cave faunas feature so prominently in the biogeographic histories of Great Basin mammals.

Paleoenvironmental Summary

The Great Basin has a spectacularly well-documented late Quaternary environmental history derived from geological evidence, plant macrofossil and pollen archives, and small mammal fossil assemblages (Grayson 2011). The Homestead Cave mammals have been used to inform on the nature of past climate change during the late Pleistocene and Holocene, as well as to understand the response of species to previously documented climatic changes during the middle Holocene (e.g., Grayson 1998, 2000a, 2000b; Lyman and O'Brien 2005). Consistent with other paleoenvironmental indicators – including faunal assemblages from elsewhere in the Bonneville Basin (Schmitt and Lupo 2012; Schmitt et al. 2002) – the Homestead mammals have been interpreted as indicating a late Pleistocene and early Holocene that was moister and cooler than what came afterwards. These conditions are suggested to have favored an expansion of sagebrush habitats with a prominent grass understory. A variety of sources indicate a middle Holocene that was warmer and drier than what came before or after, and this too has been inferred from the Homestead mammals. The mammals suggest that this phase of reduced moisture availability was associated with a decline of sagebrush and expansion of shadscale (*Atriplex confertifolia*), a shrub found in dry sediments that are highly saline. After the phase of middle Holocene aridity, environmental conditions broadly similar to the present prevailed.

SUMMARY

Boomplaas Cave and Homestead Cave are, in some important ways, ideal collections with which to illustrate the variety of analytical techniques described in subsequent chapters of this volume. They are well studied and well known, they produced large samples for each of several chronologically tightly controlled stratigraphically delimited assemblages, the collections represent temporal spans known to include major episodes of climatic variability, and the taphonomic histories of the assemblages of each are sufficiently well known as to not introduce insurmountable biases or skewing of paleoenvironmental signals.

Not all collections of ancient faunal remains provide such exemplary samples as Boomplaas Cave and Homestead Cave, so do not be misled into thinking all collections are of equal value. As should be clear from Chapter 3 and this chapter, not only do analyzing and interpreting all collections require certain analytical assumptions, some collections may simply not be amenable

to some kinds of analysis for any of a plethora of reasons. We thus call upon a variety of collections to illustrate particular analytical techniques or to underscore certain points in subsequent pages. It is our hope that, as we indicated earlier, in frequently referring to the same collections the reader need not focus too much on the particulars of those collections but instead can focus on the techniques under discussion. With the background of this and preceding chapters in hand, it is now time to turn to the focus of the volume, the analytical techniques that have been used to manipulate faunal data in such a way as to reveal their paleoenvironmental implications.