

# 11

## Nutritional Ecology of Late Pleistocene to Middle Holocene Subsistence in the Great Basin

Zooarchaeological Evidence from Bonneville Estates Rockshelter

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**B**ONNEVILLE ESTATES ROCKSHELTER (BER) PRESERVES A RECORD OF human subsistence in the west Bonneville Basin for at least the past 13,000 calendar years (Table 11.1). The modern excavation techniques employed at BER (e.g., fine-grained stratigraphic excavation and three-dimensional piece plotting of lithic artifacts and faunal specimens), together with the multitude of accelerator mass spectrometry (AMS) radiocarbon dates has allowed us to achieve a precision in matching artifacts and features with relatively short-term occupation sequences that was not obtained at other nearby caves excavated 40 to 50 years ago, such as Danger and Hogup caves. BER is also unique because human foragers began occupying the shelter at least 700 years before Danger Cave was first occupied, and 2,500 years prior to the initial occupation of Hogup Cave.

The faunal remains recovered from most of the occupation surfaces in BER are exceptionally well preserved, including those from the late Pleistocene and early Holocene layers. And because our excavations occurred more than 20 years after the seminal taphonomic studies of Binford (1981), Brain (1981), Haynes (1980), and Behrensmeier and Hill (1980), we can also tease out the relative contributions of human and nonhuman predators to the creation of that faunal record—for both the large and small faunal components. As a result, these specimens serve as an excellent sample to test models that are designed to explain changes in forager subsistence preferences (e.g., Hockett 2005).

In recent publications (Haws and Hockett 2004; Hockett and Haws 2003, 2005), we have attempted to revitalize a nutritional and demographic-based model to interpret prehistoric foraging choices during the middle and upper Paleolithic of Europe. In this chapter, I focus on the late Pleistocene, early Holocene, and middle Holocene faunal records recovered through the 2006 field season at BER using this same nutritional ecology perspective. I discuss three principal items: (1) late Pleistocene to middle Holocene climate in the

TABLE 11.1. Late Pleistocene, Early Holocene, and Middle Holocene Occupation Zones (Simplified) from Bonneville Estates Rockshelter by Radiocarbon Years BP and Their Associated Calendar Dates

STRATA	<sup>14</sup> C YEARS BP	CAL BP <sup>a</sup>	NOTES
West Block: 18b (base)	11,000 BP	12,900 BP	Hearth; no associated fauna
West Block: 18b (top)	10,500 BP	12,600 BP	Several hearths and associated fauna
West Block: 18a	10,100 BP	12,200 BP	Numerous hearths and associated fauna
East Block: 12			associated fauna
West Block: 17b	9500 BP	10,700 BP	Numerous hearths and associated fauna
East Block: 10			associated fauna
East Block: 9 (base)	8800 BP	9900 BP	Hearth; no associated fauna
West Block: 16	7200 BP	8000 BP	Hearth and associated thin organic lens with fauna
West Block: 14	6100 BP	7000 BP	Hearths and associated thick organic lens with fauna
East Block: 9 (upper)	5200 BP	6000 BP	Hearths associated with thick, deep organic pits with fauna

<sup>a</sup>Calibrated dates after Reimer 2004.

west Bonneville Basin; (2) assumptions of the nutritional ecology model; and (3) the subsistence and settlement choices of late Pleistocene/early Holocene and middle Holocene foragers at BER and related sites in the Great Basin, and whether these data suggest that they were influenced by climate change, the underpinnings of the nutritional ecology model, or both.

#### LATE PLEISTOCENE TO MIDDLE HOLOCENE CLIMATE CHANGE IN THE WEST BONNEVILLE BASIN

Madsen and Schmitt (2005) recently reviewed Holocene environmental change in the Bonneville Basin. My review here generally follows theirs for the early and middle Holocene, although additional paleoclimatic studies pertinent to understanding the BER cultural record are included below. Correlations between major shifts in climate and the occupation of BER are also highlighted.

*Younger Dryas/Latest Pleistocene, 10,800–10,100 <sup>14</sup>C BP (12,850–11,650 cal BP)*  
 Between the Last Glacial Maximum (ca. 18,000 <sup>14</sup>C BP [21,400 cal BP]) and the end of the Pleistocene epoch (traditionally set about ca. 10,100 <sup>14</sup>C BP [11,700 cal BP]), global climate witnessed a general warming trend that was offset by a millennial-scale cooling known as the Younger Dryas (e.g., Gosse et al. 1995).

At this time, the western shoreline of Lake Bonneville (Gilbert) would have been situated about 4,250 ft (1,289 m) asl, about the same elevation as the modern lakes and marshes that form Blue Lakes, located some 10 km (5 mi) east of BER (see Graf, this volume). Any drop in lake level from this Gilbert highstand would have facilitated the creation of the Blue Lakes marshes east of BER because lake levels at or above the 4,250 ft threshold would have essentially drowned the marshes under deeper water.

The Younger Dryas was a relatively cool period in the Great Basin (e.g., Bischoff and Cummins 2001), with cool and mesic-adapted small mammals occupying low-level elevations in the northern Great Basin (Grayson 1998, 2000a, 2000b; Schmitt et al. 2002b). Mature stands of sagebrush must have existed near the rockshelter during this time given that pygmy rabbit (*Brachylagus idahoensis*) and sage grouse (*Centrocercus urophasianus*) were among the most commonly identified animals in the Younger Dryas-aged sediments. Human foragers repeatedly occupied BER during this time, signaling the earliest population pulse in the western Bonneville Basin.

*Early Holocene, 10,100–8300 <sup>14</sup>C BP (11,650–9400 cal BP)*

Early Holocene climate appears to have warmed compared to the previous latest Pleistocene (Younger Dryas) conditions, but it was still relatively cool compared to the succeeding middle Holocene. Caves such as Homestead Cave and Camels Back Cave in the northern Bonneville Basin (Grayson 1998, 2000a, 2000b; Schmitt et al. 2002b; Schmitt and Madsen 2005) and Pintwater Cave in the northern Mojave Desert of southern Nevada (Hockett 2000) show that mesic small mammals continued to occupy low elevation settings throughout the Great Basin. However, while cool and wet conditions prevailed in the northern Great Basin at this time (Grayson 2000a), the southern Great Basin experienced greater warming but still relatively wet conditions (Hockett 2000). Near BER, sagebrush-adapted species such as pygmy rabbit and sage grouse continued to be present, and human foragers continued to repeatedly occupy the rockshelter.

*Early Middle Holocene, 8300–7200 <sup>14</sup>C BP (9400–8000 cal BP)*

Numerous records document a relatively rapid deterioration of climate throughout western North America ca. 9400 cal BP (Grayson 2000b; Hockett 2000; Overpeck et al. 1996; Madsen and Schmitt 2005; Schmitt et al. 2002b). This deterioration resulted in both warmer and drier conditions in the northern Great Basin, although the southern Great Basin probably continued to experience rather predictable summer precipitation (Hockett 2000). Mesic-adapted small mammals such as pika (*Ochotona princeps*), marmot (*Marmota flaviventris*), pygmy rabbit (*Brachylagus idahoensis*), sage vole (*Lemmiscus curtatus*) and other voles of the genus *Microtus*, bushytailed wood rat (*Neotoma cinerea*), and western harvest mouse (*Reithrodontomys megalotis*) were either

extirpated from or experienced significant population declines in many low elevation settings in the northern Great Basin (Grayson 2000a, 2000b; Grayson and Madsen 2000; Schmitt et al. 2002b). Near BFR, neither pygmy rabbit nor sage grouse were found in deposits that date between 8800 and 6000 <sup>14</sup>C BP (9900–6800 cal BP), signaling the dismantling of the sagebrush habitat. Humans abandoned BFR beginning in the late early Holocene (8800 <sup>14</sup>C BP [9900 cal BP]), and this settlement strategy continued throughout the early middle Holocene.

#### *The 7200 <sup>14</sup>C BP (8000 cal BP) Event*

Around 8000 cal BP, ancient Lake Agassiz catastrophically emptied into, and caused a short-term freshening of, the North Atlantic (Alley and Agüstsðóttir 2005). This occurrence—tentatively referred to as the “Finse,” “Goldilocks,” or “8k” event (Alley and Agüstsðóttir 2005; Schmidt and LeGrande 2005)—caused a short-term (perhaps no more than a decade or two) cooling in the North Atlantic and subsequent landscape-specific changes in climate on a near-global scale. Foragers reoccupied BFR for two very brief periods (radiocarbon dated at or slightly earlier than ca. 8000 cal BP) after a hiatus of nearly 2,000 years. Bison (Bison bison) appears in the faunal record of BFR for the first time in the 7200 <sup>14</sup>C BP (8000 cal BP) zone. Neither sage grouse nor pygmy rabbits, however, appear in the shelter deposits associated with this climatic event. This suggests that increases in precipitation may have occurred primarily during the summer rather than winter months in the west Bonneville Basin. The brief reoccupations of the shelter by human foragers appear to correspond closely with this 8k event, which probably brought more mesic (but warm) conditions to the west Bonneville Basin for one to several decades in one or more mesic spikes.

#### *The 6100 <sup>14</sup>C BP (7000 cal BP) Event*

Following the brief 8k climate event, conditions in the northern Great Basin appear to have returned to the warm and arid state of the early-middle Holocene. However, another relatively mesic event centered around 6100 <sup>14</sup>C BP (7000 cal BP) is recorded in the Great Basin paleoenvironmental record (Madsen and Currey 1979; Madsen and Schmitt 2005; Schmitt and Madsen 2005). At BFR, human foragers once again returned to the shelter after a 1,000-year absence following the 8k event. Sage grouse bones return to the shelter deposits after an approximately 3,500-year absence. Interestingly, neither bison nor pygmy rabbits are found in the shelter deposits of this age. This may suggest that the “7k” event was cooler than the 8k event, but still relatively brief. Based on the thickness of the occupation zones dating to this time period, human foragers either repeatedly occupied BFR or occupied the shelter for longer periods of time, or both, during the 7k event compared to the occupational intensity seen during the 8k event.

*The 5200 <sup>14</sup>C BP (6000 cal BP) Event?*

Following the 7k event, conditions once again turned warm and arid in the Great Basin (e.g., Schmitt and Madsen 2005). However, there are indications that a third middle Holocene mesic spike may have occurred in the Great Basin around 5200–5300 <sup>14</sup>C BP (6000 cal BP) (reviewed in Madsen and Schmitt 2005). BER may once again record this climatic event in the form of human occupation of the rockshelter. Following another hiatus of 1,000 years following the 7k event, foragers briefly returned to BER during this “6k” event. Artiodactyls were heavily exploited during this time. However, no sage grouse, pygmy rabbit, or bison bones were found in the shelter. The event generally corresponds to the initial occupation of many important cave and rockshelter sites across the central Great Basin (e.g., Hockett 2005), signaling the beginning of an occupational intensity that rivaled that of the late Pleistocene/early Holocene 6,000 to 7,000 years earlier.

## NUTRITIONAL ECOLOGY

Nutritional ecology models the health consequences of prehistoric dietary choice. A more detailed overview of the nutritional ecology approach can be found in Hockett and Haws 2003 and 2005. Here I note that it has only been in the past two decades that nutrition scientists have realized the powerful links between micronutrient diversity, fetal development, and infant and maternal mortality rates (e.g., Allen 2005; Ashworth and Antipatis 2001; Bendich 2001; Fall et al. 2003; Gambling and McArdle 2004; Keen et al. 2003; Ramakrishnan et al. 1999; Solomons 2000; Underwood 2002; Viteri and Gonzalez 2002). Although many excellent publications with a nutritional ecology perspective have been published over the past several decades (e.g., Schwarcz and Schoeninger 1991), it was our belief that most of them were idiosyncratic in the sense that they lacked a broader theoretical framework to focus attention on one of the main truisms of modern nutrition science: the essentiality of nutrient diversity to human health and its impact on demographic trends (Harper 1999).

Briefly, nutritional impacts to human demographic patterns center around the health and well-being of the mother and child. These impacts will vary depending on maternal consumption of the essential nutrients necessary for proper fetal-to-neonatal growth, as well as for maternal body maintenance during and immediately following pregnancy (e.g., Fall et al. 2003; Ramakrishnan et al. 1999). There are three principal reasons why micronutrients must be brought into models concerned with nutritional impacts to human mortality—and hence to human selective fitness.

First, ethnographic research supports the idea that most foragers maintained caloric intake levels above chronic energy deficiency (Lee and Devore 1968). As a result, ancient foragers who obtained calories more efficiently than others were not likely to gain a selective advantage unless chronic energy deficiency

was a leading factor in infant and maternal mortality rates. It is possible, indeed likely, that such occurrences impacted human demographic trends in specific places and times. However, many short-term and much of the long-term mortality patterns in human populations are likely to have been primarily influenced by overall nutrient diversity. Further, in higher primates, low caloric diets reduce the rate of cell damage and result in extended life expectancy rates (e.g., Yoshida et al. 1999).

Second, many micronutrients are essential to fetal development and the survival of neonates. It would be difficult for most foragers to consistently consume these critical micronutrients within a context of restricted dietary diversity. In other words, the broader the diet (note that broad or diverse diets in this context are defined by diversity of essential nutrient intake rather than by N-species consumed; see Hockett and Haws 2005:26, Figure 2), the more likely it is that human females consume the diversity of micronutrients necessary for proper fetal development. Hence, in general, diverse diets should be associated with other evidence suggesting population growth and/or improved health conditions, while more restricted diets should be associated with periods of demographic downturns and/or deteriorating health patterns. An excellent example of this principle is presented by Lockett et al. (2000:196), who reported on the health consequences of pastoralists who either did or did not consume relatively low caloric but micronutrient-dense wild plant resources during times of subsistence stress:

During 7 years of inadequate rainfall between 1965–72, agro-pastoral societies in the eastern Kalahari of Botswana thrived and remained well nourished. . . . In contrast, agro-pastoral societies who occupied the Sahel of West Africa, a zone similar to the Kalahari in climate and geography, suffered from terrible famine and hardship. . . . One primary difference between the two areas was a more diversified diet in the Kalahari characterized by an abundance of edible wild plants. Elsewhere in Africa uncultivated indigenous plants were protective during the 1984–85 Darfur famine in the Sudan where malnutrition-related mortality rates were lower among groups who used edible wild species compared to communities where such species were infrequently utilized.

Third, proteins, carbohydrates, and fats can be converted to useful energy only in the presence of specific micronutrients. Historically, this may be the most underappreciated fact in foraging theory in both the biological and anthropological sciences. But this is beginning to change. Within biology, new megacalorist theories are being developed to explain biogeographic variability based on differences in the availability of micronutrients to ruminants (e.g., Milewski and Diamond 2000). At their core, these theories are based on the understanding that body size in some mammals, including humans, is partially determined

by the availability of specific micronutrients, not simply by the availability of energy (Lagiou et al. 2005). In human evolution, researchers are determining the nutrients required for proper brain development and function, and then comparing those nutrients with those available to early hominids in order to narrow the subsistence components that would have been required for the evolution of the human brain (e.g., Broadhurst et al. 2002).

These studies are based on the essentiality of both micronutrients and macronutrients to mammalian development and maintenance. They can be further linked up the theoretical chain to the roles that nutritional factors play in the selection of populations. We may state the general proposition that selection operates on differential rates of fertility and mortality (Ward and Weiss 1976), but in order to gain interpretive power from this proposition, archaeologists must isolate and operationalize those factors that influence fertility and mortality patterns in human populations (see Hockett and Haws 2005:25, Figure 1). Nutritional ecology seeks to interpret, among other things, nutritional impacts to human mortality, and then apply those interpretations to the archaeological record. And it is within this general context that I apply the nutritional ecology model to the ecofacts recovered from BER.

#### THE BER LATE PLEISTOCENE, EARLY HOLOCENE, AND MIDDLE HOLOCENE FAUNA

The faunal remains described below date to two general time frames: (1) the late Pleistocene and early Holocene, represented by Strata 17b', 18a, and 18b in the West Block and Strata 10, 11, and 12 in the East Block (Component 6); and (2) the middle Holocene, represented by Strata 14, 15, and 16 in the West Block (Stratum 17a contained lithic artifacts and a hearth but few faunal remains) and Stratum 9 in the East Block (Components 5a, 5b, 5c) (Table 11.1; also see Graf, this volume). Stratum 19, which dates to about 12,300 <sup>14</sup>C BP (14,100 cal BP), also contains an abundance of well-preserved fauna. However, because the possibility of human occupation in BER prior to 11,000 <sup>14</sup>C BP (13,000 cal BP) has not been demonstrated, the faunal remains from Stratum 19—as well as those recovered from below this level (Stratum 20)—will be discussed in an upcoming paper.

As noted above, the late Pleistocene/Component 6 occupations generally correlate with the Younger Dryas cooling, although human foragers continued to repeatedly occupy BER until ca. 8800 <sup>14</sup>C BP (9900 cal BP). The three to four “pulses” of middle Holocene/Component 5 occupations generally correspond to the 8k, 7k, and 6k cal BP climatic events, with each separated by at least a 1,000-year occupational hiatus. As a result, these three middle Holocene occupations may be compared and contrasted with one another, as well as combined together for a general picture of middle Holocene subsistence in the west Bonneville Basin. These latter trends can then be contrasted with the late Pleistocene/early Holocene occupations.

TABLE 11.2. Number of Identified Specimens of Faunal Remains Deposited Principally by Human Foragers During the Late Pleistocene to Middle Holocene at Bonneville Estates Rockshelter

Species	COMPONENT 6		
	12,600-10,700 BP	8000 BP	7000 BP
Bison	—	1 (1)	—
Mountain sheep	3 (1)	2 (1)	—
Pronghorn	7 (1)	—	11 (1)
Deer	1 (1)	1 (1)	—
Artiodactyl	14	1	15
Large mammal	1,314	284	595
Black bear	1 (1)	—	—
Hare	169 (9)	13 (2)	77 (4)
Small mammal (burned)	261	12	58
Sage grouse	502 (18)	—	16 (1)
Grasshoppers	18 (18)	—	—
Small game	.93	.40	.83
index	—	—	.25

Note: Minimum number of individuals are included in parentheses; dates are reported in calendar years before present.

Late Pleistocene/Early Holocene Animal Procurement

The excavations of the late Pleistocene and early Holocene hearths and the sediments surrounding these features have produced the largest set of radiocarbon dates, lithic artifacts, and faunal remains yet recovered from this early period of the Great Basin. These bones represent a mixture of those deposited by humans and those accumulated by nonhuman agents (Tables 11.2 and 11.3). Taphonomic analysis can tease these components apart to various levels of certainty.

As I describe in further detail below, humans appear to have deposited the majority of artiodactyl, sage grouse, bear, and hare bones (as well as grasshoppers) in the shelter. However, most of the cottontail remains, all of the pygmy rabbit and rodent bones, and perhaps all of the waterfowl bones appear to derive from degraded raptor pellets and, to a lesser extent, from carnivore scats. The cottontail bones are biased toward young individuals, forelimb bones outnumber hindlimb bones, and mandibles were relatively common—all characteristics that generally indicate raptor pellet accumulations (Hockett 1991). A number of these bones also display single puncture marks. Many of the waterfowl bones appear similar (broken hind limb bones; evidence of slight gastric juice corrosion) to the collection of Pleistocene-aged teal and pintail bones deposited in raptor pellets in Pintwater Cave (Hockett 2000). In contrast, there is ample evidence for the systematic butchering of sage grouse carcasses, as well as the butchering and extraction of marrow from both



TABLE 11.3. Faunal Remains (NISP) Deposited Principally by Raptors and Carnivores During the Late Pleistocene to Middle Holocene at Bonneville Estates Rockshelter

	COMPONENT 6 12,600- 10,700 BP	COMPONENT 5A 8000 BP	COMPONENT 5B 7000 BP	COMPONENT 5C 6000 BP
Cottontail	239	2	33	2
Pygmy rabbit	149	—	—	—
Leporidae	685	24	73	10
Small carnivores	2	—	1	2
Raptors	10	—	—	—
Waterfowl	16	—	—	—
Passerine birds	38	—	—	2
Fish	1	—	2	—

Note: Dates are reported in calendar years before present.



FIGURE 11.1.  
Late Pleistocene/early  
Holocene sage grouse  
coracoids recovered  
from Bonneville  
Estates Rockshelter.

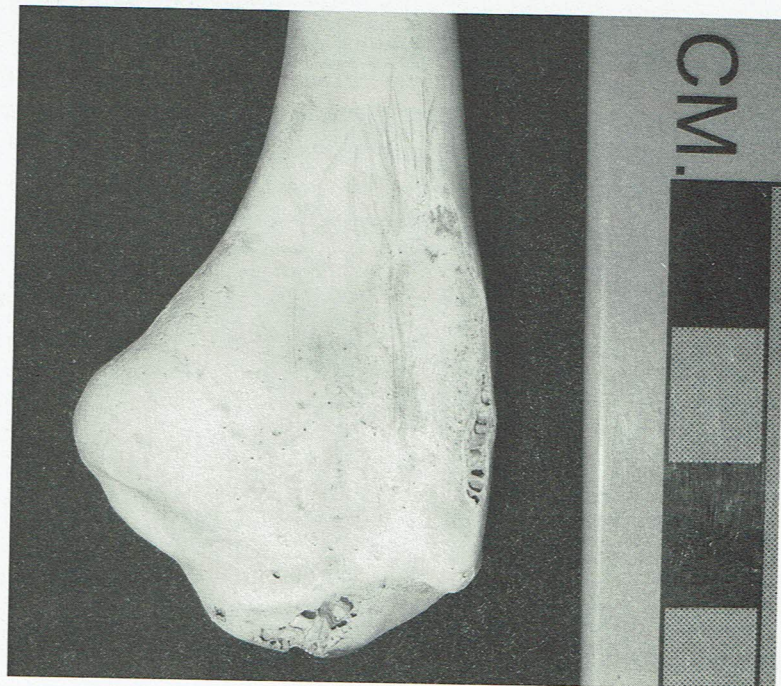


FIGURE 11.2.  
Late Pleistocene/early  
Holocene sage grouse  
proximal humerus  
with numerous cut  
marks recovered from  
Bonneville Estates  
Rockshelter.

TABLE 11.4. Sage Grouse Deposited by Human Foragers During the Late Pleistocene to Middle Holocene at Bonneville Estates Rockshelter

	COMPONENT 6 12,600- 10,700 BP	COMPONENT 5A 8000 BP	COMPONENT 5B 7000 BP	COMPONENT 5C 6000 BP
Total	502	—	16	—
Unburned	489	—	15	—
Burned	13	—	1	—
Cut	33	—	4	—
% Burned and Cut	.09	.00	.31	.00

Note: Dates are reported in calendar years before present.

artiodactyl and hare carcasses. Over 500 sage grouse bones have been identified to date (Table 11.4), some with ligaments still attached after 13,000 calendar years (Figure 11.1). These bones represent at least 16 individual birds. Three percent of the grouse bones are charred, and about 7 percent of them display stone tool cut marks (Figure 11.2). The preservation and taphonomic analysis of these bones leave no doubt that the carcasses were systematically butchered and then left behind directly surrounding the hearths dated from these levels.

All portions of the grouse carcass were recovered. The butchering or dismemberment patterns are as follows: (1) the wing joint between the proximal

TABLE 11.5. Large Mammal (Artiodactyl) Fragments Deposited Principally by Human Foragers During the Late Pleistocene to Middle Holocene at Bonneville Estates Rockshelter

	COMPONENT 6 12,600- 10,700 BP	COMPONENT 5A 8000 BP	COMPONENT 5B 7000 BP	COMPONENT 5C 6000 BP
Total	1,314	284	595	346
Unburned	877	247	519	283
Burned	437	37	76	63
Cut	2	7	45	3
% Burned and Cut	.33	.15	.20	.19

Note: Dates are reported in calendar years before present.

humerus and the scapula was separated with a stone tool of some kind; this left many proximal humeri with cut marks on the posterior side of the bone and also on the proximal blade of the scapula (Figure 11.2); (2) stone tools were also used to separate the upper femur from the pelvis; thus, several femora display slicing marks on their proximal ends (Figure 11.3); (3) the wings were further reduced in size by snapping the joints just below the proximal ends of the ulna and radius, and again just above the distal ends of these bones; this left almost every ulna and radius as diaphyses cylinders (Figure 11.4); (4) the lower leg was snapped just below the knee joint and again just above the ankle, leaving almost every tibiotarsus as a diaphysis cylinder (Figure 11.5); and (5) the feet were also snapped just below the ankle and again above the tarsals, leaving every tarso-metatarsus as a midsection (Figure 11.6). Similar long bone cylinders created by human processing of bird carcasses have been identified in late Holocene contexts from the Great Basin, such as at the Stillwater Marsh sites in western Nevada (Schmitt 1988).

Although sage grouse sterna, vertebrae, clavicles, phalanges, and skull and mandible fragments were recovered, their relative frequency values were less than those of the wing and leg portions. Thus, the axial skeleton was either processed more intensively (which rendered these bones unidentifiable), discarded in a portion of the shelter not yet excavated, or differentially transported away from the shelter.

The artiodactyl bones identified belong primarily to pronghorn (*Antilocapra americana*) but also include mountain sheep (*Ovis canadensis*) and deer (*Odocoileus hemionus*). These bones were extensively broken and form the typical pattern of relatively small long bone shaft fragments created through marrow extraction. Approximately 34 percent of these artiodactyl fragments were burned, and two fragments retained stone tool cut marks (Table 11.5).

Regarding the hares, 26 tibiae, femora, and humeri cylinders were recovered, six of which displayed stone tool cut marks (Figure 11.7). The cylinders were created by human foragers snapping or biting off the proximal and distal

FIGURE 11.4.  
Late Pleistocene/early  
Holocene sage grouse  
ulnae (*top*) and radii  
(*bottom*) diaphyses  
recovered from  
Bonnevillie Estates  
Rockshelter.

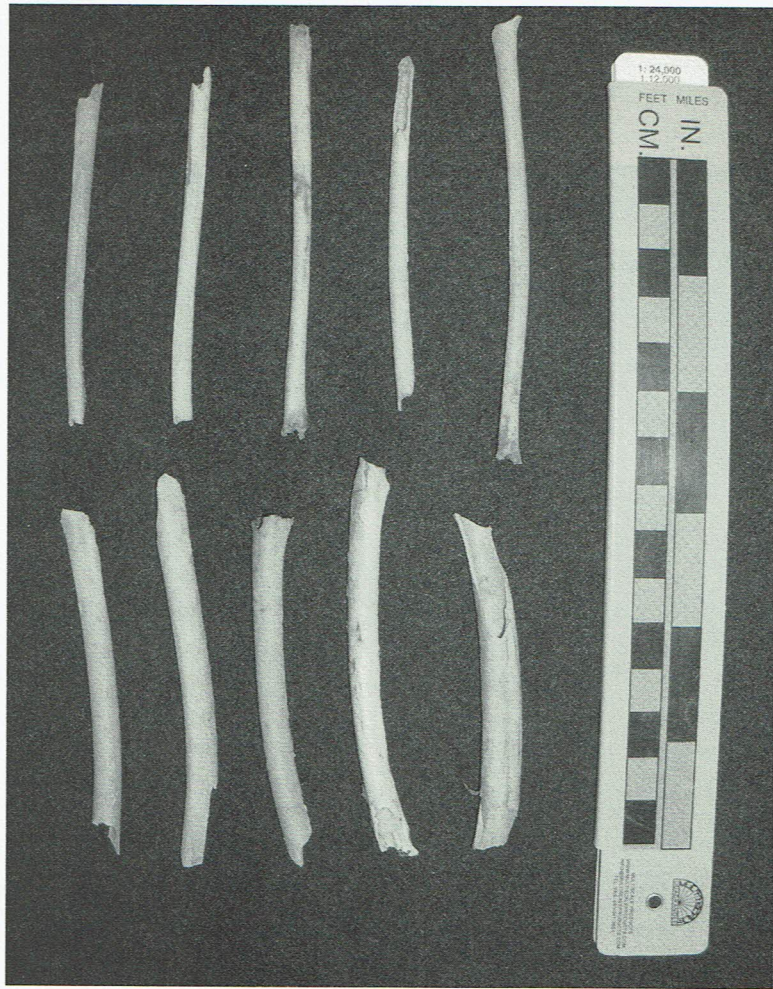


FIGURE 11.3.  
Late Pleistocene/early  
Holocene sage grouse  
femora recovered from  
Bonnevillie Estates  
Rockshelter.



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FIGURE 11.5.  
Late Pleistocene/early  
Holocene sage grouse  
tibiotarsii diaphyses  
cylinders recovered  
from Bonneville  
Estates Rockshelter.



FIGURE 11.6.  
Late Pleistocene/  
early Holocene sage  
grouse tarsometatarsii  
diaphyses recovered  
from Bonneville  
Estates Rockshelter.

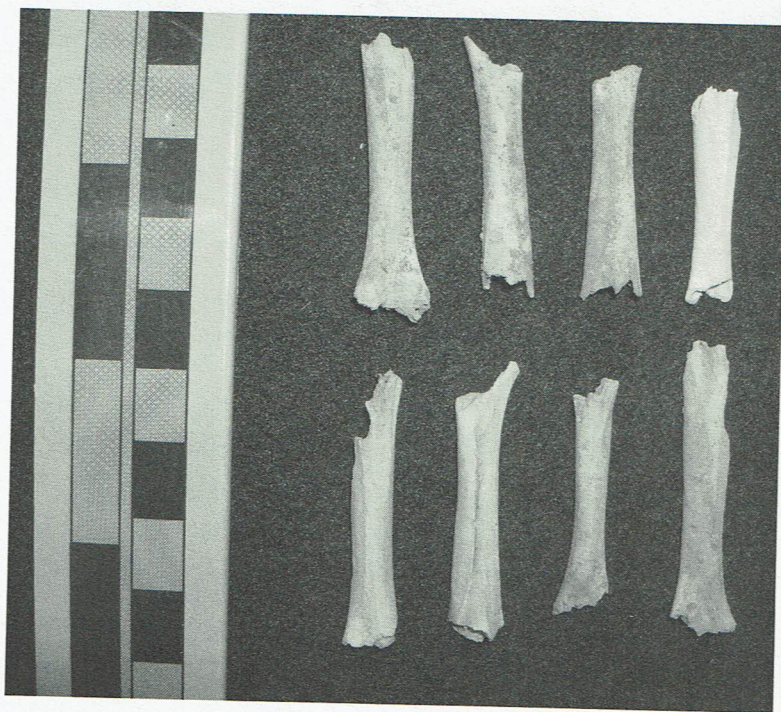


Figure 11.7:  
Late Pleistocene/  
early Holocene hare  
diaphyses cylinders  
recovered from  
Bonnevillie Estates  
Rockshelter.



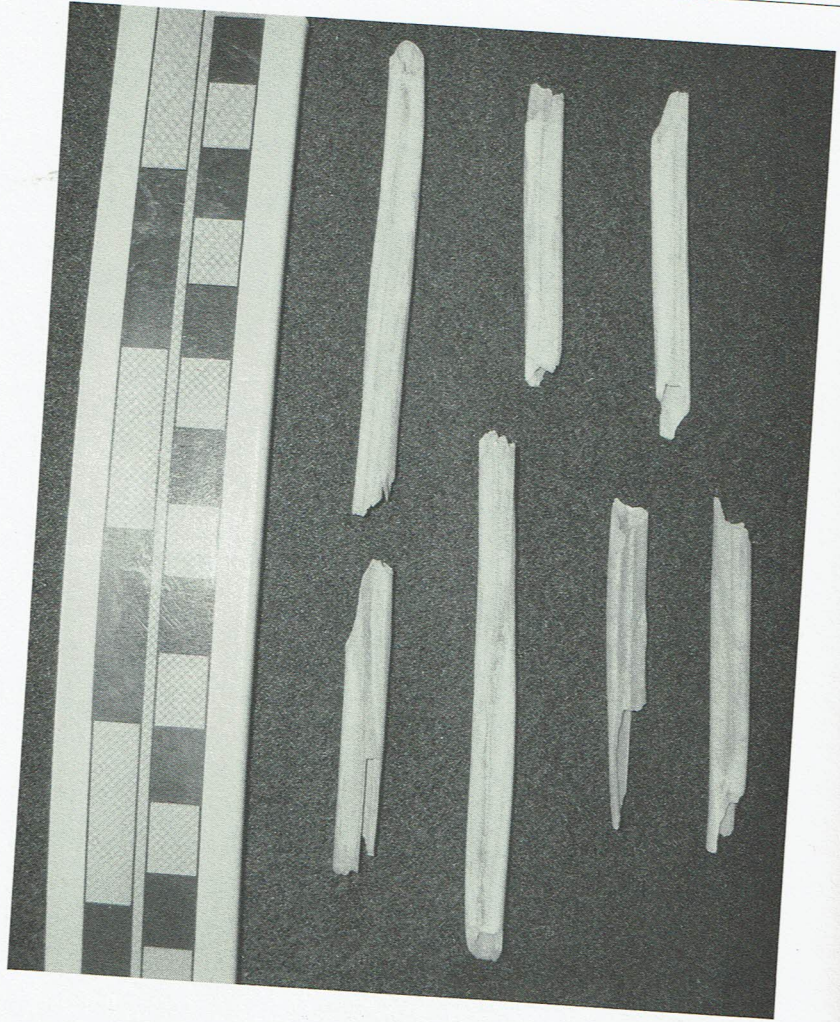


FIGURE 11.8.  
Late Pleistocene/early  
Holocene hare radii  
midsections recovered  
from Bonneville  
Estates Rockshelter.

ends to extract marrow (e.g., Schmitt 1986; Hockett 1991, 1994; Hockett and Haws 2002). These cylinders were previously known to occur in Great Basin assemblages dated as early as 7500 to 8500  $^{14}\text{C}$  BP (8400 to 9500 cal BP) (Hockett 1994), and with this analysis they are now known to occur as early as 10,500 to 10,800  $^{14}\text{C}$  BP (12,600 to 12,800 cal BP). The front limbs were also separated from the remainder of the carcasses by snapping the joints just below the proximal ulna and radius and again above the distal ends of these bones, leaving almost all radius-ulna units as midsections (Figure 11.8). These front limb bones look precisely like those recently illustrated in the middle Holocene levels from Camels Back Cave (Schmitt et al. 2004:91, Figure 4). Thus, this method of processing hare carcasses also dates to ca. 10,800  $^{14}\text{C}$  BP (12,800 cal BP) in the Great Basin. In addition, seven hare bones were burned, as were almost 200 leporid-sized bone fragments. Overall, a total of 13 of the 169 hare bones recovered (8 percent) were either cut or burned.

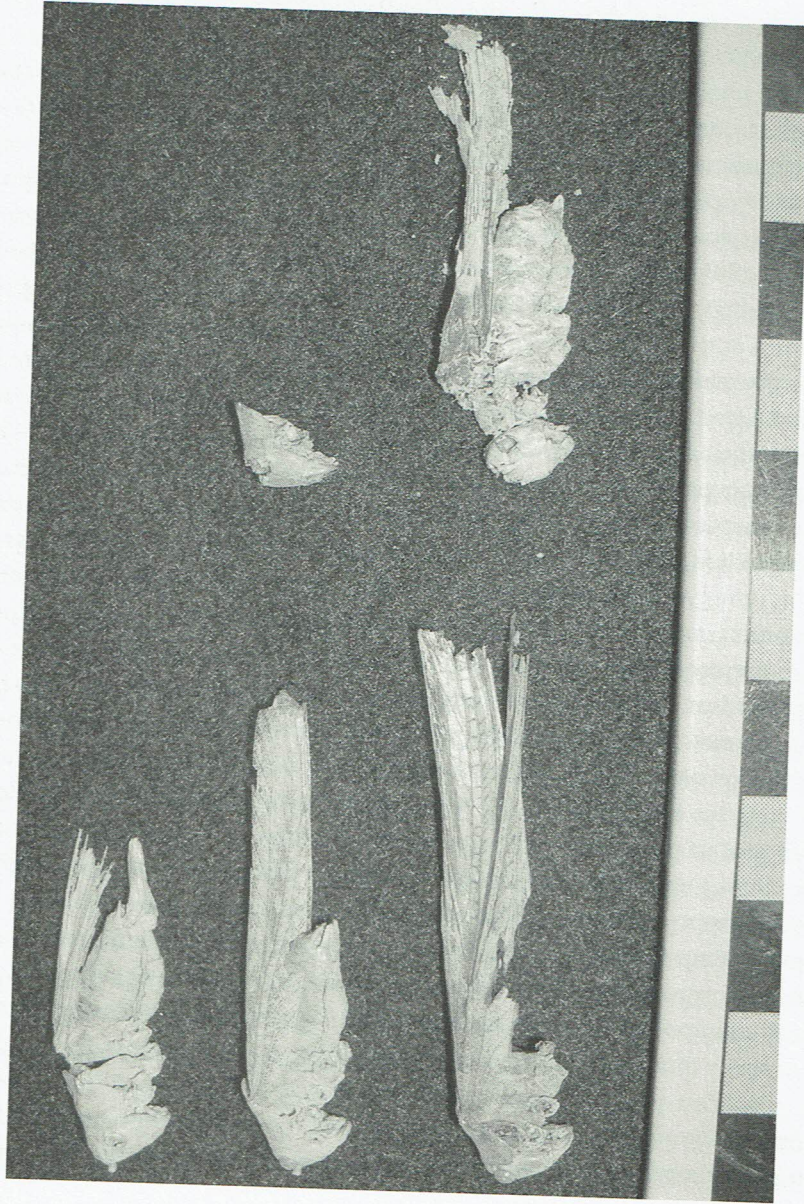


FIGURE 11.9.  
Late Pleistocene/early  
Holocene grasshoppers  
recovered from  
Bonnieville Estates  
Rockshelter.

One central phalanx of a black bear (*Ursus americanus*) was recovered from Stratum 18a. The bone was thoroughly charred, although no cut marks were visible. It therefore appears likely that late Pleistocene and early Holocene foragers occasionally hunted large carnivores in the west Bonneville Basin, although scavenging of bear parts cannot be discounted. Finally, Stratum 18a produced 18 well-preserved grasshoppers surrounding several hearths (Figure 11.9). These grasshoppers were typically complete or near-complete specimens, and most had their hind legs removed. Although grasshopper consumption is known from late Holocene-aged contexts in the

Hockett and  
in Great Basin  
cal BP) (Hock-  
early as 10,500  
ere also sepa-  
just below the  
e bones, leav-  
se front limb  
Holocene lev-  
s, this method  
cal BP) in  
re almost 200  
bones recov-



Bonneville Basin (Madsen and Kirkman 1988), the grasshoppers from BER may represent the earliest evidence for insect consumption in the Great Basin.

#### *Middle Holocene Animal Procurement*

The initial response of human foragers to the warm and arid conditions of the early-middle Holocene was to abandon the area surrounding BER. This may have occurred as early as 8800 <sup>14</sup>C BP (9900 cal BP). During the first middle Holocene-aged reoccupations of the shelter that correspond closely to the 8k climate event, the primary prey was artiodactyls (Table 11.2). Pronghorn, mountain sheep, deer, and bison also were taken. Hares were taken in smaller proportion compared to the late Pleistocene/early Holocene levels. No sage grouse or grasshoppers were consumed inside the shelter. Overall, species diversity and, perhaps, mammalian and avian biomass available near the shelter witnessed dramatic reductions. Near BER, human foragers responded in their hunting guild first by changing their settlement patterns (abandonment) and then by raising their trophic level, focusing their hunting efforts primarily on artiodactyls during the 8k reoccupation of the region.

Following the brief 8k reoccupations of the shelter, human foragers again abandoned BER for approximately 1,000 years. The 7k reoccupation that corresponds to another wet spike within the overall warm and arid middle Holocene was more intensive than the previous 8k reoccupation. The diversity of animals taken increased slightly, although artiodactyls continued to be the prey of choice (Table 11.2). Hares and sage grouse (the latter representing a single individual bird) were both consumed inside the shelter.

Following the 7k reoccupation, the shelter was again abandoned for approximately 1,000 years. Similar to the 8k reoccupation, the hunting guild associated with the 6k reoccupation saw a near complete reliance on artiodactyls (Table 11.2). Unlike the 8k reoccupation, however, which saw four different species of artiodactyls taken, human foragers during the 6k reoccupation took primarily pronghorn. Few hares and no sage grouse were taken. There is no evidence for grasshopper consumption.

### THE NUTRITIONAL ECOLOGY OF LATE PLEISTOCENE/ EARLY HOLOCENE AND MIDDLE HOLOCENE FORAGERS IN THE WEST BONNEVILLE BASIN

#### *General Patterns*

What might these data mean for our understanding of prehistoric subsistence and demographic patterns in the west Bonneville Basin? The first relatively substantial demographic increase throughout the Great Basin, as judged by overall site density, is associated with populations that manufactured Western Stemmed projectile points (e.g., Jones and Beck 1999). These populations are considered here to postdate the Clovis phenomenon (or to postdate ca. 10,800 <sup>14</sup>C BP [12,800 cal BP]), although the Cooper's Ferry site in Idaho suggests that

stemmed points may be as old as Clovis in some regions (Davis and Schweger 2004).

After two decades of survey in the region surrounding BFR in northeastern Nevada, a total of seven isolated fluted points have been recorded. This suggests extremely low population densities for the region's earliest inhabitants. In fact, with only seven isolated points known, it cannot be argued that Clovis/fluted populations were in fact residents. Instead, they likely were only occasional visitors (after Marks 2000). If compared to the Younger Dryas to early Holocene subsistence/settlement patterning described above, this suggests that Clovis populations had very different subsistence and mobility patterns than did the latest Pleistocene populations that inhabited the west Bonneville Basin near BFR. Presumably, all of the resources taken by Western Stemmed populations within a context of "seasonal rounds"—including sage grouse, medium-sized artiodactyls, insects, and probably waterfowl and fish (see discussions below)—would have been available to Clovis foragers as well. And yet we do not find an occupational pattern coupled with a consistent, diverse diet in BFR for Clovis/fluted populations. Support for the interpretation of reduced mobility within a context of subsistence-related activities targeting a diverse resource base, possibly including marsh resources, has recently been realized at the Old River Bed paleodelta sites, where as many as 500 Western Stemmed sites may be present (Oviatt et al. 2003; Rhode et al. 2005). This is not meant to imply that Western Stemmed populations were tethered year-round to low-land marsh resources. On the contrary, stemmed points have been found in the uplands of the Goshute Mountains west of BFR, and two Paleoarchaic points were found slightly farther to the west at an elevation of 2,425 m (8,000 ft) in the Cherry Creek Range. Also, BFR itself contains evidence for terrestrial resource use only. Nevertheless, while upland resources were not eschewed by Western Stemmed populations, sites dating to this time period appear to be much more common in lowland and midslope settings.

These data corroborate the suggestion by Haynes (2002) that Clovis populations had fundamentally different subsistence and mobility patterns than did Younger Dryas and early Holocene populations. Not only do fluted sites in the region consist of isolated artifacts only, but none of them have been found in upland settings, suggesting that when the pre-Western Stemmed populations were moving through the region, they were not bothering to explore the uplands as the Western Stemmed groups clearly did. From a nutritional ecology perspective, if Clovis populations chose to restrict their diet by focusing on large terrestrial herbivores within a context of high mobility, then they likely suffered from higher incidences of fetal (and perhaps maternal) mortality compared to Western Stemmed populations. Such behaviors would not spur significant population growth in the region.

In contrast, a major change in occupational intensity occurred in the Great Basin after ca. 11,000  $^{14}\text{C}$  BP (12,900 cal BP). According to the nutritional ecology model, such a population pulse should correlate with an increase in

dietary diversity, and perhaps lower mobility, the latter of which would have reduced stress on pregnant females and mothers. The Western Stemmed populations that inhabited BER between ca. 11,000 and 9500  $^{14}\text{C}$  BP (12,900 and 10,700 cal BP) hunted sage grouse, a variety of large and small terrestrial mammals, and grasshoppers. This represents a relatively broad-based diet as seen from a single site. In addition, unlike Clovis, Western Stemmed mobility patterns probably were reduced in the west Bonneville Basin as the latter groups occupied sites such as BER for much longer periods of time, on a more frequent basis, or both. Thus, these data are in conformance with the predictions of the nutritional ecology model.

Support for the link between dietary diversity and population increases in the latest Pleistocene and early Holocene of the Great Basin, however, extends far beyond the data from BER. Coprolites from Spirit Cave suggest that fish such as chub (*Sipateles bicolor*) and the seeds of bulrush (*Scirpus* spp.) were important dietary components for early Holocene populations in the western Great Basin (Napton 1997). Faunal remains from the Weed Lake Ditch, Nials, and Paulina Lake sites in Oregon suggest that waterfowl, small terrestrial game such as rabbits, and plant foods were widely consumed there (Wriston 2003). Numerous specimens of mollusk were recovered from the early Holocene layers in Last Supper Cave in northwestern Nevada (Grayson 1988). Sage grouse, waterfowl, fish, artiodactyls, rabbits, mollusks, grasshoppers and plant foods: it simply doesn't get more diverse than that in the Great Basin. As a result, these groups probably enjoyed relatively higher rates of successful fetal development, lower rates of maternal and infant mortality, and perhaps longer life expectancies than did earlier foragers who occasionally visited the region carrying fluted points. Population growth was one result for Western Stemmed foragers.

The subsistence data from the middle Holocene occupations at BER tell a very different tale. In contrast to the repeated occupations of the shelter during the late Pleistocene and early Holocene over many centuries, the middle Holocene use of BER was characterized by relatively short-term occupations of the immediate region (for perhaps no more than a couple centuries) followed by long periods of abandonment. These latter groups may have actually stayed inside the shelter for longer periods of time during each occupation compared to earlier occupations, but paradoxically, the diversity of animals taken dropped dramatically. Artiodactyl hunting was the primary focus of their animal procurement activities. Preliminary evidence suggests that the overall diversity of plant use did not increase significantly during the middle Holocene compared to earlier occupations, with both groups consuming primarily terrestrial-based foods such as seeds and cacti (Rhode and Louderback, this volume). However, the manner in which these plant resources were processed, as well as perhaps the gross amount consumed, appears to have differed with the advent of grinding stone technology in the middle Holocene (Rhode and Louderback, this volume). Overall, then, there appears to be another correlation between population

and the diversity of resources eaten during the middle Holocene, particularly in the animal fraction. In this case, as overall food diversity dropped, so too did the longer-term support of human populations in the region. This is precisely what the nutritional ecology model would predict. These general interpretations are elaborated upon in further detail below.

*The Nutritional Well-Being of Late Pleistocene/Early Holocene and Middle Holocene Foragers Near BBR: A First Approximation*

Tables 11.6 and 11.7 display the nutrient values per 100 g of various animal and plant food types that are known to have been consumed by late Pleistocene/early Holocene or middle Holocene foragers in the Great Basin. As a general rule, foragers would have increased the dietary diversity of essential nutrients they consumed by including different food types in their diet (across the table columns), not by including different forms of the same food type (up or down a single column). There is considerable variability in the amount of nutrient diversity found within certain food types, however. In general, plant foods such as green leafy vegetables (GLVs) can be highly variable in nutrient content between plant genera, but the same cannot be said for many of the genera and species of animals, particularly terrestrial herbivores. Thus, a forager is more apt to significantly diversify his or her essential nutrient intake by adding birds to a diet previously based on pronghorn, rabbits, and seeds, rather than by adding mountain sheep to that same base diet. This principle is discussed in further detail below.

If we compare the nutrient values listed in Tables 11.6 and 11.7 between food types, a number of significant points may be highlighted. Within the animal fraction, bird meat is significantly fatter than terrestrial herbivore meat. Foragers could "make up" for the leanness of terrestrial herbivore meat, however, by consuming bone marrow or rendering grease from bones through boiling (e.g., Lupo and Schmitt 1997). Grasshoppers contain as much as four times the amount of fat as terrestrial herbivore meat, so foragers could also "make up" for a loss of terrestrial herbivore fat by consuming foods such as birds, fish, insects, and certain seeds. The point is that there are various ways that Great Basin foragers could have obtained adequate amounts of fat that either included or excluded terrestrial herbivores.

While terrestrial herbivores are high in protein, so too are birds, fish, insects, mussels, and many seeds. Carbohydrates are found mainly in plant resources but also may be obtained by eating animal resources such as grasshoppers and mussels.

Diversity in micronutrient intake can also be achieved through a number of foraging strategies, but again it is the diversity of food types consumed that is the key. Minerals such as calcium are significantly more abundant in non-terrestrial animal resources such as bird eggs, fish, mussels, and many plant foods. Bird organs are also significantly higher in iron and zinc compared to terrestrial

TABLE 11.6. Macro- and Micronutrient Values of Animal Foods Potentially Consumed by Great Basin Foragers

	ARTIODACTYLS				BIRDS				GRASS-HOPPERS <sup>i</sup>	MUSSELS <sup>j</sup>
	MEAT <sup>a</sup>	MARROW <sup>b</sup>	ORGANS <sup>c</sup> AND SKIN <sup>d</sup>	HARE MEAT <sup>e</sup>	MEAT	ORGANS <sup>f</sup>	EGGS <sup>g</sup>	FISH <sup>h</sup>		
Calories	114	408	183	105	244	180	185	92	380	86
Fat	2.0	41.0	11.7	1.3	11.1	6.7	13.8	2.3	8.9	2.2
Protein	22.4	8.9	20.0	22.0	23.4	25.6	12.8	16.8	66.9	11.9
Carbohydrates	0.0	0.0	0.0	0.0	0.0	2.6	1.5	0.0	19.0	3.7
Micronutrients										
Calcium	3.0	6.1	4.1	5.0	5.9	6.6	64.0	70.0	—	26.0
Iron	3.2	6.9	19.0	4.0	4.6	26.0	3.9	1.3	—	4.0
Zinc	1.3	.98	1.8	1.6	1.9	4.6	1.4	.75	—	1.6
Magnesium	trace	34.0	21.0	32.0	25.0	24.0	17.0	30.0	—	34.0
Copper	.18	.50	1.4	.30	.26	1.1	0.6	.20	—	.09
Phosphorus	188	34.0	194	212	179	261	220	210	—	197
Potassium	353	36.0	306	449	288	230	222	380	—	320
Selenium	9.7	0.0	trace	.01	6.4	68.1	36.4	12.6	—	44.8
Vitamin A (IU)	0.0	240	9,196	0.0	88.0	31,000	674	170	—	160
Vitamin B-6	.37	0.0	.50	.50	.39	.76	.25	.20	—	.05
Vitamin B-12	6.3	0.0	27.6	7.2	.65	54.0	5.4	2.0	—	12.0
Vitamin C	0.0	0.0	12.7	0.0	5.2	4.5	0.0	0.0	—	8.0
Vitamin D	0.0	0.0	.75	0.0	0.0	0.0	.60	0.0	—	0.0
Vitamin E	.20	0.0	1.2	0.0	.70	0.0	1.3	0.0	—	.55
Vitamin K	1.1	0.0	0.0	0.0	0.0	0.0	.40	0.0	—	.10
Thiamin	.22	.04	.16	.03	.35	.56	.16	.01	—	.16
Riboflavin	.48	0.0	2.4	.06	.27	.89	.40	.07	—	.21
Niacin	6.4	.20	9.4	6.5	3.3	6.5	.20	1.2	—	1.6
Folate	4.0	0.0	105	8.0	21.0	738	80.0	15.0	—	42.0

Note: All values are per 100 g of food.

<sup>a</sup> Macronutrient and mineral values based on the pronghorn (*Antilocapra americana*); vitamin values based on deer (*Odocoileus* spp.) (USDA 2005).

<sup>b</sup> Values based on the cervid caribou/reindeer (*Rangifer tarandus*) (Kuhnlein et al. 2002; USDA 2005).

<sup>c</sup> Macronutrient and mineral values based on an average of caribou/reindeer heart, liver, and tongue (Kuhnlein et al. 2002); vitamin values based on beef liver, brains, and kidney (USDA 2005).

<sup>d</sup> Macronutrient and mineral values based on spruce grouse meat (*Dendragapus canadensis*), fire-roasted leg with skin of Canada goose (*Branta canadensis*), and duck (*Anas* spp.) meat with skin (Belinsky and Kuhnlein 2000; Kuhnlein et al. 2002; USDA 2005).

<sup>e</sup> Macronutrient and mineral values based on the hare (*Lepus americanus*) (Kuhnlein et al. 2002); vitamin values based on the wild rabbit (*Oryctolagus cuniculus* and *Sylvilagus* spp., except for folate and the B vitamins, which are based on domesticated rabbit (USDA 2005).

<sup>f</sup> Macronutrient and iron, zinc, calcium, and copper values based on Canada goose liver, gizzard, and heart (Belinsky and Kuhnlein 2000); all other values based on goose liver (USDA 2005).

<sup>g</sup> Values based on duck egg (USDA 2005).

<sup>h</sup> Values based on the sucker (*Catostomus commersoni*) (USDA 2005).

<sup>i</sup> Macronutrient values based on averages of seven species of grasshoppers and locusts.

representing the genera *Sphenarium*, *Plectotettia*, *Melanoplus*, and *Schistocerca* (Ramos-Elorduy et al. 1997).

<sup>j</sup> Values based on the blue mussel (*Mytilus edulis*) (USDA 2005).

TABLE 11.7. Macro- and Micronutrient Values of Plant Foods Potentially Consumed by Great Basin Foragers

	GLVS <sup>a</sup>	SEEDS <sup>b</sup>	FRUITS <sup>c</sup>	PINE "NUTS" <sup>d</sup>	BULBS <sup>e</sup>
Calories	82	229	56	629	32
Fat	2.0	1.5	.20	61.0	.19
Protein	2.8	8.5	1.4	11.6	1.8
Carbohydrates	35.1	49.0	13.8	19.3	7.3
Calcium	129	22.0	33.0	8.0	72.0
Iron	2.2	2.0	1.0	3.1	1.5
Zinc	.54	2.3	.23	4.3	.39
Magnesium	91.1	71.5	13.0	234	20.0
Copper	.10	.28	.11	1.0	.08
Phosphorus	31.0	214	44.0	35.0	37.0
Potassium	460	179	275	628	276
Selenium	—	22.0	.60	0.0	.60
Vitamin A (IU)	2918	9.0	42.0	29.0	997
Vitamin B-6	.09	.20	.07	.11	.06
Vitamin B-12	0.0	0.0	0.0	0.0	0.0
Vitamin C	18.5	0.0	41.0	2.0	18.8
Vitamin D	0.0	0.0	0.0	0.0	0.0
Vitamin E	0.0	.65	.10	0.0	.55
Vitamin K	174	3.4	11.0	0.0	207
Thiamin	30.0	.20	.04	1.2	.06
Riboflavin	8.3	.16	.05	.22	.08
Niacin	.38	3.2	.10	4.4	.53
Folate	38.0	38.0	8.0	58.0	64.0

Note: Values based on 100 g of food.  
<sup>a</sup> GLVs = green leafy vegetables. Macronutrient and mineral values based on averages of numerous GLVs reported in Guerrero et al. 1998; Agte et al. 2000; and Lockett et al. 2000. Most vitamin values based on averages of numerous GLVs reported in Anderson and Deskins 1995 and Agte et al. 2000.  
<sup>b</sup> Nutrient values are based on green and red lettuce (*Lactuca sativa*) (USDA 2005).  
<sup>c</sup> Nutrient values of seeds commonly consumed in the Great Basin are not readily available; these values are based on an average of a relatively low nutrient-rich seed (barley) combined with a relatively high nutrient-rich seed (rye) (USDA 2005).  
<sup>d</sup> Values based on the currant (*Ribes rubrum*) (USDA 2005).  
<sup>e</sup> Values based on the Colorado piñon pine (*Pinus edulis*) nut or seed (USDA 2005).  
<sup>f</sup> Values based on the tops and bulb of the onions *Allium cepa* and *Allium fistulosum* (USDA 2005).

herbivores and plant foods. For the vitamins, selenium is significantly more abundant in nonterrestrial herbivore resources. Bird organs can substitute for terrestrial herbivore organs for adequate consumption of vitamin B-12. On average, plant resources would provide a more consistent consumption of vitamin C, vitamin K, and folate. Nonterrestrial herbivore animals such as birds and muskels would also provide a more consistent consumption of folate, and

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TABLE 11.8. Hypothetical Average Diets of Late Pleistocene/Early Holocene vs. Middle Holocene Foragers in the Great Basin

FOODS CONSUMED	LATE PLEISTOCENE/ EARLY HOLOCENE DIET	MIDDLE HOLOCENE DIET
Rabbit	1 leg (leg and thigh)	1 leg (leg and thigh)
Pronghorn	8 ounces boneless	16 ounces boneless
Liver	1 ounce	2 ounces
Brains	1 ounce	2 ounces
Tongue	1 ounce	2 ounces
GLVs <sup>a</sup>	1 large leaf	2 large leaves
Seeds <sup>b</sup>	1 cup	6 cups
Duck	1 leg (drumstick and thigh)	—
Grouse/quail	4 ounces	—
Duck egg	1 egg	—
Fruit	1 cup currants	—
Fish	½ sucker	—

<sup>a</sup> Lettuce was used here as an approximation of nutrients consumed by eating GLVs.

<sup>b</sup> Barley was used here as an approximation of nutrients consumed by eating seeds.

birds and GLVs would provide a more consistent consumption of thiamin and riboflavin. These data are particularly significant because the underconsumption of adequate micronutrients such as vitamins A, C and E—as well as folic acid, zinc, copper, and iron—has been associated with higher incidences of failed human births (e.g., Ashworth and Antipatis 2001; Bendich 2001).

The next step in assessing whether there was a difference in overall forager health between the late Pleistocene/early Holocene and the middle Holocene is to begin modeling average dietary consumption between the two groups and analyzing the nutrients consumed as a result of those diets. Table 11.8 represents a first approximation toward this goal.

It is certainly true that we cannot know the exact proportions of foods eaten on each and every plate each and every day in the past, but we do not necessarily need access to this kind of detailed information in order to model average prehistoric diets. If we know the types of foods eaten on a consistent basis, and if we know to some degree the relative proportion that each food type contributed to the overall diet, then we can obtain an approximation of essential nutrient intake in prehistoric populations because the sum calories of the proportions of each food type consumed will be moderated by human needs and tolerance levels. In other words, if we grossly overestimate proportions of each food type known to have been consumed, then any final tally would show a calorie consumption beyond human tolerance and gut size. If we grossly underestimate these proportions, then it would show a level of chronic energy deficiency that would lead to extinction. Absent evidence for either scenario, the proportions listed in Table 11.8 are within the boundaries of human caloric

requirements and conform to the proportions listed by the USDA (2005) so

that accurate nutrient content can be calculated.

Based on the faunal and plant resources retrieved from Great Basin sites that date between the late Pleistocene and middle Holocene, Table 11.8 outlines an average diet of the two groups. The emphasis placed on the late Pleistocene/early Holocene group is on diversity, with large and small terrestrial herbivores, birds, fish, and some plant resources—including moderate amounts of fruits, seeds and GLVs—included in the diet. The rationale for placing fruits as an important part of the diet during this time is the fact that a cooler and wetter climate would have fostered more widespread and dense populations of a variety of Great Basin fruits, including currant, chokecherry, and rose (see also Schmitt and Madsen 2005). Unfortunately, grasshoppers that were eaten by late Pleistocene/early Holocene foragers at BFR could not be included in Table 11.8 because the U.S. Department of Agriculture (USDA) Web site that calculates nutrient values does not currently include insects. Consequently, the macronutrient values (discussed in detail below) for this group will probably underestimate the consumption of fat, protein, and carbohydrates, as grasshoppers provide an abundance of all three.

The middle Holocene diet was less diverse overall but may have become more "diverse" where it counted less (up and down a column rather than across columns) in terms of diversity of essential nutrient intake. The middle Holocene diet seemed to represent a "splitting apart" of the diverse diet seen in the late Pleistocene/early Holocene, with greater emphasis placed on either extremes of the foraging spectrum: large terrestrial herbivores and, with an increasing abundance of milling stones seen in the archaeological record at this time, seeds. Thus, for middle Holocene foragers I doubled the intake of terrestrial herbivores and GLVs and placed a much greater emphasis on seeds (Table 11.8). Lost during this time was a more consistent consumption of resources such as birds, fruit, and fish. Certain other resources, such as bulbs, were not included in either diet for this exercise, although further research may suggest that these potentially important resources should be included in the diets of either one or both of these groups.

Following this exercise, I then placed these values into the USDAs (2005) newly created "Diet Analysis" Web site, which calculated the individual nutrients consumed based on these diets, as well as the current recommended daily allowance (RDA) for daily nutrient consumption (Table 11.9). RDA values vary based on the sex, weight, and age of the individual. They also vary for women who are pregnant, as expecting mothers need to consume additional macro- and micronutrients to ensure a successful pregnancy. Because dietary diversity most influences human demographic trends at the level of the mother and child, I based the diet on a female that was 5'3" tall, weighing 125 lbs. For this modeling procedure, the RDA values are based on a nonpregnant female. I will specifically discuss the dietary implications of Great Basin diets through time on pregnant females in an upcoming essay.

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TABLE 11.9. Diet Analysis Comparison of Two Hypothetical Prehistoric Females Living in the West Bonneville Basin during the Late Pleistocene/Early Holocene and the Middle Holocene

NUTRIENT	LATE PLEISTOCENE/ EARLY HOLOCENE FORAGER	MIDDLE HOLOCENE FOAGER	CURRENT USDA RECOMMENDATION OR ACCEPTABLE RANGE
Food energy (kcal)	1,838	2,448	1,912
Protein (gm)	165	230	46
Carbohydrate (gm)	165	277	130
Total fiber (gm)	16	37	25
Total fat (gm)	60	44.6	40.9-71.5
Saturated fat (gm)	20	17	< 27.2
Monounsaturated fat (gm)	22	12	not established
Polyunsaturated fat (gm)	8	4	not established
Linoleic (omega-6) (gm)	6.1	3.2	12
Alpha linoleic (omega-3) (gm)	.90	.50	1.1
Vitamin A (mcg RAE)	2,112	3,744	700
Vitamin C (mg)	15	12	75
Vitamin E (mg)	4.7	5.1	15
Thiamin (mg)	1.2	1.6	1.1
Riboflavin (mg)	3.5	5.6	1.1
Niacin (mg)	41	69	14
Folate (mcg)	227	424	400
Vitamin B-6 (mg)	3	4.2	1.3
Vitamin B-12 (mcg)	35	60	2.4
Calcium (mg)	236	159	1,000
Phosphorus (mg)	1,708	2,326	700
Magnesium (mg)	226	383	310
Iron (mg)	32	44	18
Zinc (mg)	41	74	8
Selenium (mcg)	140	214	55
Potassium (mg)	2,968	2,910	4,700
Sodium (mg)	1,875	3,795	1,500-2,300

Note: This analysis is based on ecofacts recovered from BER and other similar-aged sites across the Great Basin, and on the serving sizes and foods consumed listed in Table 11.8. In both cases, the nutrient composition analyses were based on a 21-year-old female with a stature of 5'3" and a weight of 125 lbs. (USDA 2005).

The results of the dietary analyses, displayed in Table 11.9, are interesting. Both groups show sufficient calorie consumption, with the middle Holocene group consuming approximately 25 percent additional calories than the late Pleistocene/early Holocene group. This may well have been necessary for the middle Holocene group. Evidence suggests that many late Pleistocene/early

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Holocene foragers were able to tether themselves more closely to marshland and adjacent midslope resources, so these populations may have been less mobile on a day-to-day basis and, as a result, may have required fewer calories than the middle Holocene group.

Both groups show abundant consumption of proteins and carbohydrates. The middle Holocene group, however, shows a rather severe overconsumption of both types of macronutrients, but the late Pleistocene/early Holocene group less so. These data conform to the results of modern nutrition science research indicating that as dietary diversity drops, humans tend to underconsume certain nutrients and overconsume others. Both conditions can be potentially devastating to human health, particularly for a pregnant female and her developing fetus (Ashworth and Antipatis 2001).

Another interesting pattern within the macronutrient fraction is seen in the two groups' fat consumption. While both groups show adequate consumption of fat, the middle Holocene group is at the low end of the RDA scale, while the late Pleistocene/early Holocene group is at the upper end. Additionally, the late Pleistocene/early Holocene group consumed twice as much omega-6 and omega-3 fatty acids, which are critical to many aspects of human health, including brain development.

The micronutrients also tell an interesting tale. Both groups show adequate consumption of certain vitamins and minerals such as thiamin and magnesium. And while both groups show an overconsumption of many micronutrients based on the current RDA standard, the middle Holocene group appears to have exacerbated this situation to a much greater degree. Thus, for example, while the late Pleistocene/early Holocene group may have overconsumed riboflavin by three times the RDA standard, the middle Holocene group may have overconsumed this vitamin by five times the standard. A similar situation applies to vitamin A, niacin, vitamin B-6, vitamin B-12, phosphorous, iron, zinc, selenium, and sodium.

In contrast, for some of the micronutrients that were underconsumed by both groups, including vitamin C and calcium, the late Pleistocene/early Holocene group probably consumed more than the middle Holocene group. For either human group, however, the underconsumption of calcium would be especially troubling for long-term health in later years, particularly for groups that had higher rates of mobility. For the latter group, we should expect to see, for example, earlier incidences of, and greater degrees of, bone mass loss and arthritic conditions. Overall, then, the intake of micronutrients parallels the nutrition principle applied above for the macronutrients: the less diverse diet seen in middle Holocene populations likely led to more persistent hyperoverconsumption of some micronutrients and hyper-underconsumption of others. This situation likely created additional health problems for these individuals, and likely led to decreases in the percentage of successful pregnancies compared to the late Pleistocene/early Holocene group.

Prehistoric  
Pleistocene/Early

CURRENT USDA  
RECOMMENDATION  
OR ACCEPTABLE  
RANGE

1,912  
46  
130  
25  
40.9-71.5  
> 27.2

not established  
not established

12

1.1

700

75

15

1.1

1.1

14

400

1.3

2.4

1,000

700

310

18

8

55

4,700

500-2,300

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## CONCLUDING REMARK

Faunal evidence from BER and other Western Stemmed assemblages suggests that during the initial phases of population growth in the Great Basin, groups exploited a quite diverse resource base. This diversity is linked to the consumption of a variety of artiodactyls, small mammals such as hares, birds such as sage grouse and waterfowl, fish, and grasshoppers, as well as plant foods. From a broader perspective, Western Stemmed populations set the nutritional framework under which their populations could expand by consuming a broad-based diet. And expand they did.

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