Quaternary International 242 (2011) 479–501

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Climate, environment, and humans in North America's Great Basin during the Younger Dryas, 12,900–11,600 calendar years ago

Ted Goebel[a,*], Bryan Hockett[b], Kenneth D. Adams[c], David Rhode[c], Kelly Graf[a]

[a] *Center for the Study of the First Americans, Department of Anthropology, Texas A&M University, 4352-TAMU, College Station, TX 77843, USA*
[b] *Nevada State Office, U.S.D.I. Bureau of Land Management, 1340 Financial Blvd., Reno, NV 89502, USA*
[c] *Division of Earth and Ecosystem Sciences, Desert Research Institute, 2215 Raggio Parkway, Reno, NV 89512, USA*

ARTICLE INFO

Article history:
Available online 8 April 2011

ABSTRACT

Global climate change associated with the onset of the Younger Dryas chronozone affected different regions of the northern hemisphere in different ways. In the Great Basin of western North America, the effect was positive for human populations. Relatively cool temperatures causing effectively wetter conditions filled some pluvial basins with shallow but permanent lakes and other basins with well-watered marshes or meadows. Vegetation communities dominated by sagebrush and grasses promoted healthy and diverse animal populations. Ten archaeological sites from the region have been dated to the Younger Dryas chronozone. Evidence from these sites indicates that Paleoindians with skull shapes and mitochondrial DNA similar to modern western North American Indians occupied the region. These early humans produced a material culture characterized predominantly by large stemmed bifacial points, although one site contained a small fluted point. Curated tool forms and technological activities represented in analyzed lithic assemblages suggest a highly mobile settlement strategy, and redundant short-term occupations of sites indicate frequent and long-distance residential moves across territories spanning distances of up to 400 km. Paleoindian subsistence pursuits focused on artiodactyls (primarily mule deer, bighorn sheep, and pronghorn antelope), leporids (chiefly jackrabbits), birds (sage grouse and waterfowl), insects (grasshoppers), and possibly fish. Easy-to-process plants like cactus pads were also eaten, but small seeds do not seem to have been an important part of Great Basin human diets until long after the Younger Dryas, closer to 9500 cal BP. The Great Basin record contains no evidence for natural catastrophe at the onset of the chronozone. Instead, the Younger Dryas appears to have been among the best of times for human foragers in this region of North America.

1. Introduction

This paper has two objectives, to review the paleoecological and archaeological evidence for the Younger Dryas chronozone in the North American Great Basin, and to explore how humans adjusted to climatic and environmental conditions during that time. Although the precise timing of the onset of the Younger Dryas has not yet been firmly established, and the radiocarbon calibration curve for this period is still floating (Hua et al., 2009), the definition of the Younger Dryas used here follows Rasmussen et al. (2006), who ascribe the timing of this late-glacial cold period to 12,900–11,600 calendar years ago (cal BP). The Great Basin is best defined hydrographically, following Grayson (1993). It includes the interior of western North America where water drains inwardly into a series of closed basins that have no external outlet to the sea. As such, the Great Basin includes nearly all of Nevada and parts of southeastern Oregon, eastern California, western Utah, and southeastern Idaho (Fig. 1). During the late Pleistocene, temperatures were relatively cool, and for that reason conditions were more effectively wet, so that many of the region's closed basins filled with water, forming Lake Bonneville in western Utah/eastern Nevada, Lake Lahontan in western Nevada/eastern California, and other smaller lakes or shallow marshes in central and eastern Nevada, southeastern Oregon, and southeastern California. It was this physical environment that the first humans of the Great Basin colonized, and as the late Pleistocene came to a close around 12,000–11,000 cal BP, the region's human populations witnessed significant desertification of Great Basin environments.

The paper is organized into four sections. First, it reviews Great Basin lacustrine histories during the Younger Dryas; second, it reviews proxy records of biotic environments, focusing on paleobotanical evidence; third, it reviews evidence of late Pleistocene large-mammal extinctions; fourth, it summarizes and reviews

---

* Corresponding author.
E-mail address: goebel@tamu.edu (T. Goebel).

1040-6182/$ – see front matter © 2011 Elsevier Ltd and INQUA.
doi:10.1016/j.quaint.2011.03.043

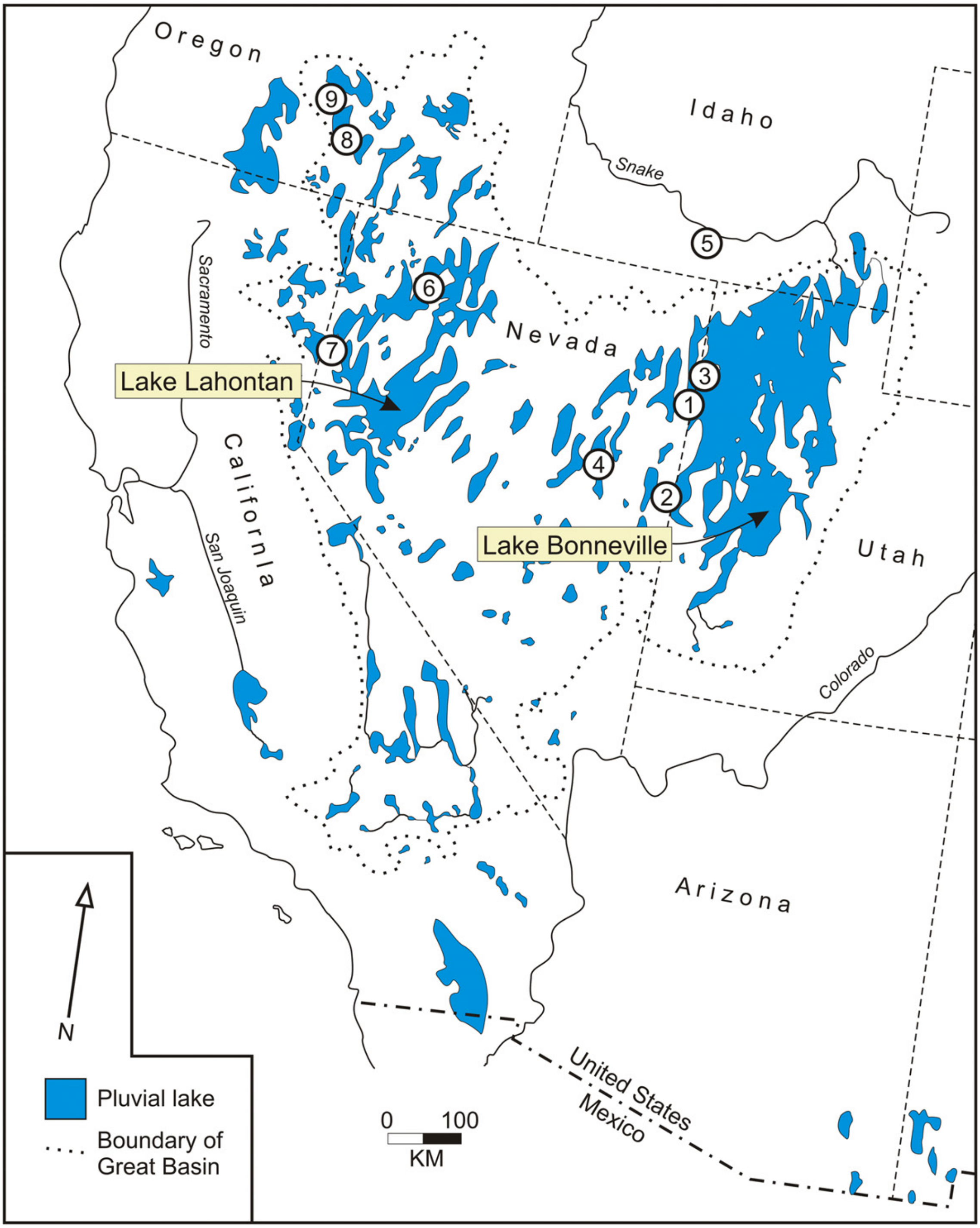

Fig. 1. Distribution of pluvial lakes within the Great Basin during the late Pleistocene (after Smith and Street-Perrott, 1983). The numbered archeological sites discussed in text are identified by numbers: 1, Bonneville Estates Rockshelter; 2, Smith Creek Cave; 3, Danger Cave; 4, Sunshine Locality; 5, Buhl; 6, Handprint Cave; 7, Pyramid Lake; 8, Paisley Five Mile Point Caves; 9, Connley Cave 4.

evidence from ten archaeological sites, in the end characterizing the human occupation of the region during the Younger Dryas. The focus is on the Bonneville and Lahontan basins, supplemented with information from other smaller pluvial-lake basins. It addresses two questions: (1) What were paleoenvironments like before, during, and after the Younger Dryas; and (2) how did humans respond to environmental change from 12,900 to 11,600 cal BP? All radiocarbon dates presented have been calibrated using the IntCal09 curve and Calib 6.0 (Reimer et al., 2009).

2. Great Basin physical environments during the Younger Dryas

Study of the Great Basin's major lacustrine systems began in the late nineteenth century, with the pioneering geological studies of G.K. Gilbert (1890; see also Oviatt, 2002) and Russell (1885). These early scientists were the first to conduct comprehensive studies of the two largest of the late Pleistocene pluvial lakes in the region—Lake Bonneville in the east and Lake Lahontan in the west.

Geological and geochemical studies since 1980 have led to the development of precise reconstructions of the last major transgressive–regressive cycles of these and other lake systems. Most indicate that shallow lakes or marshes existed in the region's numerous basins, indicating relatively cool and effectively wet conditions during the Younger Dryas chronozone (e.g., Benson et al., 1992; Adams et al., 2008).

2.1. Bonneville basin

During the late Pleistocene, the Bonneville basin filled with water to an elevation of about 1550 m, depending on differential isostatic rebound (Bills et al., 1994), creating an immense lake that spanned 450 km from north to south and 200 km from east to west (Fig. 2) (Gilbert, 1890; Oviatt et al., 1990). This transgression

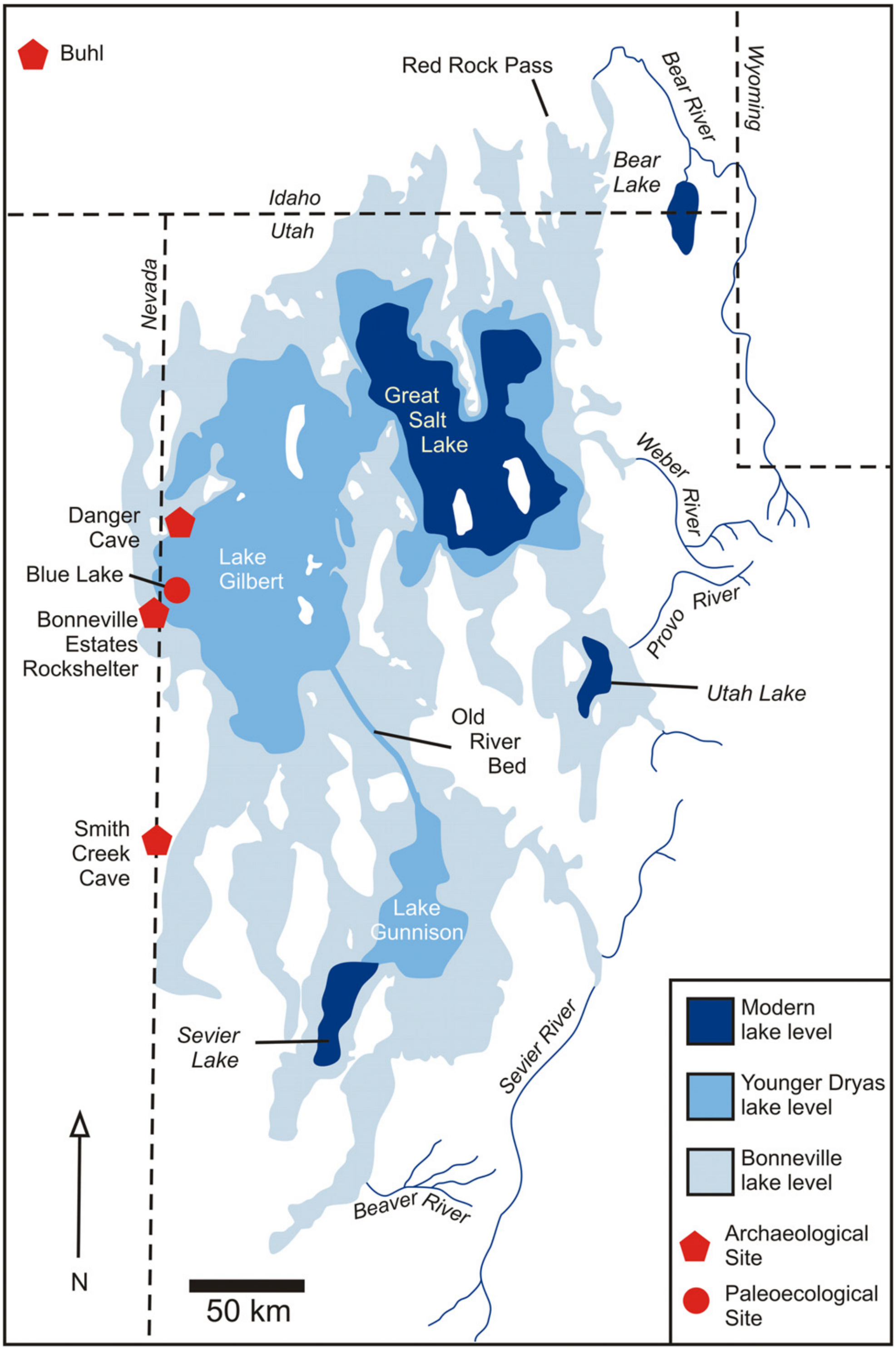

Fig. 2. Extent of late Pleistocene pluvial lakes of the Bonneville basin at 18,700 cal BP (Bonneville lake level), 12,500 cal BP (Younger Dryas lake level), and today (modern lake level) (after Oviatt et al., 2005). Important Younger Dryas-aged archaeological sites in the Bonneville basin straddle the Nevada-Utah border.

culminated about 18,700 cal BP when the level of the lake reached the elevation of Red Rock Pass and overflowed into the Snake River drainage of southeast Idaho. The lake remained at about 1550 m in elevation for about 1000 years, resulting in the formation of the Bonneville shoreline (Oviatt, 1997). However, about 16,700 cal BP the Red Rock sill failed and the lake rapidly dropped to an elevation of ~1450 m in just several months (Jewell, 2010), catastrophically flooding the Snake River Plain to the north. The lake settled at this elevation for at least 1000 years (and perhaps longer (Godsey et al., 2005)), and the Provo shoreline formed (Fig. 3a). By about 15,200 cal BP the lake receded further, but to no lower than 1325 m, and it appears to have stayed at this elevation until about 14,050 cal BP (Hart et al., 2004; cf. Godsey et al., 2005), when it fell even lower, possibly below the present-day level of Great Salt Lake (Oviatt et al., 2003). During the last recessional event especially, significant fish die-offs occurred (Broughton, 2000; Broughton et al., 2000; Hart et al., 2004).

During the late glacial, once falling to an elevation of less than 1390 m, Lake Bonneville became separated into two subbasin lakes—Gunnison in the south and Gilbert in the north. Lake Gunnison appears to have been relatively high during the Younger Dryas, perhaps overflowing into Lake Gilbert via the Old River Bed (Oviatt, 1988; Oviatt et al., 2003, 2005). At the same time, Lake Gilbert transgressed to about 1300 m, and the Gilbert shoreline formed (Currey, 1982; Oviatt et al., 2001), as a result of water flowing primarily from the Bear River and other northern sources (Hart et al., 2004). Lakes Gunnison and Gilbert were relatively shallow but still contained fresh, cold water (Broughton, 2000; Broughton et al., 2000; Madsen, 2000b; Hart et al., 2004; Oviatt et al., 2005). After the Younger Dryas, around 11,000–10,200 cal BP, Lake Gunnison receded, the Old River Bed dried up, and Lake Gilbert fell to levels below 1287 m, essentially forming Great Salt Lake (Oviatt, 1988; Oviatt et al., 2003; Rhode et al., 2005; Louderback and Rhode, 2009).

2.2. *Lahontan basin*

The Lahontan basin is made up of a series of discrete basins that became connected when lake levels rose during the late Pleistocene. The late Pleistocene highstand for Lake Lahontan, marked by the Sehoo shoreline and dated to 15,800–15,150 cal BP (Morrison, 1991; Benson et al., 1995; Adams and Wesnousky, 1998), occurs at an elevation of about 1340 m near the center of the basin and 1318 m in the north (Fig. 3b); the difference is the result of isostatic rebound and northward tilting (Adams et al., 1999; Bills et al., 2007). During the Allerød interstadial (~14,100–12,900 cal BP), the lake rapidly receded from the Sehoo shoreline, dropping more than 100 m and separating into smaller, shallower subbasin lakes. The extent of this recession is not well-known, but Pyramid Lake dropped to at least 1202 m (Thompson et al., 1986; Adams et al., 2008), and Carson Sink's lake receded to below 1190 m, perhaps even drying completely (Morrison, 1964, 1991; Adams and Wesnousky, 1998).

During the Younger Dryas, Lahontan's various subbasin lakes appear to have rebounded considerably. In Pyramid Lake basin, Briggs et al. (2005) dated a mollusk shell recovered from a late-glacial beach deposit to 12,700 cal BP. This beach stands at 1212 m and is part of a transgressive shoreline sequence that Adams et al. (2008) reported to have reached 1231 m. Subsequent radiocarbon dating on the 1231 m beach ridge demonstrates that it is much older than the Younger Dryas and current interpretations are that the lake at this time reached an elevation of about 1220 m. In the Carson Sink, lacustrine deposits roughly dating to the Younger Dryas occur at or just below 1203 m (Currey, 1988, 1990; Benson et al., 1992), and Adams and Wesnousky (1998) mapped a 1235-m shoreline in the Jessup embayment that they interpret to have formed soon after the 1190-m, Allerød-aged recession. Caskey et al. (2004) dated a beach ridge in the Lahontan Mountains at an elevation of 1228 m to slightly younger than the Younger Dryas, which may be correlative to the 1235 m shoreline at Jessup, the difference in elevation possibly due to differential isostatic rebound and faulting (Adams et al., 2008).

Following the Younger Dryas, lake levels in Pyramid Lake basin appear to have receded quickly to as low as 1153 m, based on dating of archaeological materials from Wizards Beach (Tuohy and Dansie, 1997). In the Carson Sink, however, a lake at nearly 1231 m may have persisted for as much as eight centuries following the close of the Younger Dryas, but a radiocarbon date of 10,800 cal BP on a perishable artifact from the Grimes Point burial demonstrates a recession to at least 1220 m by that time (Adams et al., 2008).

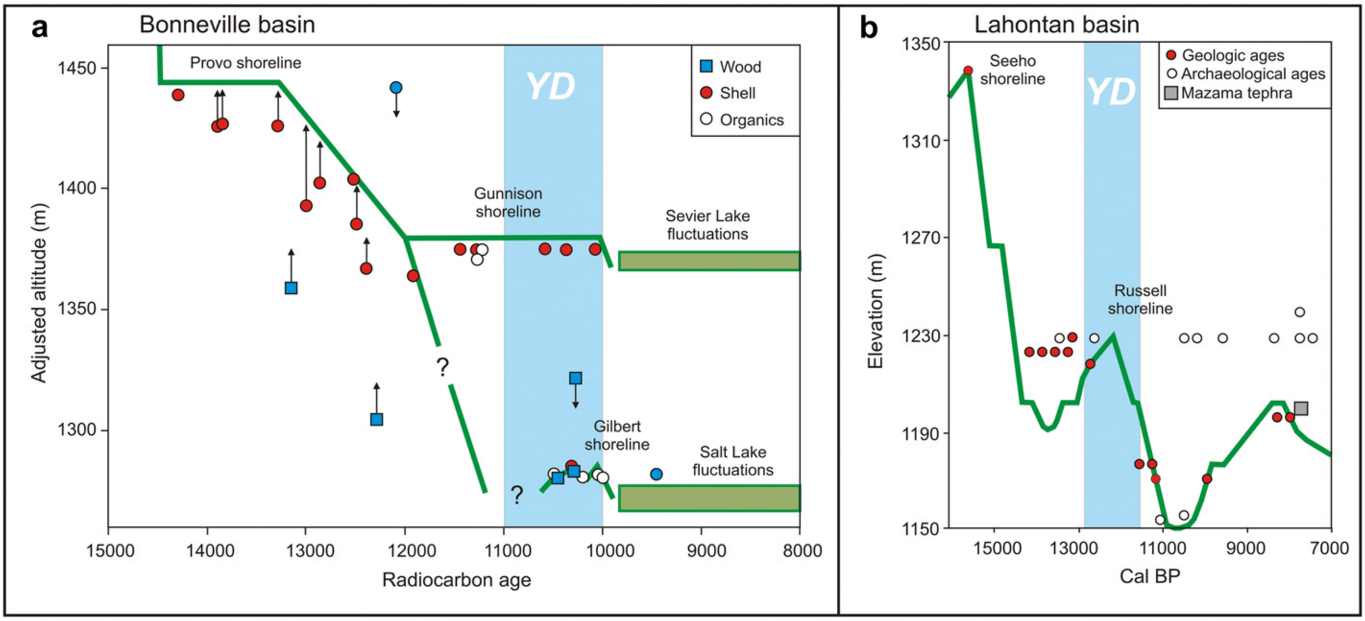

Fig. 3. Lake level histories reconstructed for (a) Lake Bonneville (after Oviatt et al., 2005) and (b) Lake Lahontan (after Adams et al., 2008).

2.3. Other Great Basin regions

Late-glacial lacustrine histories for the northern Great Basin are not as well-developed as for the Bonneville and Lahontan basins (Negrini, 2002; Minkley et al., 2004), while data from the central Great Basin suggest a relatively cool and effectively wet Younger Dryas chronozone, and data from the southern Great Basin suggest both wet and dry conditions.

Small pluvial lakes in east-central Nevada clearly reached highstands shortly after 17,000 cal BP (García and Stokes, 2006), and recessions began sometime after that date. In Jakes Valley the lowest preserved beach ridge of Lake Jakes formed about 14,700 cal BP, with complete desiccation at some point after that. In Long Valley, Lake Hubbs had receded considerably from its highstand by 13,750 cal BP, but freshwater continued to flow from nearby mountains into the pluvial-lake basin until 11,200 cal BP, and a relatively high-water table maintained a shallow marsh or wet meadow until about 10,200 cal BP (Holmes and Huckleberry, 2009).

In the southern Great Basin, the best preserved and most thoroughly studied lacustrine histories are from the Mojave River and Owens Lake basins, California. The Mojave River system is a chain of shallow subbasins separated by low sills (Wells et al., 2003). Between about 18,400 and 16,600 cal BP, regular and large-scale flooding of the Mojave River maintained deep lakes through the system, but between 16,600 and 13,700 fewer floods and severe droughts created shallower lakes that on occasion dried up completely (Wells et al., 2003:112). From 13,700 to 11,400 cal BP, effectively wetter conditions and more frequent flooding again filled Lake Mojave, with sustained overflow from the lake even leading to the expansion of shallow lakes in Death Valley during the Younger Dryas (Wells et al., 2003:112). Pluvial conditions gradually deteriorated after 11,400 cal BP. This record conforms well with evidence from fossil springs in the Mojave Desert of southern Nevada and eastern California. Quade et al. (1998:139) have documented that formation of black mats around these springs peaked during the Younger Dryas, in response to higher water tables and increased spring discharge.

Owens Lake provides a Younger Dryas record that contrasts markedly from other Great Basin lacustrine histories. This lake last transgressed to a major highstand around 15,300 cal BP (Benson et al., 1990, 1998; Benson, 1999; Bacon et al., 2006). Chemical data indicate relatively high lake levels were maintained until about 13,250 cal BP (Benson, 1999), but shoreline data indicate significant oscillations between 15,000 and 11,000 cal BP (Bacon et al., 2006), similar to the Mojave River system described above. Both chemical and shoreline records indicate significant drying occurred during the Younger Dryas, from about 12,500 to 11,500 cal BP. The lake rebounded from this Younger Dryas recession gradually, with an early Holocene transgression culminating around 8000 cal BP (Bacon et al., 2006).

2.4. Discussion

During the Younger Dryas, shallow freshwater lakes existed in the Bonneville, Lahontan, and Mojave basins. In central Nevada, smaller basins may not have contained lakes, but alluvial records suggest flowing water maintained marshes or wet meadows. Only the Owens Lake record suggests relatively dry conditions, but this drying occurred after a highstand dating to just before the beginning of the chronozone. The peculiar record from Owens Lake may be due to changing local conditions in the eastern Sierra Nevada (Benson et al., 1996). Taken together, though, the geological evidence indicates that climate in the Great Basin was relatively cool and effectively wet between 12,900 and 11,600 cal BP. Significant drying occurred after the Younger Dryas, immediately in some basins (e.g., Lahontan, Mojave) but more gradually in others (e.g., Bonneville and Hubbs).

3. Great Basin vegetation communities during the Younger Dryas

Reconstruction of vegetation communities in the Great Basin has focused on two sources of information, pollen cores and *Neotoma* sp. (woodrat) middens (Grayson, 1993). As shown below, these proxy records combine to indicate that the late glacial was cool and effectively more moist when compared to today; however, they do not indicate any appreciable change in vegetation at the beginning of the Younger Dryas, only significant warming and drying after the close of the chronozone.

3.1. Bonneville basin

Much paleobotanical research has focused on the western Bonneville basin, where D. Rhode and colleagues have analyzed numerous woodrat middens and a corresponding pollen core spanning the late Pleistocene and early Holocene (Rhode and Madsen, 1995; Rhode, 2000a,b; Louderback and Rhode, 2009). Midden studies indicate that limber pine woodlands were common ~15,500–12,800 cal BP, from mountain slopes down to the shores of Lake Bonneville. Today limber pines are restricted to some of the highest mountain peaks in the region, 1100–1200 m higher than where they grew during the late glacial. The presence of a limber pine woodland across the region during pre-Younger Dryas times indicates "substantially" cooler summers with average temperatures as much as 6–7 °C lower than today (Rhode, 2000b:146), while the absence of mesophilic shrubs (e.g., currant (*Ribes* sp.) and cinquefoil (*Potentilla* sp.)) and rarity of other conifers (spruce (*Picea* sp.) and fir (*Abies* sp.)) in the same middens suggest only slightly more mesic conditions. After 12,800 cal BP, xerophytic shrubs like shadscale (*Atriplex confertifolia*) and sagebrush (*Artemisia* sp.) became more common in the western Bonneville basin, while limber pines decreased in frequency, disappearing from low and middle elevations by 12,600 cal BP. These changes suggest higher temperatures and greater aridity during the late Younger Dryas (Rhode, 2000b), a trend that continued into the early Holocene, until around 10,200–9500 cal BP (Rhode, 2000a), when the Great Basin became much warmer.

Until recently, pollen records from the Bonneville basin and surrounding areas contained little evidence of late-glacial plant communities, because of unconformities in the records or coarse sampling intervals (e.g., Thompson, 1992; Davis, 2002). A new sediment core from Blue Lakes, western Bonneville basin, however, has provided a fine-grained pollen record for the last 15,000 years (Louderback and Rhode, 2009). This record confirms that pine and sagebrush dominated the landscape through the late glacial (Allerød and Younger Dryas), until about 11,500–11,000 cal BP, when these plants were largely replaced by xerophytic shrubs like shadscale and saltbush (*Atriplex* sp.) (Fig. 4).

3.2. Lahontan basin and other Great Basin subregions

Fossil woodrat middens from the western Great Basin combine to indicate that the late glacial was generally cooler and more mesic than today (Wigand and Rhode, 2002), but they provide little details about vegetation shifts immediately before or after the Younger Dryas. A woodrat midden from near Pyramid Lake, for example, indicates that juniper, sagebrush, and grasses persisted at middle and low elevations through the period, and that these were gradually replaced by warmer/dryer-adapted shrubs in the early Holocene (after about 11,900 cal BP) (Nowak et al., 1994). As in the eastern Great Basin, conifers (e.g., whitebark pine in the Lahontan basin; limber pine and white fir in the northern Mojave Desert) grew at relatively low elevations early in the late glacial, and they

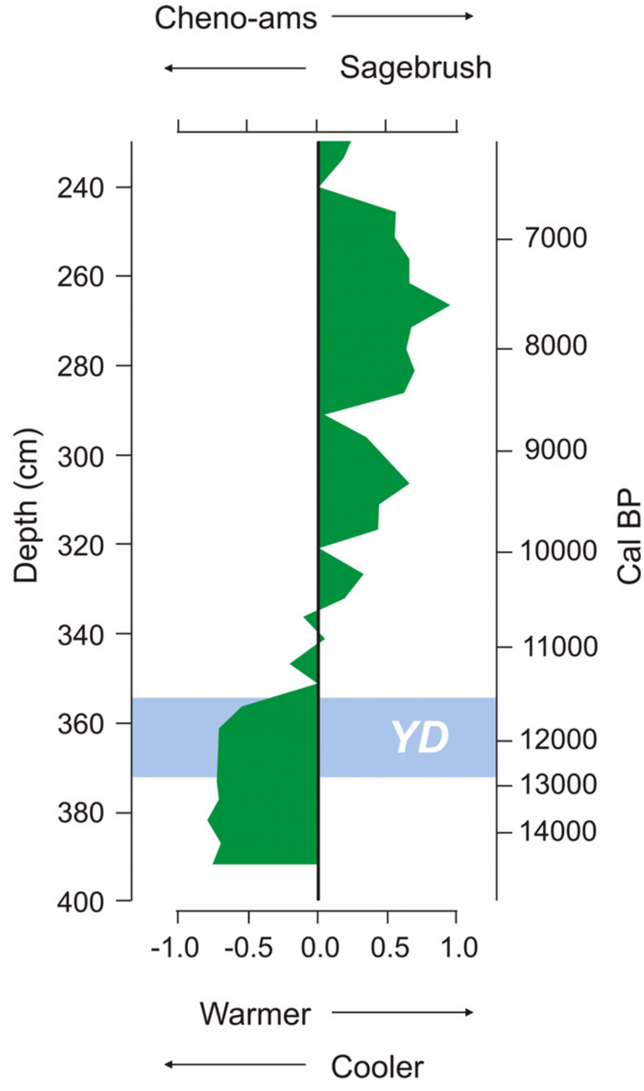

Fig. 4. Pollen ratios of xeric desert shrubs (Chenopodiaceae-*Amaranthus*)/mesic sagebrush (*Artemisia*) for the late Pleistocene–early Holocene, for Blue Lake (after Louderback and Rhode, 2009).

retreated to higher elevations by the early Holocene (Wigand and Rhode, 2002). In the Mojave Desert, pinyon pine (*Pinus monophylla*) and juniper (*Juniperus* sp.) persisted in lower elevations until about 13,400 cal BP and 11,000 cal BP, respectively (Wigand and Rhode, 2002).

A similar trend has been identified in pollen cores from the uplands of the northwestern Great Basin (Oregon), where sagebrush grassland and subalpine forest communities gave way to open forests and steppe communities about 11,000 cal BP (Minckley et al., 2007). Mensing's (2001) pollen record from Owens Lake provides a more detailed vegetation history for the late glacial. Ratios of mesophilic sagebrush pollen to xerophytic chenopod and greasewood (*Sarcobatus* sp.) pollen suggest that the late Allerød was relatively dry, Younger Dryas was effectively wetter, and immediate post-Younger Dryas period was dry again (Mensing, 2001). This record, however, does not precisely conform with the lacustrine history for Owens Lake presented by Benson (1999) and Bacon et al. (2006) and discussed above. Taken together, the lacustrine and pollen records suggest that conditions in the Owens Lake watershed may have been cool and dry during the Younger Dryas, but that relatively mesic vegetation persisted around a shrinking Owens Lake.

3.3. Discussion

Unfortunately most paleovegetation records have not been of a sufficiently high resolution to detect specific vegetation changes before, during, and after the Younger Dryas. Woodrat midden studies suggest relatively cool, but not necessarily wet conditions persisted through the late glacial, and pollen records from Blue Lake in the east and Owens Lake in the west indicate significant warming and aridification after the Younger Dryas.

4. Large-mammal extinctions

Did terminal Pleistocene large-mammal extinctions occur in the Great Basin during the Younger Dryas, or had they occurred earlier, during the Allerød interstadial? Certainly many large mammals did persist into the Holocene (e.g., mule deer, mountain sheep, pronghorn, and bison); however, a number of species became extinct, including Yesterday's camel, Shasta ground sloth, horse, Columbian mammoth, shrub ox, and short-faced bear (Grayson, 1993). Direct dates on bone or dung are most useful in addressing the timing of these extinction events (Fig. 5). The youngest known Yesterday's camel (*Camelops hesternus*) has been directly radiocarbon dated to 11,330 ± 60 ^{14}C BP (13,300–13,150 cal BP) at the Sunshine locality, eastern Nevada (Cannon et al., 2009; Holmes and Huckleberry, 2009). Shasta ground sloth (*Nothrotheriops shastensis*) appears to have persisted to 11,360 ± 260 ^{14}C BP (13,500–12,900 cal BP), based on directly dated dung from Gypsum Cave, southern Nevada (Long and Martin, 1974). A horse (*Equus* sp.) mandible from Fishbone Cave, western Nevada, yielded a date of 11,350 ± 40 ^{14}C BP (13,300–13,200 cal BP) (Dansie and Jerrems, 2004), and this has been recently corroborated by a direct date of 11,130 ± 40 ^{14}C BP (13,100–12,950 cal BP) on horse bone from Paisley Five Mile Point Caves in central Oregon (Jenkins, 2007). The youngest known Columbian mammoth (*Mammuthus columbi*) in the region dates to 11,220 ± 110 ^{14}C BP (13,250–13,000 cal BP), according to a direct date on bone from Huntington Canyon, Wasatch Mountains, Utah (Madsen, 2000a), and the youngest known shrub ox (*Euceratherium* sp.) dates to 11,950 ± 50 ^{14}C BP (13,900–13,700 cal BP), according to a direct date on a maxilla from Falcon Hill, Lahontan basin, Nevada (Dansie and Jerrems, 2004). A bone of short-faced bear (*Arctodus simus*) from Huntington Canyon yielded a date of 10,870 ± 75 ^{14}C BP (12,800–12,650 cal BP) (Madsen, 2000a), but this likely was not an economically important species for early humans. These direct dates suggest that the large-bodied fauna of the late Pleistocene Great Basin had become extinct immediately prior to the onset of the Younger Dryas.

Besides short-faced bear, the only case of now-extinct large-mammal remains during the Younger Dryas is problematic. Dansie and Jerrems (2004) report the direct dating of two osseous artifacts from Pyramid Lake, Nevada—a unibeveled point they argue was made on mammoth ivory and directly dated to 10,360 ± 50 ^{14}C BP (12,400–12,100 cal BP), and a barbed bone point they argue was made on a mammoth rib and directly dated to 10,340 ± 40 ^{14}C BP (12,400–12,100 cal BP). G.A. Haynes (personal communication 2005), however, surmises that the unibevelled point was actually made on some kind of bone, not ivory, and that the barbed point could have been made on some other bone than mammoth, so that these taxonomic assignments need to be confirmed through ancient DNA analyses. Aside from these two possible cases, no extinct large-mammal species have been dated to the Younger Dryas in the Great Basin.

These data indicate that by the onset of the Younger Dryas, most of the now-extinct large-mammal fauna had been eradicated from the Great Basin landscape, so that modern large-mammal fauna characterized the environments of the region (see also Hockett and Dillingham, 2004). This is a point returned to below in the discussion of archaeological evidence of human subsistence.

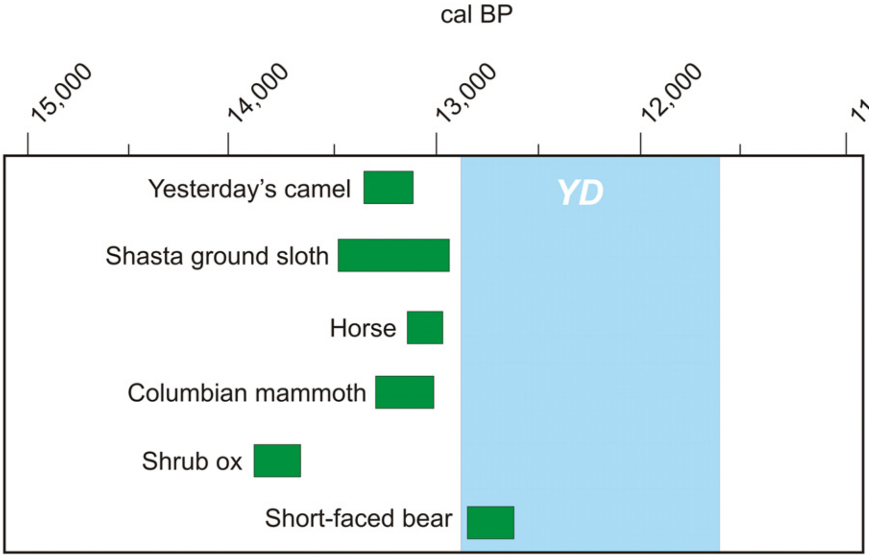

Fig. 5. Youngest known directly dated cases of extinct fauna from the Great Basin. With the exception of short-faced bear, extinctions in the region appear to have occurred during the late Allerød, not during the early Younger Dryas.

5. Archaeology

The early-period archaeological record of the Great Basin has been reviewed recently in a number of publications (Jenkins et al., 2004). The focus is only on archaeological sites that have yielded radiocarbon ages in association with cultural materials assignable to the Younger Dryas, 12,900–11,500 cal BP. This includes nine archaeological sites in the Great Basin (Bonneville Estates Rockshelter, Smith Creek Cave, Danger Cave, Sunshine locality, Handprint Cave, surface artifacts from the shore of Pyramid Lake, Paisley Five Mile Point Caves, Connley Cave 4, and Fort Rock Cave), and a tenth (Buhl) that occurs close to the northeast margin of the Great Basin in south-central Idaho. Each of these ten sites is discussed in detail below, starting with sites in the greater Bonneville basin region (including east-central Nevada and south-central Idaho).

5.1. Bonneville Estates Rockshelter

Bonneville Estates is a large, open rockshelter situated upon the high shoreline of Pleistocene Lake Bonneville (Fig. 6), about 50 km south of West Wendover, Nevada. Schroedl and Coulam (1989) tested the rockshelter in 1988, and the authors' team excavated there from 2000 through 2009, opening an area of about 60 m^2 (Rhode et al., 2005; Goebel et al., 2007; Graf, 2007). The rockshelter is for the most part a "dry cave", so that perishable ecofacts and artifacts are well-preserved, and it is well-stratified, with a series of six discernible cultural components that span from 13,000 cal BP to historic times. Sediments within the shelter consist of a series of silt-and-rubble deposits interdigitated with well-preserved organic layers (Fig. 7), the latter resulting from a variety of depositional agents including human and animal activities, including woodrat nesting (Graf, 2007).

The Paleoindian component in Bonneville Estates Rockshelter comes from deposits labeled strata 18b, 18a, and 17b' (Graf, 2007). In the western area of the shelter, these strata are well-preserved deposits of vegetal material, but in the central and eastern areas, they give way to silt-and-rubble deposits. Across all of these areas, hearth features filled with charcoal, ash, and charred plant remains occur, and associated with these hearths are stone artifacts, animal bones, and occasional bone and fiber artifacts. So far, 50 AMS radiocarbon dates have been obtained on 41 hearths and two bones dating from the shelter's terminal Pleistocene–early Holocene deposits (Fig. 8). These dates clearly document that Paleoindian use of the shelter began about 13,000 cal BP and continued periodically until about 9600 cal BP. Commonalities among the hearths and associated archaeological assemblages indicate that human activities in the vicinity did not change much during and immediately after the Younger Dryas.

Diagnostic lithic artifacts include eight stemmed points on obsidian or fine-grained volcanic rock (e.g., basalt) (Goebel, 2007:163) (Fig. 9c–e and g). Besides an unidentifiable fragment of yet another bifacial point, other lithic artifacts include six bifaces (two early-stage, two late-stage/finished, and two fragmented), four end or side scrapers (Fig. 9q) (including one end scraper on a blade (Fig. 9l)), two gravers, one denticulate, one side scraper/biface, and six retouched flakes (Goebel, 2007:163). Low proportions of debitage pieces with cortex (3%) and high proportions of complex platforms on debitage (68%) suggest that most technological activities carried out in the shelter related to secondary reduction of bifaces (Goebel, 2007:162, 166–167). Raw materials used to make the Paleoindian tools came from a variety of distant sources, many located more than 100 km from the rockshelter

Fig. 6. View of Bonneville Estates Rockshelter in 2009, looking north. Trucks are parked on the wave-cut beach of the Bonneville shoreline (photo by T. Goebel).

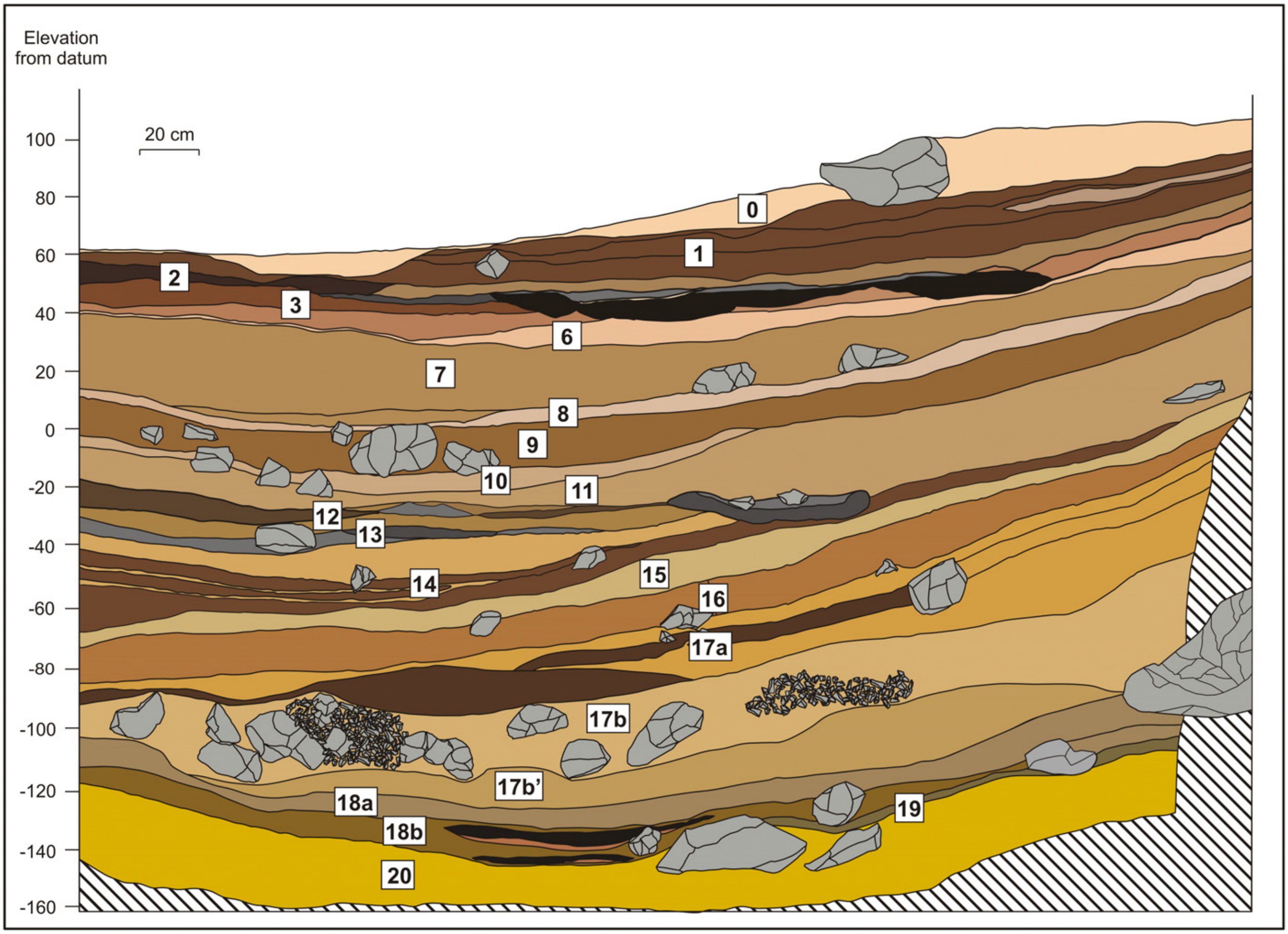

Fig. 7. East-facing stratigraphic profile along W14 grid line in Bonneville Estates Rockshelter. Younger Dryas-aged cultural occupations occur in strata 18b and 18a at the base of the profile. Stratum 17b' contains a cultural layer dating to immediately after the Younger Dryas, ~11,500–11,000 cal BP (illustration by K. Graf).

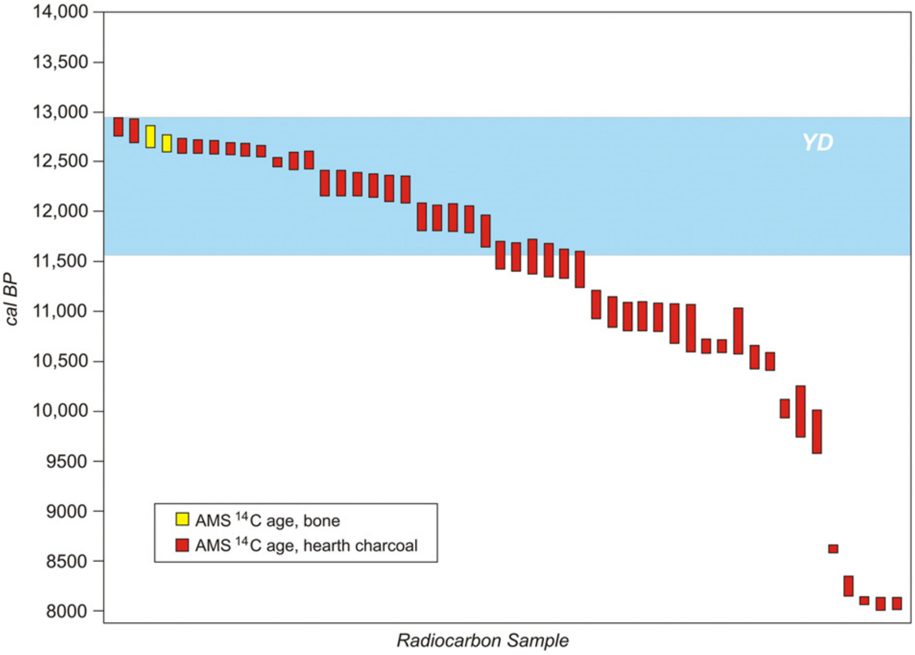

Fig. 8. The 50 calibrated radiocarbon ages dating 41 hearths and two bones from the terminal Pleistocene–early Holocene layers in Bonneville Estates Rockshelter.

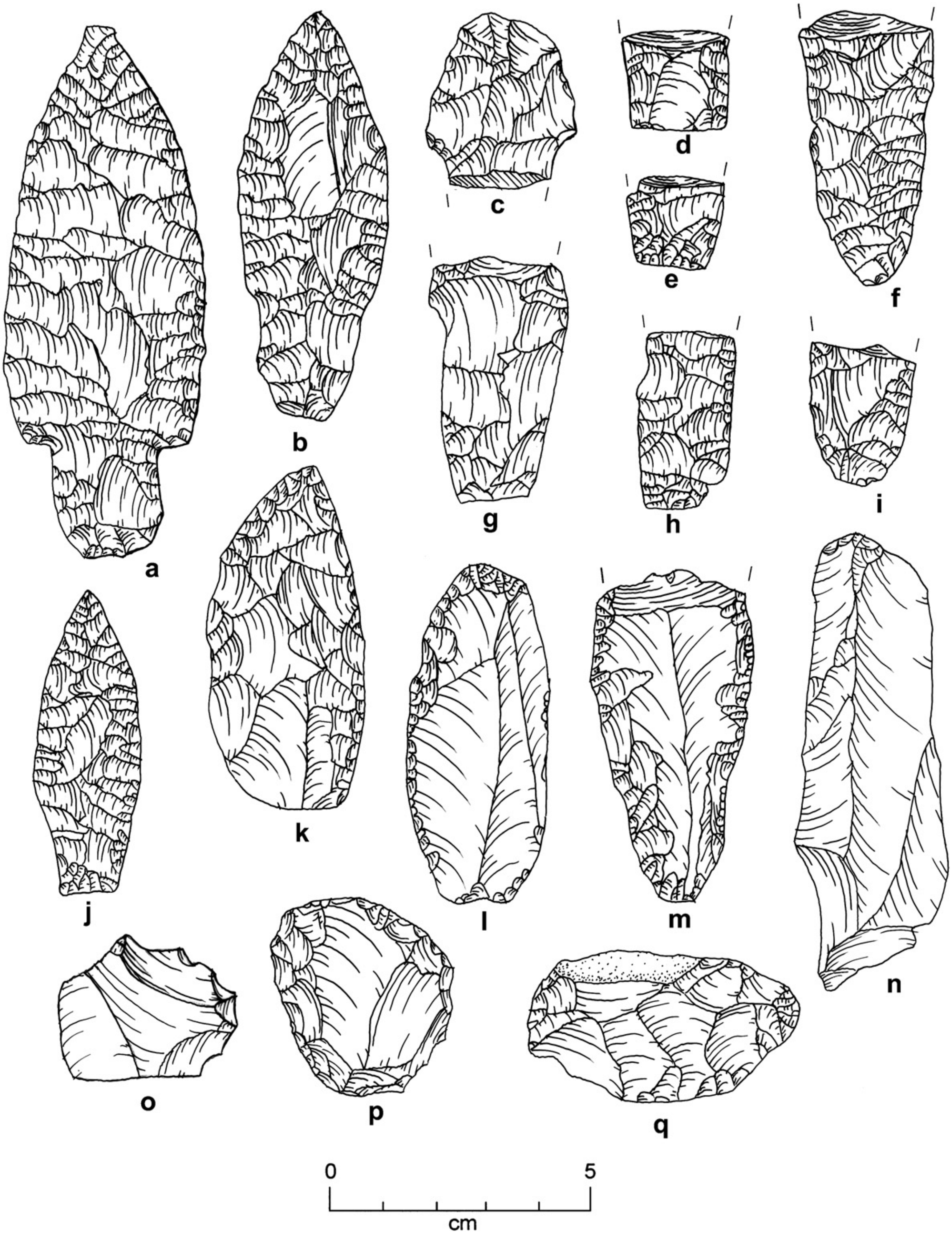

Fig. 9. Lithic artifacts from Younger Dryas-aged archaeological sites in the Great Basin region: a–j, stemmed points or stemmed point fragments; k, late stage biface; l–n, blades or retouched blades; o, graver; p–q, unifacial scrapers (a, Buhl; b, n, o, Sunshine; c–e, g, k–l, q, Bonneville Estates Rockshelter; f, h–i, p, Smith Creek Cave; j, m, Handprint Cave). Artifact b is from layers immediately above Younger Dryas-aged layer at Sunshine. Artifacts redrawn from other publications (a, Green et al., 1998; b, o, Jones et al., 1996; c–e, g, k, l, q, Goebel, 2007; f, h–i, p, Bryan, 1979; j, m, Gruhn and Bryan, 1988; n, Jones and Beck, 2009).

(Goebel et al., 2007:176–177). Local stones, including even nearby Ferguson Wash obsidian, were used infrequently, especially when compared to later Archaic assemblages. Together, these technological indicators suggest that Paleoindian occupations of Bonneville Estates were of short duration, and that occupants typically arrived at the shelter with an already prepared, transported tool kit. These patterns suggest high degrees of mobility.

Perishable artifacts include a complete eyed bone needle (Fig. 10c), tip fragments of three needles or awls (Fig. 10d–f), two fragments of a carved bone (likely segmented to produce a series of beads) (Fig. 10g–h), an antler pressure flaker (Fig. 10i), and several short segments of plant fiber twine.

Faunal remains from the Paleoindian layers at Bonneville Estates include specimens deposited principally by humans as well as

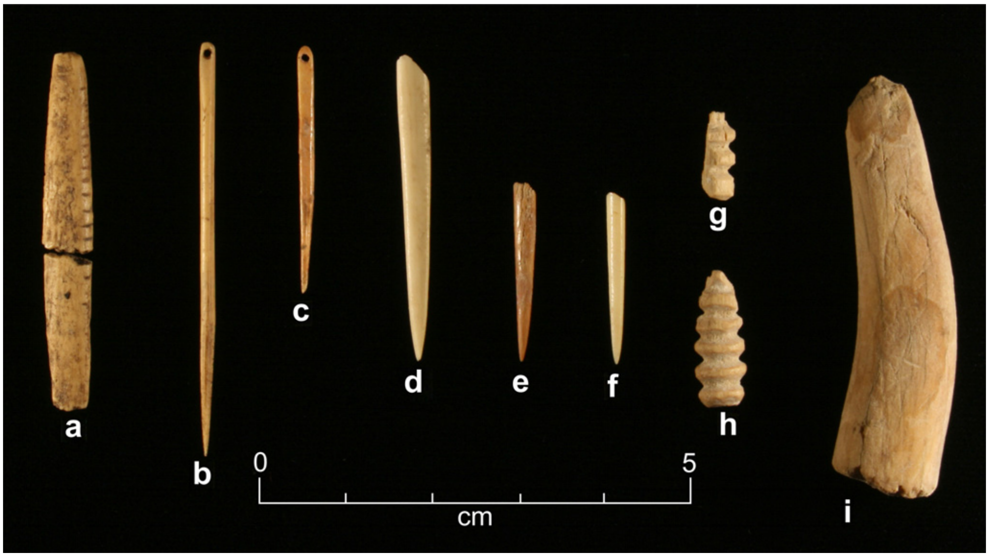

Fig. 10. Osseous artifacts from Buhl (a–b) and Bonneville Estates Rockshelter (c–i): a, incised bone pin; b–c, eyed bone needles; d–f, pointed tips of bone needles or awls; g–h, fragments of a possible bone bead perform; i, antler pressure flaker. Photograph by Heather Smith.

raptors and carnivores (Hockett, 2007:211–212). Those attributable to human activity (through evidence of burning, cutting, or patterned butchery) total more than 2000 specimens and consist of artiodactyls (including pronghorn (*Antilocapra americana*), mountain sheep (*Ovis canadensis*), and mule deer (*Odocoileus hemionus*)), black bear (*Ursus americanus*), hare (*Lepus* sp.), sage grouse (*Centrocerus urophasianus*), and grasshopper (Caelifera) (Hockett, 2007:211). Cottontail (*Sylvilagus* sp.) and pygmy rabbit (*Brachylagus idahoensis*) are also common in the assemblage, but these appear to have accumulated through non-human agents (Hockett, 2007:212). Hare bones, however, regularly bear stone tool cut marks and their limb bone shaft cylinders were regularly snapped of their proximal and distal ends to extract marrow (Hockett, 2007:217–218). Similarly, nearly 10% of the sage grouse bones show signs of burning or cutting with a stone tool, and many more show consistent patterns of carcass dismemberment (Hockett, 2007:213–214). The 18 well-preserved grasshoppers were typically complete or near-complete, with most lacking their hind legs (Hockett, 2007:219). Together these data indicate that Paleoindians focused subsistence on terrestrial resources while at Bonneville Estates Rockshelter. Their diet was diverse and included terrestrial mammals, birds, and insects.

The early Bonneville Estates hearths ($n = 53$) contain a well-preserved paleobotanical record of late Pleistocene and early Holocene environments and diets. So far, analyses of the contents of eleven hearths have been presented (Rhode and Louderback, 2007). These contained cactus parts and numerous small seeds (Rhode and Louderback, 2007:236–237). Cactus remains, including burned spines, spine clusters, epidermis fragments, and a single cactus seed, indicate humans used cactus flesh for food (Rhode and Louderback, 2007:240). Many of the seeds of other plants probably resulted from foraging activities of non-human agents (e.g., woodrats), because seeds were also present in sediment samples away from the hearths. Nonetheless, a few seed types (including ricegrass (*Oryzopsis hymenoides*), dropseed sandgrass (*Sporobolus* sp.), Great Basin wild rye (*Leymus* cf. *cinereus*), goosefoot (Chenopodiaceae), sunflower (Asteraceae), mustard (Brassicaceae), bulrush (*Scirpus* sp.), and cattail (*Typha* sp.)) show up in significantly larger quantities in the hearths than in non-hearth sediment samples, suggesting humans may have had something to do with their accumulation (Rhode and Louderback, 2007:239). Early occupants of the shelter, for example, may have used cattail fluff to start fires, leading to accumulation of charred cattail seeds in the hearths (Rhode and Louderback, 2007:239). The lack of groundstone in the Bonneville Estates Paleoindian assemblage, however, as well as a lack of signs of grinding on any of the seeds, suggest that if humans were consuming these seeds, they were not doing so intensively like later Archaic occupants of the shelter (Rhode and Louderback, 2007:240).

The record of Paleoindians at Bonneville Estates is unique in the Great Basin in that stone, bone, and perishable artifacts occur in direct association with human-modified faunal remains and human-created hearth features. Small groups of hunter-gatherers repeatedly returned to the rockshelter throughout the Younger Dryas, focusing subsistence activities on artiodactyls, hares, sage grouse, and grasshoppers. The large quantity of sage grouse remains, which occur around nearly every excavated Younger Dryas hearth in the rockshelter, suggests that these animals may have been hunted during leks, when male and female grouse assembled and males carried on displays and courtships. Courtship occurs in the spring, typically in flat, open areas near dense stands of sagebrush where females nest (Gibson, 1996; Schroeder et al., 1999; Aspbury and Gibson, 2004). The flat Bonneville shoreline terrace located in front of Bonneville Estates, as well as nearby Provo terrace surfaces, likely acted as prime stages for sage grouse leks. The presence of pygmy rabbits suggests that mature, dense stands of sagebrush also grew in the vicinity, so all the elements were present for spring sage grouse courtships to occur. Sage grouse likely were susceptible to human predation during these times; perhaps the awls, needles, and cordage segments in the Bonneville Estates assemblage are related to production and maintenance of nets used to capture sage grouse. Sage grouse display a rather marked degree of sexual dimorphism, and the variability in size of the sage grouse bones recovered suggests that both males and females were captured, butchered, and eaten at Bonneville Estates. These observations together suggest hunting on leks, which would indicate a spring occupation of the shelter. The sage grouse-eating Paleoindians continued to use Bonneville Estates and butcher and eat grouse inside the shelter centuries after the close of the Younger Dryas, until about 9500 cal BP.

5.2. Smith Creek Cave

Smith Creek Cave is located along the eastern flank of the Snake Range, east-central Nevada. Situated at 2040 m above sea level, 460 m above the high Bonneville shoreline, the cave looks out over Smith Creek Canyon and the broad Snake Valley, which during the Younger Dryas would have been more than 50 km from the southern edge of Lake Gilbert. The cave has a large opening that faces to the southeast; Paleoindian deposits occur in a level area at the mouth of the cave, where A.L. Bryan excavated between 1968 and 1974 (Bryan, 1979, 1988) (Fig. 11).

The cultural occupation at Smith Creek Cave is sealed, well-preserved, and clearly dated to the Younger Dryas. The stratigraphic profile is characterized by loose silt-and-rubble deposits reaching about 1 m in depth, but the main cultural component, which Bryan called the "Mt. Moriah occupation", occurs in a deposit of grey ash and silt about 50 cm below the modern surface (Bryan, 1979:183–184). Bryan's team exposed several hearth features in the ash deposit; five of them were radiocarbon dated (Bryan, 1979:183). Artifacts and hearth features also occurred in a deposit of "dung, rubble, and pink silt" immediately overlying the ash and silt deposit (Bryan, 1979:185).

Radiocarbon dating of the Mt. Moriah occupation has been controversial. Bryan (1979:190) originally obtained ten "acceptable" dates on charcoal and wood samples that ranged from 11,740 ± 130 to 9940 ± 160 ^{14}C BP, and on this basis he concluded that the cultural occupation spanned from about 13,800 to 11,500 cal BP, with the "*main*" occupation occurring about 13,500 cal BP (Bryan, 1988:65; emphasis in original). Later Bryan (1988) reported three additional AMS radiocarbon dates of 12,060 ± 450 (on camelid hair), 10,840 ± 250 (bovid hair), and 10,420 ± 100 (S-twist cordage) ^{14}C BP, which to him confirmed the early age of the cultural layer and even suggested that human occupation began before 13,800 cal BP and continued for up to 2000 years (Bryan, 1988:68).

Others have been more conservative in their estimates of the age of the Mt. Moriah occupation. Thompson (1985) and Goebel et al. (2007) rejected dates on natural materials, focusing instead on charcoal samples from hearths and perishable artifacts like cordage. When considered in this way, the age of the cultural occupation falls squarely within the Younger Dryas. Thompson (1985:117) put it at 12,600 cal BP, while Goebel et al. (2007:155) concluded it to be 12,600–11,300 cal BP, but possibly as early as 13,100 cal BP, if a seemingly discordant early date for one of the hearths could be replicated.

Smith Creek is a dry cave like Bonneville Estates Rockshelter, so that numerous macrobotanical and faunal remains were recovered during excavations. Among the plant remains identified were pine (*Pinus* sp.) and spruce (*Picea* sp.) cones, twigs of sagebrush (*Artemisia* sp.) and Rocky Mountain juniper (*Juniperus scopulorum*), and pits of western chokecherry (*Prunus virginiana*), none unequivocally introduced into the cave by humans. Bryan (1979) originally assigned the pine cones to lodgepole pine (*P. contorta*), but more likely they are bristlecone pine (*P. longaeva*). These plants occur in the Snake Range today, but typically at much higher elevations, while modern vegetation near the cave mouth is an interesting combination of shadscale (*Atriplex* sp.), Utah juniper (*Juniperus osteosperma*), Mormon tea (*Ephedra* sp.), and currant (*Ribes* sp.). These differences indicate cooler and more mesic conditions during the Younger Dryas. Animal bones have been attributed to mountain sheep (*O. canadensis*), mountain lion (*Felis concolor*), leporids (*Lepus* and *Sylvilagus* sp.), rodents (*Marmota*, *Neotoma*, *Spermophilus*, *Microtus*, and *Thomomys*), lizards (*Sceloporus* sp.), fish, and birds (Bryan, 1979:185–186); however, many of these remains were probably introduced into the cave by non-human agents. Numerous artiodactyl bones are splintered and macerated, possibly from cooking (Bryan, 1979:185). Besides bones, hairs identified as artiodactyl, camelid, bovid, and lagomorph were also recovered (Bryan, 1979:185, 1988:60), but none can be shown to have been unequivocally associated with the cultural occupation.

Fig. 11. View of Smith Creek Cave in 2010, looking northeast. To the right of seated figure (J.L. Keene) is A.L. Bryan's 1968–1974 excavation pit. The pit's walls are banked by sand bags placed there recently by G.T. Jones (photo by T. Goebel).

The Mt. Moriah assemblage includes 2535 artifacts, of which 2449 are stone, 64 bone, and 19 perishable (Bryan, 1979:196). Raw materials among debitage pieces are 59% local quartzite, 27% exotic obsidian (the closest possible source being about 100 km away), 8% fine-grained volcanic rock (i.e., basalt), and 7% cherts and chalcedonies. Among the stone artifacts are 229 tools, including 18 bifaces, 14 unifacial scrapers (Fig. 9p), and 197 "microtools" variably described as gravers, burins, denticulates, notches, and retouched flakes (Bryan, 1979:198–204). All of the bifaces are broken, nearly all appear to have originally functioned as projectile points (Bryan, 1979:197), and several were reused after breaking as scrapers, gravers, or burins (Bryan, 1979:205). Most of the bifaces were made on obsidian, but three chert and two basalt biface fragments also occur. All diagnostic forms represented in the assemblage are stemmed points (Fig. 9f, h–i).

Most of the "bone artifacts" are simply macerated, cut or scraped fragments of bone, but Bryan (1979:219–221) also describes eight small bone perforators, awls, and gouges, two bone flakes, and two pieces of bone debitage. Perishables include five cordage fragments of milkweed, four fragments of cane, four small rolls of birch bark, and single examples of a small coil of sinew, yucca quid, plant fiber piece, and wad of juniper bark (interpreted to possibly represent some moccasin padding) (Bryan, 1979:222–224).

The Mt. Moriah occupation at Smith Creek Cave closely parallels the record from Bonneville Estates Rockshelter. First, the age of the occupation seems to span the Younger Dryas interval. Second, the cave's occupants discarded numerous broken and used-up stemmed bifacial points as well as small cordage fragments and bone piercing tools. Third, repeated occupations produced a living floor littered with ephemeral hearth features, remains of fauna, and fragments of plants. Fourth, the bifaces were predominantly manufactured on exotic obsidians, and although geochemical analyses have not been conducted on these artifacts, it is likely that some of the represented sources were shared with the occupants of Bonneville Estates.

5.3. Danger Cave

Danger Cave lies 18 m above the Gilbert shoreline and is located near the town of Wendover, Utah, in the western Bonneville basin. Early excavations occurred in the 1940s and 1950s, the latter directed by Jennings (1957). Danger Cave's record was long thought to represent an unbroken series of "unspectacular and uniform" cultural occupations spanning from the late Pleistocene to late Holocene (Jennings, 1957:279), but recent work by D. Rhode and D. Madsen (1998; Rhode et al., 2006) has led to revision of this presumed continuous, monotonous record. Especially interesting is the recently reinvestigated Younger Dryas record (Rhode et al., 2005).

The earliest occupation of the cave is represented by Jennings' stratum DI, which occurs on the surface of presumed lacustrine beach sand (Jennings, 1957; Grayson, 1988). Careful analyses of old and new radiocarbon dates—10,270 ± 650 (Jennings, 1957) as well as 10,310 ± 40 and 10,270 ± 50 ^{14}C BP (Rhode et al., 2005)—indicate that DI likely dates to the Younger Dryas, ~12,200 cal BP (Grayson, 1988; Rhode et al., 2005; Goebel et al., 2007). The age of the overlying cultural layer, called DII by Jennings (1957), is more difficult to interpret. As Rhode et al. (2005) report, this component seems to include as many as three separate occupations which span from 11,700–8200 cal BP. Most of the cultural remains from Jennings' DII assemblage appear to have originated from the upper part dating to less than 9600 cal BP. This is supported by both artifactual and faunal evidence: DII's diagnostic bifacial point assemblage contains notched forms more characteristic of the early-middle Holocene (Rhode et al., 2005), and identifiable faunal remains indicate warmer and drier conditions than inferred for the period immediately post-dating the Younger Dryas (Grayson, 1988). Lower DII, with radiocarbon dates of 12,000 to 10,600 cal BP, apparently contained few cultural remains; either these represent just ephemeral occupation of the cave or post-depositional mixing (Grayson, 1988; Rhode et al., 2005). For these reasons, consideration of the Younger Dryas record from Dry Creek focuses just on DI.

The remains from DI were few in number. Grayson (1988:16) reports the identification of 449 faunal remains. He points out that although Jennings' crews reportedly screened excavated sediment, they did so intermittently and with mesh sizes reaching ½ inch (1.27 cm) (Grayson, 1988:12). Nonetheless, the faunal remains from DI are environmentally expressive and worth reviewing here. Pygmy rabbits (*Sylvilagus idahoensis*), marmots (*Marmota flaviventris*), and bushy-tailed woodrats (*Neotoma cinerea*) make up 8%, 4% and 25% of the DI faunal assemblage, respectively, and they either occur in very low percentages or do not recur in the Danger Cave record subsequently. Among birds an important pattern is that 38 identifiable remains from DI belong to sage grouse (*C. urophasianus* or cf. *C. urophasianus*). The occurrence of sage grouse drops to two in DII and zero after that. All of these species are indicative of cooler/effectively wetter conditions than today. Pygmy rabbits and sage grouse in particular do best in thick sagebrush habitat, so their presence in the DI deposits indicates a sagebrush steppe existed in the vicinity of Danger Cave and the Gilbert shoreline during the Younger Dryas. One other group of fauna is of importance, too, and that includes water birds, especially dabbling ducks (*Anas* sp., *Aythya* sp.) and grebes (*Podiceps* sp.), which are common in DI (Parmalee, 1988). According to Grayson (1988:32), their presence indicates at least "ephemeral ponding" of water in the Danger Cave vicinity, and other proxy records indicate a "large shallow lake" existed in the western Bonneville basin during this time (Rhode et al., 2005:221). Did humans introduce any of these remains into the DI deposits? Grayson (1988) points out that the sage grouse bones were directly associated with Jennings' excavated DI hearths, and Parmalee (1988) describes bone breakage patterns reminiscent of those characterizing sage grouse remains from Bonneville Estates, so possibly the sage grouse remains were the product of Younger Dryas human subsistence activities.

Plant remains from DI have been recently recovered by Rhode and Madsen (Rhode et al., 2006; Rhode and Louderback, 2007:245). Their exposure of the Jennings' preserved stratigraphic profile (the 143 face), deep in the interior of the cave, led to sampling of several hearth features directly accelerator radiocarbon dated to 12,200 cal BP. Contents of these hearths included fruits and seeds of greasewood (*Sarcobatus vermiculatus*), saltbush (*Atriplex* sp.), ricegrass (*O. hymenoides*), cactus (*Opuntia* sp.), and fiddleneck (*Amsinckia* sp.), but nearly all of these were uncharred and none were ground, suggesting they were the product of rodent, not human, activity (Rhode and Louderback, 2007:245). Instead, only charcoal of greasewood and sagebrush as well as tiny bone fragments found in the hearths appear to have been the result of human activity. Pickleweed (*Allenrolfea occidentalis*) seeds and chaff, which are so common in later deposits, do not occur in DI or lower DII (Rhode et al., 2006). Six human coprolites, finally, also came from DI (Fry, 1976), but more recently these were dated to much later times (9760–3000 cal BP) (Rhode et al., 2006:334).

DI artifacts from Jennings' excavations include chert and obsidian debitage, a lanceolate point that may be of the Haskett stemmed point type, several scrapers, and several knotted pieces of twine (Jennings, 1957). Apparently a few fragments of groundstone were recovered, too, but the lack of ground seeds in the DI hearths suggests that these were intrusive (like Fry's analyzed coprolites) or were used for other purposes than grinding seeds (Rhode et al., 2006). Rhode et al. (2005:221) also recovered more debitage and knotted milkweed fibers from the 143 face hearths (see also Rhode and Louderback, 2007).

The Younger Dryas occupation of Danger Cave seems ephemeral (much like coeval occupations at Bonneville Estates and Smith Creek Cave), especially when compared to the DII and later occupations (Rhode et al., 2006:336). Jennings (1957) appears to have retrieved few artifacts, and he described the hearth features as small and unprepared. This characterization matches Rhode and Madsen's observations in 2004; however, a surprising result of their analyses was the recovery of small stone-flaking debris in the sediment samples. Perhaps renewed excavations of these features could still provide important information about the Younger Dryas occupation of Danger Cave.

5.4. *Sunshine Well*

Sunshine is located in southern Long Valley, east-central Nevada. Besides an extensive surface collection of Paleoindian artifacts reaching more than 11,000 specimens, excavations yielded more than 7500 artifacts from sealed deposits dating to the terminal Pleistocene and early Holocene (Beck and Jones, 2009:77). Test excavations in 1989 were carried out by a multidisciplinary team from the Nevada State Museum and Desert Research Institute (Dansie, 2009), whereas C. Beck and G.T. Jones conducted extensive geoarchaeological trenching and archaeological excavations there between 1992 and 1997. Beck and Jones (2009) present a comprehensive report of these field studies.

Stratigraphically, terminal Pleistocene–early Holocene artifacts occur in three deposits, labeled E, D, and C, from bottom upward. Stratum E (labeled F/G during field studies) yielded a series of radiocarbon dates on charcoal and bone spanning from about 13,800 to 11,200 cal BP; however, charcoal dates more specifically fall between about 12,900 and 11,250 cal BP, indicating that this stratum dates to the Younger Dryas. The dated bones were redeposited from an older setting. Sedimentologically, stratum E consists of fluvial sand and gravel beds (Holmes and Huckleberry, 2009:67). The sands are crossbedded and gravels are subrounded, and the deposits generally fine upward, with gravels occurring at the base of the stratum (Holmes and Huckleberry, 2009:67). The site's investigators interpret these deposits to represent a high-energy braided channel that reduced in strength through the Younger Dryas. Some faunal remains show signs of water transport

(Cannon et al., 2009:223), and many of the stone artifacts occur in the gravels near the base of stratum E (Jones and Beck, 2009:42), together indicating that a major portion of the assemblage was redeposited. Jones and Beck (2009:52) further point out that the frequency of artifacts decreased upward through stratum E, as the alluvium became finer. Thus, most of the materials—both stone artifacts and faunal remains—from stratum E were in a secondary context; however, a few artifacts from the finer sands near the top of stratum E may have been in a primary context, because inferred transport energy by this time was too low to move artifacts a significant distance.

Strata D and C, higher in the Sunshine profile, date to post-Younger Dryas times, about 11,500–11,200 and 11,200–10,000 cal BP, respectively (Holmes and Huckleberry, 2009:67–71). Stratum D is alluvial in character, similar to upper stratum E, and represented by two facies, fluvial channel deposits and distal alluvial fan deposits. Stratum C consists of marl and silty clay deposits containing pedogenic structures. The marl is interpreted to represent shallow ponding of water, while the weathered silty clay represents wetland soil or cienega (Holmes and Huckleberry, 2009:73–74).

Overall, the stratigraphic record at Sunshine indicates that running water (from rain and snow melt) from the mountains and springs surrounding Sunshine fed the paleochannel at the site through the Younger Dryas, but toward the end of this period, about 11,500 cal BP, surface runoff slackened and aridification began. Standing water or a high-water table persisted until close to 10,000 cal BP, after which the Sunshine locality dried up considerably, if not completely (Holmes and Huckleberry, 2009:73).

The majority of the Younger Dryas archaeological record from stratum E at Sunshine, therefore, is redeposited; the recovered remains, however, still have some research value. Certainly, stratum E is sealed by strata D and C, which date to 11,500–10,000 cal BP, providing an upper limiting date for stratum E and suggesting that its contents likely date to the Younger Dryas (although some of its redeposited contents could be older, as directly dated camel remains indicate). As a result of this, fauna from stratum E are useful proxies for Younger Dryas climate, and among the recovered artifacts from stratum E are diagnostic bifacial points that provide important chronological data points for these forms.

Fauna from stratum E consist of fishes including minnows and suckers, and birds are predominantly water birds; together these fauna indicate that a body of water, perhaps a shallow lake or series of ponds, existed in Long Valley during the Younger Dryas. Large-bodied mammals include extinct forms of camel and horse. The 17 elements of camel and the single element of horse show no unambiguous signs of human modification, and none are burnt or calcined (Cannon et al., 2009:224). Direct AMS radiocarbon dates of 13,300–13,150 cal BP on the camel remains are significantly older than dates on charcoal from stratum E, suggesting that they are redeposited. Together, these two aspects of the extinct fauna suggest they are natural occurrences, unrelated to the cultural occupation of the site. The extant fauna consists mostly of small mammals (i.e., cottontail (*Sylvilagus* sp.), jackrabbit (*Lepus* sp.), pygmy rabbit (*B. idahoensis*), squirrel (*Spermophilus* sp.), kangaroo rat (*Dipodomys* sp.), pocket gopher (*Thomomys* sp.), vole (Arvicolinae)), but carnivores (coyote (*Canis* cf. *latrans*), American mink (*Mustela vison*), red fox (*Vulpes vulpes*)) also occur. The cottontails and pygmy rabbits suggest significant sagebrush cover during the Younger Dryas. Burned elements from stratum E include single examples of waterfowl, pygmy rabbit, and squirrel, as well as three examples of jackrabbit (one of which is calcined) (Cannon et al., 2009:224). This burning could have been of human origin, but because no hearths were exposed in the excavation, the burning could be natural. This, coupled with obvious signs of water transport on leporid and vole bones (Cannon et al., 2009:223), implies that much of the stratum E faunal assemblage is not directly associated with lithic artifacts from the deposit.

Stone artifacts from stratum E total 1045 pieces. Most are cherts (46%) or fine-grained volcanic rocks (FGV) (38%), but obsidian (6%) and quartzite (<1%) also occur (Beck and Jones, 2009:82–83). Significantly, 99% of the debitage (totaling 1023 pieces) is non-cortical (Beck and Jones, 2009:82–83). The near absence of cortical pieces (1%) indicates little primary reduction took place on the site. This is further supported by the occurrence of just four cores. Tools, 18 in number, include eight bifaces, six unifaces, and four bifacial points. Most are on chert (13), while just four are on FGV and one is on obsidian (Beck and Jones, 2009:83). The 1993 excavation yielded one multiple spurred graver, two amorphous bifaces, and two blade fragments of stemmed points; these were generally associated with dates of 10,240 ± 80 and 10,250 ± 60 ^{14}C BP (12,100–11,800 cal BP) (Jones and Beck, 2009:36). In 1995, from stratigraphic trench 3, a large biface was recovered (Jones and Beck, 2009:40), and in loader trench 1, finds included a crescent fragment, long curved blade (Fig. 9n), base of a fluted point, graver (Fig. 9o), and combination graver/notch (Jones and Beck, 2009:42). In 1996, also from stratigraphic trench 3, Jones and Beck (2009:52) recovered a large chert biface interpreted to represent a stemmed point preform, a large chert end scraper, and a FGV biface. Most of these came from the coarse gravel deposit at the base of stratum E (Jones and Beck, 2009:54), indicating their redeposition. The large blade, however, came from the sands near the top of stratum E, and Jones and Beck (2009:54) interpret this to mean that the artifact occurred in a primary context.

The finds from loader trench 1 are especially significant to the discussion of the Younger Dryas. The presence of the fluted point base suggests that this bifacial point form was being produced in the central Great Basin during the Younger Dryas, perhaps during post-Clovis times, but because it was redeposited it could have been made earlier. Its small size and appearance suggest it to be non-Clovis, perhaps a Clovis derivative (Beck and Jones, 2009:162–163). The crescent fragment also came from the same excavation, and although one might want to associate it with the fluted point, these artifacts were from a secondary context, and from other nearby excavations (ST3 and the 1993 excavation block) three distal fragments of stemmed points and a stemmed point perform also came from this deposit (Jones and Beck, 2009:36, 52). Certainly the fluted point, stemmed points, and crescent were deposited together at Sunshine during the Younger Dryas; but whether they were all made and used by humans during the Younger Dryas cannot be determined with the evidence at hand.

5.5. *Buhl*

The Buhl site is located in the Snake River valley in southern Idaho, outside the hydrographic Great Basin, but it is considered here because of its proximity to the Bonneville basin and other Younger Dryas-aged sites like Bonneville Estates Rockshelter, Danger Cave, and Sunshine Well. The Buhl site is actually just one archaeological feature, a human burial accidentally discovered in 1989 in an active gravel quarry (Green et al., 1998). Direct AMS dating of a sample of human bone produced a date of 10,675 ± 95 ^{14}C BP (12,700–12,400 cal BP), but geological studies of the remains' stratigraphic context suggested an earlier age to the researchers. The burial was in a layer of eolian sand immediately above a gravel deposit attributed to the Bonneville flood, and it appeared to have been partially dug into the gravels. Green et al. (1998:444) concluded that the sand likely accumulated very soon after the Bonneville floodwaters subsided, so that the actual age of the remains could be much earlier than the radiocarbon date suggested, closer to 17,500 than 12,500 cal BP. Despite this, the single radiocarbon date is accepted as representative of the age of the Buhl burial, although the feature could date to an earlier time.

Green et al. (1998:445) describe the Buhl remains as "one of the best-preserved Paleoindian skeletons ever recovered". It consisted of a nearly complete skull and post-cranium, except that parts of the lower skeleton were missing, presumably from modern gravel quarrying. The individual represented appears to have been an adult female, about 20 years of age at death, 160–170 cm in stature, and of American Indian/East Asian morphology. The dentition had significant oblique occlusal wear, which the investigators attributed to "actual tooth-to-tooth contact by eating prepared foods" (Green et al., 1998:445). Isotopic studies of the same bone that yielded the radiocarbon date suggested a diet heavy on meat and fish. Surprisingly, the bone's δ15N value was much higher than expected for an individual interred in the intermountain west of North America, being on par with modern Arctic seabirds, seals, and polar bears, suggesting a terrestrial diet supplemented by anadromous fish (Green et al., 1998:448–449).

Four artifacts and a badger (*Taxidea taxus*) baculum were associated with the burial. These included an obsidian stemmed point (Fig. 9a), fragment of an eyed bone needle (Fig. 10b), and two fragments of an incised bone pin or awl (Fig. 10a). Neither the point nor the needle showed signs of having been used (the needle seemed to have been recently broken but the tip never materialized in the screening of the burial's matrix), suggesting they as well as the incised pin and baculum served as grave offerings.

The remains from Buhl are significant on two counts. First, the isotopic data suggest that this adult woman had a broad diet that included a large amount of fish. Second, if the four artifacts were indeed grave offerings, then they indicate that her tool kit included not just bone sewing tools but also stone hunting and processing tools made on obsidian, the closest primary source of which would have been Browns Bench, Nevada, about 70 km south of the burial site.

5.6. Handprint Cave

Located in the Black Rock Desert of the Lahontan basin, northwest Nevada, Handprint Cave has been only minimally excavated. Gruhn and Bryan (1988) dug three test pits there in 1987, and in one of them they recovered a stemmed bifacial point (Fig. 9j) and retouched blade (Fig. 9m), both on cryptocrystalline silicate rock (see also Bryan, 1988). These occurred within the top 30 cm of the excavation and were associated with charcoal that yielded a date of 10,740 ± 70 ^{14}C BP (12,700–12,600 cal BP), as well as several bovid hairs and a single strand of human hair (Gruhn and Bryan, 1988). On a stalagmitic column adjacent to the test pit were red-painted handprints, but these cannot be unequivocally linked to the buried finds. The preliminary nature of the test excavations at Handprint Cave makes the dating of the artifacts tenuous (Adams et al., 2008:618); certainly this large cave deserves more attention to ascertain whether an early Younger Dryas occupation is indeed represented in its deposits.

5.7. Pyramid Lake artifacts

The Younger Dryas-aged osseous artifacts from Pyramid Lake were discussed briefly above in the context of large-mammal extinctions. One of the artifacts is a cylindrical point 130 mm in length with a beveled base; the other is a "harpoon" with a series of 10 unilateral barbs and a beveled base (Dansie and Jerrems, 2004:59). These were recovered along a beach of Pyramid Lake, not from an excavated context, and although both have been directly dated to about 12,200 cal BP, these dates should be treated as lower-limiting ages because the tools could have been manufactured on old bone and because other directly dated materials (i.e., sagebrush twine and human bone) from the same beach are significantly younger, about 10,900 cal BP (Adams et al., 2008).

5.8. Paisley Five Mile Point Caves

The Paisley Caves are located in Summer Lake valley, south-central Oregon, which during the late Pleistocene was a subbasin of Lake Chewaucan. From 1938 to 1940, L. Cressman excavated in caves 1–3, uncovering lithic artifacts in association with bones of extinct fauna stratigraphically below volcanic ash from Mt. Mazama (Cressman, 1940, 1986), which erupted about 7840 cal BP. In 2002, D. Jenkins renewed archaeological investigations at Paisley, and since then he and his team have made some remarkable discoveries, most importantly coprolites containing ancient human DNA directly dated to pre-Clovis times, about 14,600–13,900 cal BP (Jenkins, 2007:70; Gilbert et al., 2008).

Discussion here centers on two of the Paisley Caves, 2 and 5. Late Pleistocene materials occur in a poorly sorted loam deposit with much angular rock debris, in between large steep-sided boulders (Jenkins, 2007:64). Although artifacts, human-modified ecofacts, and animal remains have been recovered from the lower layers of the caves, there is also much evidence of rodent disturbance. Associated with remains of extinct fauna are modern artifacts including a fragment of "tightly woven light brown fabric", a piece of cotton thread AMS dated to less than 280 cal BP, and a human coprolite directly AMS dated to about 4700 cal BP (Gilbert et al., 2008:S23; Jenkins, 2007:66). Nonetheless, for Cave 5 there is a bimodal distribution of artifacts and faunal remains by elevation, with a large proportion of finds occurring very low in the deposits, at depths of 175–220 cm below the modern surface, suggesting the occurrence of one, possibly two, late Pleistocene cultural layers (Jenkins, 2007:68; Gilbert et al., 2008:S24).

Materials from caves 2 and 5 radiocarbon dated to the Younger Dryas include two human coprolites (the first with two discordant dates of about 12,800 and 11,550 cal BP, and the second with a single date of about 12,600 cal BP), three grass threads (combined to date to ~12,500 cal BP), a segment of braided sagebrush (*Artemisia* sp.) twine (~12,050 cal BP), and charred, processed edible tissue (~11,800 cal BP). Contents of the Younger Dryas-aged coprolites have not been presented, but one of the ca. 14,000-cal-BP coprolites contained abundant fibrous vegetal remains and phytoliths, indicating a herbivorous diet (Goldberg et al., 2009). The edible tissue fragment was recovered from a possible hearth feature (Jenkins, 2007:69–70). Associated extinct faunal remains are much older (14,500–12,900 cal BP) (Jenkins, 2007:69), again suggesting potential mixing, not just between late Pleistocene and later Holocene, even modern, materials, but also among multiple late Pleistocene deposits dating to before and during the Younger Dryas. From Cave 5 Jenkins (2007:73) recovered several stone artifacts that are assigned relatively to the Younger Dryas based on obsidian-hydration analysis. These include a biface and flake.

Results from the Paisley excavations are still unfolding, but first publications document use of the caves during the Younger Dryas, and like at other sites, local extinctions of large-bodied fauna had occurred before this time. But these publications also indicate that the lower deposits at Paisley, especially from Cave 5, show obvious signs of bioturbation and mixing, so establishing a primary association between directly dated materials and some of the undated remains (e.g., stone artifacts) may prove difficult. More recent excavations in the Paisley Caves, though, are documenting intact, well-stratified sections of sediment that span the Younger Dryas and earlier, so additional information on Younger Dryas chronology and subsistence in this cave is forthcoming (Jenkins et al., 2010).

5.9. *Fort Rock Cave*

Fort Rock Cave is located in Fort Rock Valley, central Oregon. L. Cressman originally excavated the cave in 1937 and 1938 (Cressman and Williams, 1940; Cressman, 1962, 1986), and S. Bedwell resumed excavations there in 1966 and 1967 (Bedwell, 1970, 1973; Bedwell and Cressman, 1971). Cressman's work in the 1930s resulted in the discovery of more than 75 fragments of well-preserved sagebrush-bark sandals and a fragment of a twined, single-warp basket, but these came from deposits thought to post-date the Younger Dryas (Aikens, 1993:27), and one (from an amateur artifact collector's private collection) was later directly dated to 10,600–9700 cal BP (Bedwell and Cressman, 1971:6). In 1967, Bedwell removed some very large boulders from the cave with dynamite and a bulldozer, allowing him to penetrate deeper into the cave's preserved sediments, thereupon finding deposits dating to as early as 17,000–14,700 cal BP (Bedwell and Cressman, 1971:3, 6).

Evidence for a Younger Dryas-aged human occupation of Fort Rock Cave hinges upon one radiocarbon date—10, 200 ± 230 ^{14}C BP (12,400–11,400 cal BP)—on charcoal from square 10, stratum 2, level 8 (Bedwell, 1973). Bedwell's reports do not provide details on the stratigraphic context or artifact and faunal associations of this date, but he does generally describe stratum 2 as a "cobble-filled, brown silt" with charcoal and humus (Bedwell, 1973:16). He also provides illustrations of four stemmed point fragments that appear generally associated with the date: two from lower in stratum 2 (in level 9) in square 10 (Bedwell, 1973:77–78); one from the same elevational context as the date (stratum 2, level 8), but from adjacent square 11 (Bedwell, 1973:77); and one from square 11 that came from lower in stratum 2, in level 10 (Bedwell, 1973:104). Besides these four stemmed points, Bedwell did not provide details on the associated lithic or faunal assemblages.

The terminal Pleistocene–early Holocene materials from Fort Rock Cave were grouped into "Unit 3", which included materials assumed to date from about 12,900–8800 cal BP (Bedwell, 1973:143–149). The problem with this is that Bedwell included in his description of this cultural unit artifacts not just from his various excavation blocks in 1966 and 1967, but also Cressman's earlier assemblage from 1938. Among finds from this unit are a stone drill (from square 10), gravers, "a number of" manos (Bedwell, 1973:148), one crescent and two crescent fragments (from squares 6, 10, and 11) (Bedwell, 1973:149), and of course the numerous sandals from 1938 and a single example from 1966 (Bedwell, 1973:149). Apparently, most of the lithic artifacts were made on obsidian (Bedwell, 1973:143). The publications about the site cannot be used to distinguish which of these artifacts came from deposits specifically associated with the Younger Dryas-aged radiocarbon date as opposed to later early Holocene deposits. The same is true of the faunal assemblage: Bedwell (1973:31) reported the presence of remains of only brush rabbit (*Sylvilagus bachmani*) from square 10, level 10, and deer from square 11, level 10. Other reported remains cannot be unequivocally associated with the radiocarbon date.

Despite the vague reporting on the excavations at Fort Rock Cave, stemmed points were found in association with charcoal dated to the Younger Dryas. This evidence is accepted tentatively, though, because the single date has not been corroborated with additional dates from the stratum. The sandals and basket fragment likely came from deposits dating to the early Holocene, while other artifacts including mano fragments may have come from post-Younger Dryas-aged deposits.

5.10. *Connley Cave 4*

These caves are located in Fort Rock Valley of central Oregon and were excavated by S. Bedwell in 1967 (Bedwell, 1973) and more recently by University of Oregon in 1999–2001 (Beck et al., 2004). According to Bedwell's original excavations, Connley Cave 4, areas A and B, contained cultural deposits that may date to the Younger Dryas. The published report on the excavations is vague in describing associations of radiocarbon dates and archaeological materials, but suggests the following.

Connley Cave 4A yielded a date of 10,100 ± 400 ^{14}C BP (12,400–11,200 cal BP) from stratum 4, level 35, and a date of 9150 ± 150 ^{14}C BP (10,550–10,200 cal BP) from higher in the stratum, level 31 (Bedwell, 1973:35). Cave 4B yielded a date of 10,600 ± 190 ^{14}C BP (12,700–12,150 cal BP) from stratum 4, level 38, the lowest floor from the cave (Bedwell, 1973:35). The problem with this date is that higher up in the stratum, in level 32, Bedwell (1973:35) obtained a date of 11,200 ± 200 ^{14}C BP (13,300–12,900 cal BP). Nonetheless, a date of 9670 ± 180 ^{14}C BP (11,200–10,700 cal BP) from the intervening level 34 suggests the 12,700–12,150 cal BP date may be accurate. Together, the dates from stratum 4 in Connley Cave 4A and 4B suggest a Younger Dryas occupation of both areas that continued into post-Younger Dryas times.

Teasing a Younger Dryas archaeological assemblage from Bedwell's (1973) report is a difficult task. Plant macrofossils throughout stratum 4 include sagebrush (*Artemisia* sp.), pine (*Pinus* sp.), and bitterbrush/cliff rose (*Purshia* sp.), not a surprising association for late glacial Fort Rock valley (Bedwell, 1973:54). Associated faunal remains from lower stratum 4 in areas 4A and 4B include brush rabbit (*S. bachmani*), jackrabbit (*Lepus* sp.), deer (*Odocoileus*), pocket gopher (*Thomomys* sp.), pika (*Ochotona* sp.), microtines (*Microtus* sp.), owl (Strigiforme), duck (Anatidae), and plover (Charadriinae) (Bedwell, 1973:25–26). Bedwell also identified remains of turkey, but Grayson (1977) later re-identified these as sage grouse (*C. urophasianus*). Pikas today occupy high-elevation areas of central Oregon, and their presence in lower stratum 4 suggests colder, more mesic conditions than today (Bedwell, 1973:55). Similarly, the presence of water birds indicates that a shallow, open-water lake existed close to Connley Caves during the Younger Dryas (Bedwell, 1973:55). From upper stratum 4, dating to post-Younger Dryas times, elk (*Cervus canadensis*), grebe (Podicipedidae), and tui chub (*Gila bicolor*) are added to the faunal inventory. No extinct fauna were recovered from Connley Cave 4 (Bedwell, 1973:25–26).

Artifact proportions are fairly low for the Younger Dryas-aged levels of stratum 4 (from level 35 downward) and much higher following the Younger Dryas, in levels 34–30 (Bedwell, 1973:38) (Fig. 12). A complete list of artifacts from the various levels of stratum 4 (let alone a general inventory of artifacts from all of stratum 4) cannot be found in Bedwell's (1973) report, but perusal of accompanying artifact illustrations suggests that a flake core and two possible gravers came from these lowest deposits (Bedwell, 1973:117, 120). Higher up, above level 35 in potentially post-Younger Dryas-aged deposits, many more artifacts were recovered. From Connley Cave 4, Haskett stemmed bifacial points, a possible concave-based fluted point, bifaces, scrapers, a bone awl, and possibly one fragment of a mano characterize the artifact assemblage presumably dating to between 11,600 and 10,200 cal BP (Bedwell, 1973:143–149).

This pattern of a strong Younger Dryas occupation seems to be duplicated by more recent excavations in Connley Caves 5 and 6 by University of Oregon (Beck et al., 2004). Cultural occupations in these caves post-date 11,000 cal BP, and they appear to be considerably mixed.

6. Discussion and conclusions

6.1. *Physical environments of the Younger Dryas*

Lake-level histories of the Great Basin show that pluvial lakes responded to millennial-scale climate change during the late

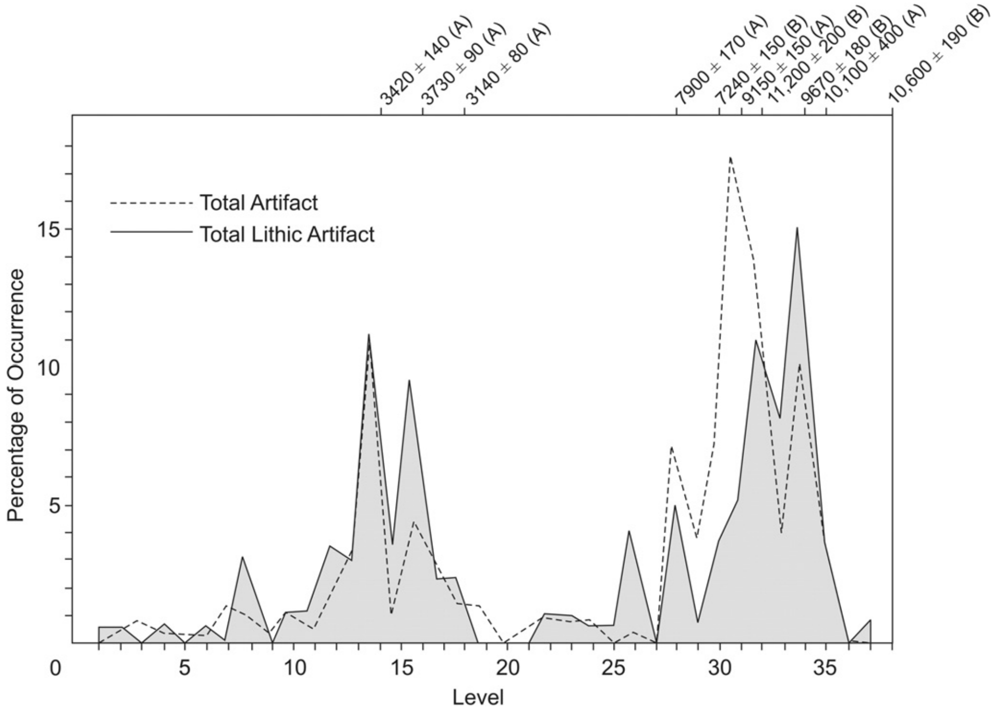

Fig. 12. Distribution of artifacts recovered from S. Bedwell's excavations at Area A of Connley Cave 4 (redrawn from Bedwell, 1973:38). Radiocarbon dates from areas A and B are shown across the top of the graph. Younger Dryas-aged deposits apparently include levels 35 and lower. According to these data, the cultural occupation at Connley Cave 4 was most intensive during the early Holocene, after the Younger Dryas.

glacial. These records generally agree that the Great Basin was cool and effectively wet during the late glacial and early post-glacial periods, in comparison with the Holocene. High-resolution records, however, more specifically suggest that conditions during the late Allerød were relatively dry, while the Younger Dryas was more mesic, with shallow freshwater lakes forming in the Bonneville, Lahontan, and Mojave basins. Owens Lake was full immediately prior to the beginning of the Younger Dryas (but relatively dry during most of the chronozone), and high-altitude pluvial basins in central Nevada contained well-watered marshes or meadows. These mesic conditions persisted into the early Holocene, until about 10,200 cal BP, after which the region's pluvial lakes largely dried up. A more mesic Great Basin, however, may not have resulted from increases in precipitation, but instead from cooler temperatures and less evapotranspiration.

6.2. *Biotic environments of the Younger Dryas*

Paleobotanical records present a similar but more muted climate history for the late glacial. Conifers grew at much lower elevations than in the Holocene, and sagebrush shrubs and grasses were common, again indicating cooler, effectively wetter conditions. More specifically, the vegetation history from Owens Lake suggests the late Allerød was relatively arid, while the Younger Dryas was more mesic. Cool, effectively wet conditions appear to have persisted into the early Holocene, as xerophytic shrubs like shadscale and saltbush gradually replaced sagebrush and grasses in lower elevations, and conifers disappeared altogether, except on high-elevation slopes. Drying occurred at different times and different rates in the Great Basin's varied environments, but the process was largely complete by about 10,200 cal BP.

The youngest known directly dated occurrences of large-bodied Pleistocene fauna indicate that yesterday's camel, Shasta ground sloth, horse, mammoth, and shrub ox had become extinct before the onset of the Younger Dryas. Most extinction events appear to have occurred during the preceding Allerød interstadial, and among the Great Basin's extinct large-bodied fauna, only short-faced bear persisted into the early Younger Dryas, to 12,650 cal BP. The osseous artifacts recovered from the eroded shore of Pyramid Lake in western Nevada, which date to 12,400–12,100 cal BP, may have been made on mammoth ivory and bone, but these identifications need to be confirmed through ancient DNA analysis. No other archaeological components clearly dating to the Younger Dryas have yielded evidence of extinct large-bodied fauna. Instead they contain assemblages made up of extant Great Basin fauna.

6.3. *Archaeological chronology*

The best dated archaeological record of the Younger Dryas in the Great Basin comes from Bonneville Estates Rockshelter, where 50 AMS radiocarbon age estimates date 41 hearths to the late Pleistocene and early Holocene. Paleoindians obviously used the shelter repeatedly from 12,900 cal BP to 10,500 cal BP. The earliest hearths are coeval with the onset of the Younger Dryas, and the latest hearths indicate continued use of Bonneville Estates for another 1000 years following the close of the chronozone. Dated hearths from Danger Cave and Smith Creek Cave similarly indicate human use of the caves spanning from around the beginning of the Younger Dryas until close to 11,000 cal BP. A Younger Dryas occupation also occurs at the Sunshine locality in east-central Nevada, but dates there are on dispersed charcoal and associated artifacts and faunal remains occur in a secondary alluvial context. The adult female skeleton recovered from Buhl, Idaho, also dates squarely within the Younger Dryas, 12,700–12,400 cal BP. Together, the data from Bonneville Estates Rockshelter, Danger Cave, Smith Creek Cave, Sunshine, and Buhl indicate that an established human population inhabited the Bonneville basin and immediately surrounding areas during the Younger Dryas (Fig. 13).

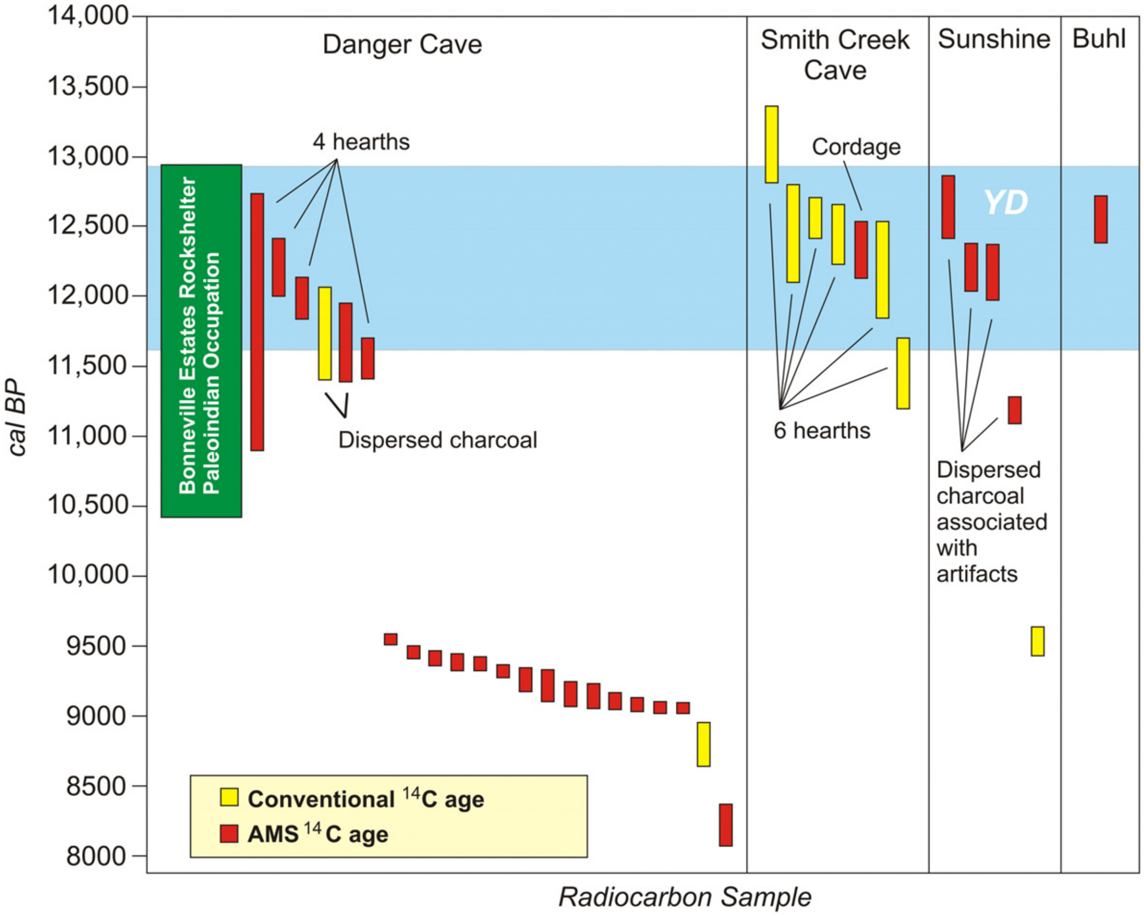

Fig. 13. Calibrated radiocarbon chronology of late Pleistocene/early Holocene archaeological sites in the Bonneville region, including east-central Nevada and south-central Idaho. Dates from Bonneville Estates Rockshelter are summarized on the left side of the graph, because they are shown in detail in Fig. 8.

Elsewhere in the Great Basin, archaeological components clearly dating to the Younger Dryas are difficult to find. In the Lahontan basin, Handprint Cave may contain a Younger Dryas occupation, but the sediments there are shallow and dated charcoal was not from an archaeological feature. The two bone artifacts recovered from an eroded beach of Pyramid Lake clearly date to the Younger Dryas, but because they did not come from excavated contexts the possibilities that they were manufactured on older, mined osseous material, or were curated for a long time before finally being incorporated into the archaeological record cannot be ruled out. The dearth of well-dated cultural occupations assignable to the Younger Dryas in the Lahontan basin is in stark contrast to what happened after the Younger Dryas. Radiocarbon dates from 13 of the earliest archaeological sites in the basin indicate more intensive human use of the region occurred *after* the Younger Dryas during the early Holocene, between 11,300 and 9500 cal BP (Adams et al., 2008) (Fig. 14).

In the northern Great Basin, evidence for a Younger Dryas occupation is equally uncertain. This is the case for Fort Rock Cave and Connley Cave 4, where charcoal dating to the Younger Dryas was recovered, in apparent association with artifacts and faunal remains. Unfortunately, though, the archaeological report describing these finds is vague, and most of the early cultural remains from the two caves appear to come from deposits post-dating the Younger Dryas. Even Bedwell (1973:37–38; see also Bedwell and Cressman, 1971:9) points out that the most intensive occupation of Fort Rock basin occurred between 12,900 and 8800 cal BP. At Paisley Caves 2 and 5 the evidence for humans during the Younger Dryas is much stronger. Human coprolites and artifacts have been directly dated to the chronozone, but even here Younger Dryas-aged cultural remains seem to be few in number and potentially mixed with younger materials. Excavations at Paisley are ongoing and reports of field work are just preliminary; certainly continued work will provide additional details on the Younger Dryas occupations there.

6.4. Human biology and genetics

No Younger Dryas-aged human remains have been recovered from the Great Basin, but the adult female from Buhl, Idaho, only 70 km from the northern edge of the hydrographic Great Basin, does date to the Younger Dryas, and remains of adult males from Wizards Beach and Spirit Cave in the Lahontan basin, western Nevada, post-date the Younger Dryas by about 1000 years. Morphological and metric analyses of these remains indicate a highly variable population (Neves and Blum, 2000; Powell, 2005), but the presence of morphological features characteristic of modern Native Americans in Buhl (e.g., flat cheek bones, projecting nose, moderate sagittal keeling (Green et al., 1998:446–447)) and Wizards Beach (e.g., round brain case, broad, flat cheeks, tall projecting nose, general robusticity (Powell, 2005:151)), as well as craniometric similarities between Wizards Beach and modern Native Americans (Nelson, 1998; Steele and Powell, 1999), indicate a link between the late glacial/early postglacial populations of the Great Basin and modern American Indians. This relationship is further reinforced by mitochondrial DNA recovered from a Paisley Caves human coprolite directly dated to the Younger Dryas. This specimen carried haplogroup B2, which is

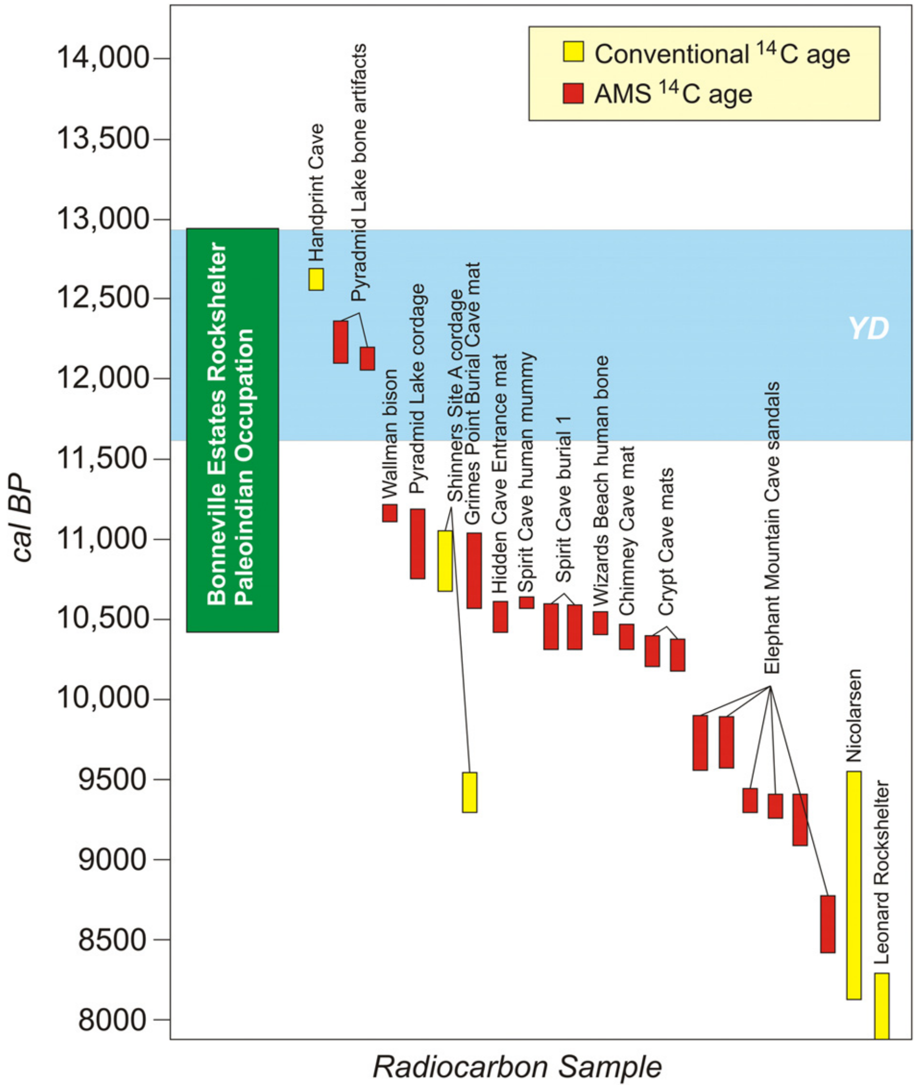

Fig. 14. Calibrated radiocarbon chronology of late Pleistocene/early Holocene archaeological sites in the Lahontan region, Nevada. The Bonneville Estates Rockshelter dates from Fig. 8 are summarized on the left side of the graph for comparison.

common among western North American Indians today. With this information, the Younger Dryas humans of the Great Basin can be labeled as “Paleoindian.”

6.5. Lithic artifacts and technologies

Without question, Paleoindians of the Great Basin made and used stemmed bifacial points. These constitute the dominant projectile point form coming from dated Younger Dryas occupations, including Bonneville Estates Rockshelter, Smith Creek Cave, Sunshine locality, Buhl, Fort Rock Cave, and possibly Danger Cave and Handprint Cave. Connley Cave 4 and other northern Great Basin caves with presumed late glacial or early post-glacial occupations (e.g., Cougar Mountain Cave, Paisley Caves) also contain stemmed points (Bedwell, 1973), but not necessarily dating to the Younger Dryas. A small fluted point was also recovered from deposits dating to the Younger Dryas at Sunshine, but nowhere else in the Great Basin have such forms been found in a firmly dated late glacial context. Fluted points do date to the Younger Dryas in other areas of western North America (Pitblado, 2003), so the occurrence of a “non-Clovis” fluted point in such a context at Sunshine is not surprising.

Other tool forms commonly found in Younger Dryas lithic assemblages include bifaces in various stages of production, and unifacially worked end scrapers, side scrapers, and gravers. A bifacial crescent also occurs in the excavated Sunshine assemblage (and possibly in Younger Dryas-aged deposits at Fort Rock Cave), and single examples of blades have been found in Younger Dryas contexts at Bonneville Estates Rockshelter, Sunshine, and possibly Handprint Cave. Smith Creek Cave also yielded a large number of very small denticulated tools, but the cave’s early deposits are also full of sheep dung suggesting that sheep trampling could have led to the peculiar edge damage recorded on these artifacts. Groundstone artifacts are absent or rare in the assemblages, with the possible exception of Fort Rock Cave, but these could date to the early Holocene.

Lithic technologies focused on production of stemmed bifaces and flake tools. Raw materials vary between sites, but overall some patterns recur. Bifacial tools commonly were produced on obsidians and fine-grained volcanic rocks, while unifacial tools commonly were produced on cherts. Debitage analyses and studies of technological activities have been presented for just two assemblages (Bonneville Estates and Sunshine). These indicate that preforms and finished tools were often transported large distances (100–500 km), and that secondary reduction and tool refurbishing were the most common activities represented at the sites. High proportions of formally shaped and hafted tools further indicate preparation of curated tool kits, not just among bifaces but also unifacial flake tools. All of the bifacial points from Bonneville Estates and Smith Creek Cave are fragmented, and those from Smith Creek Cave appear to have been recycled and reused. These characteristics indicate that the Younger Dryas stone tool assemblages consisted mostly of curated forms.

6.6. *Osseous and perishable technologies*

An exciting new development in Younger Dryas archaeology of the Great Basin has been the accumulation of evidence concerning osseous and perishable technologies. Small eyed bone needles have been recovered from Bonneville Estates and Buhl, and fragments of larger bone awls have been recovered from Bonneville Estates and Smith Creek Cave. Other bone tools include the directly dated beveled point and barbed harpoon from Pyramid Lake, and several flaked pieces of bone from Smith Creek Cave. Items of personal adornment have been recovered as well and include a bead preform from Bonneville Estates and an incised pin from Buhl.

Segments of plant fiber twine have begun to recur at Younger Dryas sites, too, having been recovered so far from Bonneville Estates, Danger Cave, Smith Creek Cave, and Paisley Five Mile Point Caves. These are of a very small diameter and sometimes knotted. Their functions are so far not known, but some may represent fragments of nets. Other perishable finds include small miscellaneous objects like wood shavings, small rolls of birch bark, an antler pressure flaker, and a coil of sinew from the Bonneville basin's dry caves. The sandals and basket fragment from Fort Rock Cave post-date the Younger Dryas.

Works of art have not been recovered from the Great Basin's Younger Dryas sites, but the painted handprints on the wall of Handprint Cave are spatially associated with the stemmed point, blade, and charcoal sample dated to the Younger Dryas. A relationship cannot be proven at this point, but AMS dating of organic residues in the pictographs could potentially ascertain the artwork's age.

6.7. *Human diets*

Younger Dryas humans in the Great Basin clearly had a broad diet, but one that did not include extinct fauna. Artiodactyl remains, often fragmented, charred, or calcined, occur in most assemblages, indicating the hunting of mule deer, bighorn sheep, and pronghorn antelope was a common activity in the Great Basin since the late Pleistocene. Many small mammals occur in the Younger Dryas-aged faunal assemblages, but the few taphonomic studies that have been accomplished on these remains suggest that most were the product of non-human agents. At Bonneville Estates, for example, leporids (including jackrabbits, cottontails, and pygmy cottontails) occur in high numbers, but only remains of jackrabbits were unequivocally modified by humans.

Birds occur frequently in the Great Basin's Younger Dryas assemblages. Danger Cave and Connley Cave 4 have remains of waterfowl, but none can be shown to be unambiguous products of human activities. Sage grouse, however, were clearly consumed by humans at Bonneville Estates, and this terrestrial bird's occurrence in the Danger Cave and Connley Cave 4 assemblages further suggests they were a mainstay in Paleoindian diets during the Younger Dryas.

Fish remains have not been recovered in any of the Younger Dryas sites except in low numbers, and their occurrence at Sunshine and Connley Cave 4 is probably a result of natural agents. The bone chemistry of the Buhl woman, though, suggests that she consumed significant quantities of marine resources, and in southern Idaho the only opportunity to do this would have been through seasonal harvesting of anadromous fish (e.g., salmon), which historically spawned in the upper Snake River drainage as far as Shoshone Falls, just 40 km east of the Buhl site. Other examples of fish consumption among Great Basin Paleoindians are tui chub and sucker remains found in the fecal boli of the Spirit Cave mummy (Eiselt, 1997). At 1000 years after the Younger Dryas, these stomach contents indicate that fishing had become an important component of Paleoindian subsistence by the earliest Holocene.

Grasshoppers from around several hearths at Bonneville Estates provide evidence that humans consumed insects during the late Pleistocene. This is not surprising given that later humans in the Great Basin regularly harvested grasshoppers, sometime in large quantities, both ethnographically and prehistorically (Madsen, 1989).

None of the authors would deny that Great Basin Paleoindians consumed plants; however, unequivocal evidence of this has been difficult to find in the region's Younger Dryas archaeological sites. At Smith Creek Cave, a possible yucca quid was recovered from the Paleoindian occupation, and at Bonneville Estates, Paleoindians appear to have consumed cactus pads and used cattail fluff to start fires in hearths. Seeds that occur in the Bonneville Estates hearths are not always charred, certainly not ground, and also occur away from hearths where woodrats and other rodents likely accumulated them. The same is true for Danger Cave, but hearth samples from the DI deposits are still very few in number. If Great Basin humans consumed seeds during the Younger Dryas, they did so without grinding them and in quantities much lower than in the later Archaic. The records from Bonneville Estates and Danger Cave suggest instead that intensive seed processing and consumption began after the Younger Dryas, around 9500 cal BP, coincident with a significant increase in the amount of groundstone artifacts occurring in the assemblages.

6.8. *Settlement organization*

Records from Pyramid Lake, Handprint Cave, and Paisley Caves are too limited to provide useful information about site function and duration of occupation; however, the other sites can provide useful hints about Paleoindian settlement organization during the Younger Dryas. Occupations at Bonneville Estates, Smith Creek Cave, and Danger Cave seem to present a redundant pattern of repeated short-term use. Hearths are simple and accumulations of artifacts and ecofacts around the hearths are relatively sparse. The apparent redundancy within and between these sites is compelling given that they occur at different elevations—Danger Cave near the floor of the Bonneville basin (1295 m a.s.l.), Bonneville Estates at the high shoreline of Lake Bonneville (1580 m), and Smith Creek Cave on an upland slope overlooking the high shoreline (2040 m). Each is progressively farther from local marshes or sources of freshwater today. This redundant pattern suggests that Younger Dryas humans organized settlement around a residentially mobile system, and that occupation durations at residences like Bonneville Estates, Danger Cave, and Smith Creek Cave were relatively short (days or weeks instead of months or years).

Studies of lithic technological organization can inform on the degree and character of mobility, too. Such studies, however, have only been conducted on the assemblages from Bonneville Estates and Sunshine. They indicate that Younger Dryas foragers practiced long-range transport of lithic resources, frequently carrying obsidians and other tool stones more than 100 km, sometimes as much as 200–400 km. Conveyance zones appear to have had a strong north–south orientation (Jones et al., 2003), and transported raw-material packages were typically in the form of preforms or finished tools. Use of local raw materials is more limited at Bonneville Estates in its Paleoindian occupations than in its later Archaic occupations, and the lack of obvious raw-material stockpiling at both Bonneville Estates, Smith Creek Cave, and Sunshine suggest short-term occupations. Like the data presented above, these signs point to a high-mobility settlement strategy in which whole groups moved to seasonally available resources—not just adult males, but in some cases adult females and children, too.

Elston and Zeanah (2002) have suggested that male and female Paleoindians in the Great Basin may have had different tool kits, different levels of mobility (with men moving more frequently and greater distances than females), and different raw-material acquisition opportunities (with men acquiring exotic obsidians and other tool stones more frequently). However, the presence of a complete obsidian stemmed point under the skull of the Buhl woman implies that this raw material and artifact type may have been used by women as well as men. This small detail could be hinting at something very important—that the Paleoindian assemblages at Bonneville Estates and Smith Creek Cave (not to mention Danger Cave), characterized by broken and reused stemmed points, bone needles and awls, and twine segments, were produced by women and children as much as by men. These small groups periodically revisited the shelters, where they repaired tools (and possibly nets) and from which they hunted and gathered local resources. Stays were relatively short, perhaps on the order of days or weeks. If annual ranges were as large as the lithic conveyance zones mapped out by Jones et al. (2003) suggest, then it is possible that the adult woman buried at Buhl had herself visited Danger Cave, Bonneville Estates, Smith Creek Cave, or Sunshine, or at least knew of someone who had visited one of these places.

6.9. *Conclusions*

Most of the Paleoindian sites in the Great Basin dating to the Younger Dryas occur in caves or rockshelters, so the interpretations of human behavior presented here are likely skewed somewhat. However, there are commonalities in technological activities and organization evident between the Bonneville Estates Rockshelter and Sunshine open-air lithic records, suggesting that these sites generally represent the same subsistence-settlement system. Together with the other data reviewed above, the following tentative conclusions are offered:

1. Younger Dryas environments and climates in the Great Basin were relatively cool and mesic, and these conditions appear to have continued several centuries after the end of the chronozone, with the shift to warmer, drier conditions happening gradually in some places and more rapidly in others.
2. No prey species appear to have gone extinct in the Great Basin during the Younger Dryas; instead several members of the large-bodied fauna of the region had gone extinct before 12,900 cal BP, during the Allerød interstadial.
3. Radiocarbon chronologies indicate that the Bonneville basin was occupied by an established human population during the Younger Dryas; however, other regions of the Great Basin do not have such a rich record. In the Lahontan and Fort Rock basins, intensive human occupations seems to have followed the Younger Dryas, beginning after 11,600 cal BP, but this pattern could be due to sampling.
4. The Younger Dryas inhabitants of the Great Basin were craniometrically and genetically Paleoindians, suggesting an ancestor-descendent relationship with some modern Native Americans.
5. Great Basin Paleoindians during the Younger Dryas maintained a rich stone, bone, and perishable tool kit, one that facilitated high-mobility characterized by frequent moves, long-distance tool transport, and residential mobility.
6. Human diets during the Younger Dryas were diverse and included large-bodied mammals like mule deer, bighorn sheep, and pronghorn antelope, small-bodied birds and mammals such as sage grouse and jackrabbits, insects such as grasshoppers, and plant foods, including cactus pads and possibly small seeds. Intensive consumption of seeds did not become important until the early-middle Holocene, at least in the Bonneville basin.

Only ten sites have been radiocarbon dated to the chronozone, a seemingly poor record for such a large area of the western North American continent. However, hundreds of surface and near-surface sites with stemmed points occur across the Great Basin desert, and certainly some of these represent human occupations spanning 12,900–11,600 cal BP. For example, a series of stemmed-point sites have been found along the Old River Bed of the Bonneville basin, which flowed throughout the Younger Dryas and for several centuries following it (Schmitt et al., 2007), and some of the most extensive stemmed-point lithic scatters in the Lahontan basin (e.g., Sadmat and Coleman) are elevationally just above Younger Dryas lake levels (Adams et al., 2008). Additionally, obsidian-hydration analysis of flakes and non-diagnostic bifaces from surface sites that do and do not contain stemmed points also suggest that many Younger Dryas-aged sites may exist and have remained “invisible” to direct radiocarbon dating. If some of these and other Great Basin surface sites with stemmed or even concave-based points date to the Younger Dryas interval, then the density of human populations in the region would have been much higher than the current set of radiocarbon-dated sites suggests. Even in the Mojave Desert this may have been the case. This region contains dense and extensive surface lithic scatters of stemmed and concave-based points (e.g., China Lakes, eastern California) (Davis, 1978), and it may just be that early humans did not frequent the region’s few rockshelters because of their locations away from critical resources. Another important taphonomic lesson can be found in the record from the Sunshine locality, where Younger Dryas-aged occupations occur many meters under the modern surface, in very hard-to-access contexts. Furthermore, considering that nearly all of the securely dated Younger Dryas cultural occupations in the Great Basin have been reported in just the last 15 years (e.g., Bonneville Estates Rockshelter, Buhl, Danger Cave, Sunshine), it becomes apparent that continued survey and excavation in the region will undoubtedly turn up a rich record of Younger Dryas human occupation. In any case, the number of well-dated Younger Dryas sites in the Great Basin far outnumber pre-Younger Dryas sites, suggesting that the first recognizable population pulse in the Great Basin occurred during the Younger Dryas. Populations apparently continued to increase after the Younger Dryas into the earliest Holocene.

To develop a more complete picture of the human experience in the Great Basin during the Younger Dryas, we need more datable archaeological occupations and high resolution (better than millennial-scale) paleoecological records. Despite these shortcomings, the record available today suggests that Younger Dryas Paleoindians in the Great Basin witnessed few obvious changes in fauna or flora. Large-mammal extinctions appear to have occurred before the Younger Dryas, during the Allerød interstadial, and in the Bonneville basin there is little evidence for a cessation of the Younger Dryas way of life until about 1000 years after the end of the chronozone. The Lahontan and Fort Rock basins may have witnessed even more intensive human occupations after the Younger Dryas instead of during it. Global climate change at the onset of the Younger Dryas appears to have had a positive effect on humans in the Great Basin region. Seemingly the Younger Dryas as well as the first 1000–2000 years of the early Holocene were among the best of times—certainly not the worst of times—for prehistoric humans in the Great Basin.

Acknowledgments

The Archaeology Program at the National Science Foundation, U.S.D.I. Bureau of Land Management, and Sundance Archaeological Research Fund at the University of Nevada Reno supported our investigations at Bonneville Estates Rockshelter. Special thanks to Josh Keene for preparing Fig. 9, Heather Smith for preparing Fig. 10, and Lawrence Straus for inviting us to participate in this special volume of *Quaternary International*.

References

Adams, K.D., Wesnousky, S.G., 1998. Shoreline processes and the age of the Lake Lahontan highstand in the Jessup embayment, Nevada. Geological Society of America Bulletin 110, 1318–1332.

Adams, K.D., Wesnousky, S.G., Bills, B.G., 1999. Isostatic rebound, active faulting, and potential geomorphic effects in the Lake Lahontan basin, Nevada and California. Geological Society of America Bulletin 111, 1739–1756.

Adams, K.D., Goebel, T., Graf, K., Smith, G.M., Camp, A.J., Briggs, R.W., Rhode, D., 2008. Late Pleistocene and early Holocene lake-level fluctuations in the Lahontan basin, Nevada: implications for the distribution of archaeological sites. Geoarchaeology: An International Journal 23 (5), 608–643.

Aikens, C.M., 1993. Archaeology of Oregon. U.S. Department of the Interior, Bureau of Land Management, Portland, Oregon, 302 pp.

Aspbury, A.S., Gibson, R.M., 2004. Long range visibility of greater sage grouse leks: a GIS-based analysis. Animal Behaviour 67, 1127–1132.

Bacon, S.N., Burke, R.M., Pezzopane, S.K., Jayko, A.S., 2006. Last glacial maximum and Holocene lake levels of Owens Lake, eastern California, USA. Quaternary Science Reviews 25, 1264–1282.

Beck, C., Jones, G.T., 2009. The Archaeology of the Eastern Nevada Paleoarchaic, Part I: The Sunshine Locality. University of Utah Anthropological Papers Number 126. University of Utah Press, Salt Lake City, 262 pp.

Beck, C., Jones, G.T., Jenkins, D.L., Skinner, C.E., Thatcher, J.J., 2004. Fluted or basally-thinned? Re-examination of a lanceolate point from the Connley Caves in the Fort Rock basin. In: Jenkins, D.L., Connolly, T.J., Aikens, C.M. (Eds.), Early and Middle Holocene Archaeology of the Northern Great Basin. University of Oregon Anthropological Papers 62, pp. 281–294.

Bedwell, S.F., 1970. Prehistory and Environment of the Pluvial Fort Rock Lake Area of Southcentral Oregon. Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

Bedwell, S.F., 1973. Fort Rock Basin: Prehistory and Environment. University of Oregon Books, Eugene. 188 p.

Bedwell, S.F., Cressman, L.S., 1971. Fort Rock report: Prehistory and environment of the pluvial Fort Rock Lake area of south-central Oregon. In: Aikens, C.M. (Ed.), Great Basin Anthropological Conference 1970 Selected Papers. University of Oregon Anthropological Papers No. 1. University of Oregon Press, Eugene, pp. 1–26.

Benson, L., 1999. Records of Millennial-scale Climate Change from the Great Basin of the Western United States. Mechanisms of Global Climate Change at Millennial Time Scales. In: Geophysical Monograph 112. American Geophysical Union. pp. 203–225.

Benson, L., Kashgarian, M., Rubin, M., 1995. Carbonate deposition, Pyramid Lake subbasin, Nevada: 2, lake levels and polar jet stream positions reconstructed from radiocarbon ages and elevations of carbonates (tufas) deposited in the Lahontan basin. Palaeogeography, Palaeoclimatology, Palaeoecology 117, 1–30.

Benson, L.V., Currey, D.R., Dorn, R.I., Lajoie, K.R., Oviatt, C.G., Robinson, S.W., Smith, G.I., Stine, S., 1990. Chronology of expansion and contraction of four Great Basin lake systems during the past 35,000 years. Palaeogeography, Palaeoclimatology, Palaeoecology 78, 241–286.

Benson, L.V., Currey, D.R., Lao, Y., Hostetler, S.W., 1992. Lake-size variations in the Lahontan and Bonneville basins between 13,000 and 9000 ^{14}C yr B.P. Palaeogeography, Palaeoclimatology, Palaeoecology 95, 19–32.

Benson, L.V., Burdett, J.W., Kashgarian, M., Lund, S.P., Phillips, F.M., Rye, R.O., 1996. Climatic and hydrologic oscillations in the Owens Lake basin and adjacent Sierra Nevada, California. Science 274, 746–748.

Benson, L.V., Lund, S.P., Burdett, J.W., Kashgarian, M., Rose, T.P., Smooth, J.P., Schwartz, M., 1998. Correlation of late-Pleistocene lake-level oscillations in Mono Lake, California, with North Atlantic climate events. Quaternary Research 49, 1–10.

Bills, B.G., Adams, K.D., Wesnousky, S.G., 2007. Viscosity structure of the crust and upper mantle in western Nevada from isostatic rebound patterns of Lake Lahontan shorelines. Journal of Geophysical Research 112, B06405. doi:10.1029/2005JB003941.

Bills, B.G., Currey, D.R., Marshall, G.A., 1994. Viscosity estimates for the crust and upper mantle from patterns of lacustrine shoreline deformation in the eastern Great Basin. Journal of Geophysical Research 99, 22,059–22,086.

Briggs, R.W., Wesnousky, S.G., Adams, K.D., 2005. Late Pleistocene and late Holocene lake highstands in the Pyramid Lake subbasin of Lake Lahontan, Nevada, USA. Quaternary Research 64, 257–263.

Broughton, J.M., 2000. The Homestead cave ichthyofauna. In: Madsen, D.G. (Ed.), Late Quaternary Paleoecology in the Bonneville Basin. Utah Geological Survey Bulletin, vol. 130, pp. 103–121.

Broughton, J.M., Madsen, D.B., Quade, J., 2000. Fish remains from Homestead Cave and lake levels of the past 13,000 years in the Bonneville basin. Quaternary Research 53, 392–401.

Bryan, A.L., 1979. Smith Creek Cave. In: Tuohy, D., Rendall, D.L. (Eds.), The Archaeology of Smith Creek Canyon, Eastern Nevada. Nevada State Museum Anthropological Papers No. 17, Carson City, pp. 162–251.

Bryan, A.L., 1988. The relationship of the stemmed point and fluted point traditions in the Great Basin. In: Willig, J.A., Aikens, C.M., Fagan, J.L. (Eds.), Early Human Occupation in Far Western North America: The Clovis-Archaic Interface. Nevada State Museum Anthropological Papers No. 21, Carson City, pp. 53–74.

Cannon, M.D., Livingston, S.D., Broughton, J.M., 2009. Faunal remains from the Sunshine locality. In: Beck, C., Jones, G.T. (Eds.), The Archaeology of the Eastern Nevada Paleoarchaic, Part I: The Sunshine Locality. University of Utah Anthropological Papers Number 126. University of Utah Press, Salt Lake City, pp. 218–228.

Caskey, S.J., Bell, J.W., Ramelli, A.R., Wesnousky, S.G., 2004. Historic surface faulting and paleoseismicity in the area of the 1954 Rainbow Mountain-Stillwater earthquake sequence, central Nevada. Bulletin of the Seismological Society of America 94, 1255–1275.

Cressman, L.S., 1940. Studies on early man in south central Oregon. In: Carnegie Institution of Washington Year Book Number 39, Washington, D.C, pp. 300–306.

Cressman, L.S., 1962. The sandal and the cave: the Indians of Oregon. Beaver Books, Portland, Oregon. 81 p.

Cressman, L.S., 1986. Prehistory of the northern area. In: d'Azevedo, W.L. (Ed.), Great Basin. Handbook of North American Indians, vol. 11. Smithsonian Institution Press, Washington D.C., pp. 120–126.

Cressman, L.S., Williams, H., 1940. Early man in south central Oregon: evidence from stratified sites. In: Cressman, L.S., Williams, H., Krieger, A.D. (Eds.), Early Man in Oregon: Archaeological Studies in the Northern Great Basin. University of Oregon, Eugene, pp. 53–78.

Currey, D.R., 1982. Lake Bonneville: Selected Features of Relevance to Neotectonic Analysis U.S. Geological Survey Open-File Report 82–1070.

Currey, D.R., 1988. Isochronism of final Pleistocene shallow lakes in the Great Salt Lake and Carson Desert regions of the Great Basin. In: Program and Abstracts of the Tenth Biennial Meeting. American Quaternary Association, p. 117.

Currey, D.R., 1990. Quaternary palaeolakes in the evolution of semidesert basins, with special emphasis on Lake Bonneville and the Great Basin, U.S.A. Palaeogeography, Palaeoclimatology, Palaeoecology 76, 189–214.

Dansie, A.J., 2009. History of fieldwork at Sunshine Well, Long Valley, Nevada, 1962–1990. In: Beck, C., Jones, G.T. (Eds.), The Archaeology of the Eastern Nevada Paleoarchaic, Part I: The Sunshine Locality. University of Utah Anthropological Papers Number 126. University of Utah Press, Salt Lake City, pp. 10–24.

Dansie, A.J., Jerrems, W.J., 2004. Lahontan chronology and early human occupation in the western Great Basin: a new look at old collections. In: Lepper, B.T., Bonnichsen, R. (Eds.), New Perspectives on the First Americans. Center for the Study of the First Americans, College Station, Texas, pp. 55–63.

Davis, E.L., 1978. Associations of people and a Rancholabrean fauna at China Lake, California. In: Bryan, A.L. (Ed.), Early Man in America from a Circum-Pacific Perspective. Occasional Papers No. 1. Department of Anthropology, University of Alberta, Edmonton, pp. 183–217.

Davis, O.K., 2002. Late Neogene environmental history of the northern Bonneville basin: a review of palynological studies. In: Hersler, R., Madsen, D.B., Currey, D.R. (Eds.), Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, vol. 33. Smithsonian Institution Press, Washington, D.C, pp. 295–307.

Eiselt, B.S., 1997. Fish remains from the Spirit Cave paleofecal material: 9,400 year old evidence for Great Basin utilization of small fishes. Nevada Historical Society Quarterly 40 (1), 117–139.

Elston, R.G., Zeanah, D.W., 2002. Thinking outside the box: a new perspective on diet breadth and sexual division of labor in the Prearchaic Great Basin. World Archaeology 34, 103–130.

Fry, G.F., 1976. Analysis of Prehistoric Coprolites from Utah. In: University of Utah Anthropological Papers Number 97. University of Utah Press, Salt Lake City. 45 p.

García, A.F., Stokes, M., 2006. Late Pleistocene highstand and recession of a small, high-altitude pluvial lake, Jakes Valley, central Great Basin, USA. Quaternary Research 65, 179–186.

Gibson, R.M., 1996. A re-evaluation of hotspot settlement in lekking sage grouse. Animal Behaviour 52, 993–1005.

Gilbert, G.K., 1890. Lake Bonneville. Monographs of the United States Geological Survey 1, 438 p.

Gilbert, M.T., Jenkins, D.L., Götherstrom, A., Naveran, N., Sanchez, J.J., Hofreiter, M., Thomsen, P.F., Binladen, J., Higham, T.F.G., Yohe II, R.M., Parr, R., Cummings, L.S., Willerslev, E., 2008. DNA from pre-Clovis human coprolites in Oregon, North America. Science 320, 786–789.

Godsey, H.S., Currey, D.R., Chan, M.A., 2005. New evidence for an extended occupation of the Provo shoreline and implications for regional climate change, Pleistocene Lake Bonneville, Utah, USA. Quaternary Research 63, 212–223.

Goebel, T., 2007. Pre-Archaic and early Archaic technological activities at Bonneville Estates Rockshelter: a first look at the lithic artifact record. In: Graf, K.E., Schmitt, D.N. (Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 156–184.

Goebel, T., Graf, K., Hockett, B., Rhode, D., 2007. The Paleoindian occupations at Bonneville Estates Rockshelter, Danger Cave, and Smith Creek Cave (eastern Great Basin, U.S.A.): interpreting their radiocarbon chronologies. In: Kornfeld, M., Vasil'ev, S., Miotti, L. (Eds.), On Shelter's Ledge: Histories, Theories and Methods of Rockshelter Research. BAR International Series, Oxford, pp. 147–161.

Goldberg, P., Berna, F., Macphail, R.I., 2009. Comment on "DNA from pre-Clovis human coprolites in Oregon, North America". Science 325, 148-c.

Graf, K.E., 2007. Stratigraphy and chronology of the Pleistocene to Holocene transition at Bonneville Estates Rockshelter, eastern Great Basin. In: Graf, K.E., Schmitt, D.N. (Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 82–104.

Grayson, D.K., 1977. A review of the evidence for early Holocene turkeys in the northern Great Basin. American Antiquity 42 (1), 110–114.

Grayson, D.K., 1988. Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas. In: Anthropological Papers of the American Museum of Natural History, vol. 66 Part 1. New York, 130 p.

Grayson, D.K., 1993. The Desert's Past: a Natural Prehistory of the Great Basin. Smithsonian Institution Press, Washington D.C.

Green, T.J., Cochran, B., Fenton, T.W., Woods, J.C., Titmus, G.L., Tieszen, L., Davis, M.A., Miller, S.J., 1998. The Buhl burial: a Paleoindian woman from southern Idaho. American Antiquity 63, 437–456.

Gruhn, R., Bryan, A., 1988. The 1987 archaeological fieldwork at Handprint Cave, Nevada. Nevada Archaeologist 6 (2), 1–13.

Hart, W.S., Quade, J., Madsen, D.B., Kaufman, D.S., Oviatt, C.G., 2004. The ^{87}SR/^{86}SR ratios of lacustrine carbonates and lake-level history of the Bonneville paleolake system. GSA Bulletin 116 (9/10), 1107–1119.

Hockett, B., 2007. Nutritional ecology of late Pleistocene to middle Holocene subsistence in the Great Basin: zooarchaeological evidence from Bonneville Estates Rockshelter. In: Graf, K.E., Schmitt, D.N. (Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 204–230.

Hockett, B., Dillingham, E., 2004. Paleontological Investigations at Mineral Hill Cave. Technical Report 18. Bureau of Land Management, Reno.

Holmes, A.M., Huckleberry, G.A., 2009. Stratigraphy and paleoenvironment. In: Beck, C., Jones, G.T. (Eds.), The Archaeology of the Eastern Nevada Paleoarchaic, Part I: The Sunshine Locality. University of Utah Anthropological Papers Number 126. University of Utah Press, Salt Lake City, pp. 67–76.

Hua, Q., Barbetti, M., Fink, D., Kaiser, K.F., Friedrich, M., Kromer, B., Levchenko, V.A., Zoppi, U., Smith, A.M., Bertuch, F., 2009. Atmospheric ^{14}C variations derived from tree rings during the early Younger Dryas. Quaternary Science Reviews 28, 2982–2990.

Jenkins, D.L., 2007. Distribution and dating of cultural and paleontological remains at the Paisley Five Mile Point Caves in the northern Great Basin. In: Graf, K.E., Schmitt, D.N. (Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 57–81.

Jenkins, D.L., Davis, L., Hockett, B., Stafford, T., Willerslev, E., 2010. Chrono-stratigraphic Analysis of Late Pleistocene to Middle Holocene Deposits in the Paisley Caves of South-central Oregon Paper presented at the 32nd biennial Great Basin Anthropological Conference, Layton, Utah.

Jenkins, D.L., Connolly, T.J., Aikens, C.M., 2004. Early and middle Holocene archaeology in the northern Great Basin: dynamic natural and cultural ecologies. In: Jenkins, D.L., Connolly, T.J., Aikens, C.M. (Eds.), Early and Middle Holocene Archaeology of the Northern Great Basin. University of Oregon Anthropological Papers 62. Museum of Natural History and Department of Anthroology, University of Oregon, Eugene, pp. 1–20.

Jennings, J.D., 1957. Danger Cave. In: University of Utah Anthropological Papers Number 27. University of Utah Press, Salt Lake City. 328 p.

Jewell, P.W., 2010. River Incision, Circulation, and Wind Regime of Pleistocene Lake Bonneville, USA. Palaeogeography, Palaeoclimatology, Palaeoecology 293, 41–50.

Jones, G.T., Beck, C., 2009. The Hamilton college excavations, 1992–1996. In: Beck, C., Jones, G.T. (Eds.), The Archaeology of the Eastern Nevada Paleoarchaic, Part I: The Sunshine Locality. University of Utah Anthropological Papers Number 126, Salt Lake City, pp. 25–66.

Jones, G.T., Beck, C., Jones, E.E., Hughes, R.E., 2003. Lithic source use and Paleoarchaic foraging territories in the Great Basin. American Antiquity 68, 5–38.

Jones, G.T., Beck, C., Nials, F.L., Neudorfer, J.J., Brownholtz, B.J., Gilbert, H.B., 1996. Recent archaeological and geological investigations at the Sunshine locality, Long Valley, Nevada. Journal of California and Great Basin Anthropology 18, 48–63.

Long, A., Martin, P.S., 1974. Death of American ground sloths. Science 186, 638–640.

Louderback, L.A., Rhode, D.E., 2009. 15,000 years of vegetation change in the Bonneville basin: the Blue Lake pollen record. Quaternary Science Reviews 28 (3–4), 308–326.

Madsen, D.B., 1989. A Grasshopper in Every Pot. Natural History July, 22–24.

Madsen, D.B., 2000a. A high-elevation Allerød-Younger Dryas megafauna from the west-central Rocky Mountains. In: Madsen, D.B., Metcalf, M.D. (Eds.), Intermountain Archaeology. University of Utah Anthropological Papers Number 122. University of Utah Press, Salt Lake City, pp. 100–115.

Madsen, D.B., 2000b. Late Quaternary Paleoecology in the Bonneville basin. Utah Geological Survey Bulletin 130 190 p.

Mensing, S.A., 2001. Late-glacial and early Holocene vegetation and climate change near Owens Lake, eastern California. Quaternary Research 55, 57–65.

Minkley, T.A., Bartlein, P.J., Shinker, J.J., 2004. Paleoecological response to climate change in the Great Basin since the last glacial maximum. In: Jenkins, D.L., Connolly, T.J., Aikens, C.M. (Eds.), Early and Middle Holocene Archaeology of the Northern Great Basin. University of Oregon Anthropological Papers 62. Museum of Natural History and Department of Anthroology, University of Oregon, Eugene, pp. 21–30.

Minckley, T.A., Whitlock, C., Bartlein, P.J., 2007. Vegetation, fire, and climate history of the northwestern Great Basin during the last 14,000 years. Quaternary Science Reviews 26, 2167–2184.

Morrison, R.B., 1964. Lake Lahontan: Geology of the Southern Carson Desert U.S. Geological Survey Professional Paper 401.

Morrison, R.B., 1991. Quaternary stratigraphic, hydrologic, and climatic history of the Great basin, with emphasis on Lake Lahontan, Bonneville, and Tecopa. In: Morrison, R.B. (Ed.), Quaternary Nonglacial Geology: Conterminous U.S. Geological Society of America, Boulder, pp. 283–320.

Nelson, A. R., 1998. A craniofacial perspective on North American Indian population affinities and relations. Ph.D. dissertation, Department of Anthropology, University of Michigan.

Negrini, R.M., 2002. Pluvial lake sizes in the northwestern Great Basin throughout the Quaternary period. In: Hersler, R., Madsen, D.B., Currey, D.R. (Eds.), Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, vol. 33. Smithsonian Institution Press, Washington, D.C, pp. 11–52.

Neves, W.A., Blum, M., 2000. The Buhl burial: a comment on Green et al. American Antiquity 65, 191–193.

Nowak, C.L., Nowak, R.S., Tausch, R.J., Wigand, P.E., 1994. A 30 000 year record of vegetation dynamics at a semi-arid locale in the Great Basin. Journal of Vegetation Science 5, 579–590.

Oviatt, C.G., 1988. Late Pleistocene and Holocene lake fluctuations in the Sevier Lake Basin, Utah, USA. Journal of Paleolimnology 1, 9–21.

Oviatt, C.G., 1997. Lake Bonneville fluctuations and global climate change. Geology 25 (2), 155–158.

Oviatt, C.G., 2002. Bonneville basin lacustrine history: the contributions of G.K. Gilbert and Ernst Antevs. In: Hersler, R., Madsen, D.B., Currey, D.R. (Eds.), Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, vol. 33. Smithsonian Institution Press, Washington, D.C, pp. 121–128.

Oviatt, C.G., Currey, D.R., Miller, D.M., 1990. Age and paleoclimatic significance of the Stansbury shoreline of Lake Bonneville, northeastern Great Basin. Quaternary Research 33, 291–305.

Oviatt, C.G., Miller, D.M., Zachary, C., McGeehin, J., 2001. Refining the age of the lake transgression to the Gilbert shoreline in the Lake Bonneville basin, Utah, USA. EOS, Transactions, American Geophysical Union Fall Meeting Supplement 82, F755.

Oviatt, C.G., Madsen, D.B., Schmitt, D.N., 2003. Late Pleistocene and early Holocene rivers and wetlands in the Bonneville basin of western North America. Quaternary Research 60, 200–210.

Oviatt, C.G., Miller, D.M., McGeehin, J.P., Zachary, C., Mahan, S., 2005. The Younger Dryas phase of Great Salt Lake, Utah, USA. Palaeogeography, Palaeoclimatology, Palaeoecology 219, 263–284.

Parmalee, P.W., 1988. Avian remains from Danger Cave. In: Grayson, D.K. (Ed.), Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas. Anthropological Papers of the American Museum of Natural History, Part 1. New York, vol. 66, pp. 37–43.

Pitblado, B.L., 2003. Late Paleoindian Occupation of the Southern Rocky Mountains: Early Holocene Projectile Points and Land Use in the High Country. University Press of Colorado, Boulder. 292 p.

Powell, J.F., 2005. The First Americans: Race, Evolution, and the Origin of Native Americans. Cambridge University Press, Cambridge. 268 p.

Quade, J., Forester, R.M., Pratt, W.L., Carter, C., 1998. Black Mats, Spring-fed Streams, and Late-glacial-age Recharge in the Southern Great Basin.

Rasmussen, S.O., Andersen, K.K., Svensson, A.M., Steffensen, J.P., Vinther, B.M., Calusen, H.B., Siggaard-Andersen, M.-L., Johnsen, S.J., Larsen, L.B., Dahl-Jensen, D., Bigler, M., Röthlisberger, R., Fischer, H., Goto-Azuma, K., Hansson, M.E., Ruth, U., 2006. A new Greenland ice core chronology for the last glacial termination. Journal of Geophysical Research 111, D06102.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heation, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., Weyhenmeyer, C.E., 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon 51, 1111–1150.

Rhode, D., 2000a. Middle and late Wisconsin vegetation history in the Bonneville basin. In: Madsen, D.B. (Ed.), Late Quaternary Paleoecology in the Bonneville basin. Utah Geological Survey Bulletin, vol. 130, pp. 137–148.

Rhode, D., Madsen, D.B., 1998. Pine nut use in the early Holocene and beyond: the Danger Cave archaeobotanical record. Journal of Archaeological Science 25, 1199–1210.

Rhode, D., 2000b. Holocene vegetation history in the Bonneville basin. In: Madsen, D.B. (Ed.), Late Quaternary Paleoecology in the Bonneville Basin. Utah Geological Survey Bulletin, vol. 130, pp. 149–164.

Rhode, D., Louderback, L.A., 2007. Dietary plant use in the Bonneville basin during the terminal Pleistocene/early Holocene transition. In: Graf, K.E., Schmitt, D.N.

(Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 231–247.

Rhode, D., Madsen, D.B., 1995. Late Wisconsin/early Holocene vegetation in the Bonneville basin. Quaternary Research 44, 246–260.

Rhode, D., Goebel, T., Graf, K.E., Hockett, B.S., Jones, K.T., Madsen, D.B., Oviatt, C.G., Schmitt, D.N., 2005. Latest Pleistocene–early Holocene human occupation and paleoenvironmental change in the Bonneville basin, Utah-Nevada. In: Pederson, J., Dehler, C.M. (Eds.), Interior Western United States. Geological Society of America Field Guide 6, Boulder, pp. 211–230.

Rhode, D., Madsen, D.B., Jones, K.T., 2006. Antiquity of early Holocene small-seed consumption and processing at Danger Cave. Antiquity 80, 328–339.

Russell, I.C., 1885. Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada. Monographs of the United States Geological Survey 11, 288.

Schmitt, D.N., Madsen, D.B., Oviatt, C.G., Quist, R., 2007. Late Pleistocene/early Holocene geomorphology and human occupation of the Old River Bed Delta, western Utah. In: Graf, K.E., Schmitt, D.N. (Eds.), Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene–Holocene Transition. University of Utah Press, Salt Lake City, pp. 105–119.

Schroedl, A.R., Coulam, N.J., 1989. Bonneville Estates Rockshelter: Cultural Resources Report 435-01-8906. P-III Associates, Salt Lake City. Unpublished report submitted to Bureau of Land Management, Elko, Nevada.

Schroeder, M.A., Young, J.R., Braun, C.E., 1999. *Centrocerus urophasianus*: Sage Grouse. The Birds of North America, vol. 425 28 p.

Smith, G.I., Street-Perrott, F.A., 1983. Pluvial lakes of the western United States. In: Wright, Jr, H.E., Porter, S.C. (Eds.), Late-Quaternary Environments of the United States. The Late Plesitocene, vol. 1. University of Minnesota Press, Minneapolis, pp. 190–214.

Steele, D.G., Powell, J.F., 1999. Peopling of the Americas: a historical comparative perspective. In: Bonnichsen, R., (Ed.), Who Were the First Americans? Center for the Study of the first Americans. Oregon State University, Corvallis, pp. 97–126.

Thompson, R.S., 1985. The age and environment of the Mount Moriah (Lake Mohave) occupation at Smith Creek Cave, Nevada. In: Mead, J.I., Meltzer, D.J. (Eds.), Environments and Extinctions: Man in Late Glacial North America. Center for the Study of Early Man. University of Maine at Orono, pp. 111–119.

Thompson, R.S., 1992. Late Quaternary environments in Ruby Valley, Nevada. Quaternary Research 37, 1–15.

Thompson, R.S., Benson, L.V., Hattori, E.M., 1986. A revised chronology for the last Pleistocene lake cycle in the central Lahontan basin. Quaternary Research 25, 1–9.

Tuohy, D.R., Dansie, A., 1997. New information regarding early Holocene manifestations in the western Great Basin. Nevada Historical Society Quarterly 40 (1), 24–53.

Wells, S.G., Brown, W.J., Enzel, Y., Anderson, R.Y., McFadden, L.D., 2003. Late Quaternary geology and paleohydrology of pluvial Lake Mojave, southern California. In: Enzel, W., Wells, S.G., Lancaster, N. (Eds.), Paleoenvironments and Paleohydrology of the Mojave and Southern Great Basin Deserts. Geological Society of America Special Paper 308, Boulder, Colorado, pp. 79–114.

Wigand, P.E., Rhode, D., 2002. Great Basin vegetation history and aquatic systems: the last 150,000 years. In: Hersler, R., Madsen, D.B., Currey, D.R. (Eds.), Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, vol. 33. Smithsonian Institution Press, Washington, D.C, pp. 309–367.