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Terminal Pleistocene/Early Holocene Environmental Change at the Sunshine Locality, North-Central Nevada, U.S.A.

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Sedimentological, faunal, and archaeological investigations at the Sunshine Locality, Long Valley, Nevada reveal a history of human adaptation and environmental change at the last glacial–interglacial transition in North America's north-central Great Basin. The locality contains a suite of lacustrine, alluvial, and eolian deposits associated with fluvially reworked faunal remains and Paleoindian artifacts. Radiocarbon-dated stratigraphy indicates a history of receding pluvial lake levels followed by alluvial downcutting and subsequent valley filling with marsh-like conditions at the end of the Pleistocene. A period of alluvial deposition and shallow water tables (9,800 to 11,000 ^{14}C yr B.P.) correlates to the Younger Dryas. Subsequent drier conditions and reduced surface runoff mark the early Holocene; sand dunes replace wetlands by 8,000 ^{14}C yr B.P. The stratigraphy at Sunshine is similar to sites located 400 km south and supports regional climatic synchroneity in the central and southern Great Basin during the terminal Pleistocene/early Holocene. Given regional climate change and recurrent geomorphic settings comparable to Sunshine, we believe that there is a high potential for buried Paleoindian features in primary association with extinct fauna elsewhere in the region yet to be discovered due to limited stratigraphic exposure and consequent low visibility.
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Key Words: **stratigraphy; fauna; Paleoindian; Younger Dryas; Great Basin.**

INTRODUCTION

There is growing evidence that climate change at the end of the Pleistocene was both rapid and global in extent. Several types of proxy paleoclimatic records have long been used to gain insight into the nature and timing of glacial–interglacial climate change, but it has only been recently, particularly with the advent of ice core studies, that we have been able to determine that dramatic shifts in climate can occur at decadal to century timescales (Severinghaus *et al.*, 1998; Taylor, 1999), a frequency much greater than can be attributed to orbital forcing. These rapid oscillations in climate have been linked to interactions between the Laurentide ice sheet and deep-water formation in the North Atlantic (Broecker, 1994), possibly enhanced by tidal-driven

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vertical mixing in the oceans (Keeling and Whorf, 2000). Although these ocean–glacial processes are driven by mechanisms confined to a specific part of the northern hemisphere, their effect on climate appears to be global (Benson *et al.*, 1997; Denton and Hendy, 1994).

The idea that environmental change in nonglacial settings is linked to distant glacial processes is not new. For example, Antevs (1948) hypothesized that the Laurentide ice sheet played a role in the relatively moist pluvial, late-Pleistocene conditions of the Great Basin in western North America by pushing the westerly storm track farther south. More recent paleoenvironmental studies (Thompson *et al.*, 1993) support that hypothesis, and researchers have linked Great Basin environmental change with distant North Atlantic phenomena such as Dansgaard–Oscher oscillations and Heinrich events (e.g., Benson *et al.*, 1997; Madsen, 2000; Oviatt, 1997; Quade *et al.*, 1998). With ice-core studies, there is decadal temporal resolution in identifying some of these major climatic shifts, but less temporal precision of possible teleconnected events in places such as the Great Basin. Moreover, the specific impacts of these ocean–glacial interactions in the Great Basin and elsewhere are unlikely to be synchronous over a broad area. Geomorphic and biological responses to climate change can vary significantly in space due to varying intrinsic dynamics and thresholds. Consequently, even though environmental change in the Great Basin during the Pleistocene to Holocene transition can be broadly correlated with events in the North Atlantic, the type, timing, and regionality of that environmental change still need to be better defined.

This paper focuses on the last glacial–interglacial transition in the Great Basin by presenting the results of interdisciplinary investigations at the Sunshine Locality, a buried, Paleoindian archaeological site that contains a terminal Pleistocene/early Holocene stratigraphic record. Although terminal Pleistocene/early Holocene archaeological sites are known in the Great Basin, nearly all are surface sites that lack associated buried deposits and therefore provide little paleoenvironmental information. In contrast, the Sunshine Locality contains fluvially reworked Paleoindian and Rancholabrean fauna in a depositional sequence that correlates well with other geological–climatic records in the Great Basin. Our study supports the notion that local geomorphic change is associated with a regional environmental shift linked to global climatic events during the terminal Pleistocene/early Holocene.

THE SUNSHINE LOCALITY

The Sunshine Locality is part of a National Historic District that encompasses nearly 60 km^2 located in southern Long Valley, about 60 km northwest of Ely, Nevada (Fig. 1), at the eastern edge of the central Great Basin. The study area consists of linear, north-trending mountain ranges separating hydrologically closed valleys. Mountains are block-faulted and composed primarily of Paleozoic limestone. Relief between valleys and mountains in the study area exceeds 1220 m but reaches 2000 m in surrounding areas. This area is a mid-latitude desert-steppe, with cold winters and warm summers and a mean annual precipitation of 250 mm. Valleys contain dry lakebed and shoreline features indicating that lakes formerly occupied these lowlands (Mifflin and Wheat, 1979). At an elevation of 1873 m, vegetation in the valley bottom is dominated by a shadscale (*Atriplex confertifolia*) and sagebrush (*Artemisia tridentata*) steppe including big sagebrush winterfat (*Ceratoides lanta*), rabbitbrush (*Chrysothamnus nauseosus*), and Indian ricegrass (*Orzyopsis hymenoides*).

The Historic District encompasses a rich terminal Pleistocene/early Holocene surface archaeological record, principally bordering a stream channel herein referred to as Sunshine Wash (Fig. 1). Sunshine Wash begins east of Sunshine Well where a number of smaller washes draining the southeastern piedmont of Long Valley dissect relict beach deposits of Pluvial lake Hubbs (see Mifflin and Wheat 1979, Fig. 8) and join to form a single broad channel, in places nearly one-half kilometer wide. Incised into lacustrine deposits, the wash travels generally northwest for several kilometers before ending in multiple distributary channels on the valley floor. Sunshine Wash thus postdates the latest Pleistocene high stand of Pluvial Lake Hubbs, dated by Young and McCoy (1984) at $17{,}520 \pm 570$ ^{14}C yr B.P., using mollusks from the higher shorelines.

Excavations

The Sunshine Locality has been investigated intermittently by archaeologists and geologists for three decades (e.g., Hutchinson, 1988; Tadlock, 1966; York, 1974). In 1987 the Desert Research Institute (DRI) in cooperation with the Nevada State Museum placed a series of deep backhoe trenches in Sunshine Wash and atop the adjacent terraces to better define the vertical sequence and horizontal extent of geological deposits (Nials and Davis, 1990; Fig. 1). These excavations discovered mammal (including *Camelops*), fish, and bird bone (Dansie, 1990), organic lenses, and several small flake artifacts (Hicks, 1990), all contained in alluvial deposits at significant depths (ca. 3 m). In 1993, a 5×6 m block was excavated 4 m deep by Beck and Jones near areas previously trenched and augered in 1987 and 1992 (Fig. 1), yielding a total of 6,738 lithic artifacts and 801 identifiable faunal specimens (Jones *et al.*, 1996). Most of the artifacts and fauna were contained in redeposited slopewash at the top of the stratigraphic section; more than 700 artifacts and 150 identifiable faunal specimens, however, were recovered from the alluvial sediments near the base of the section. In 1995, a backhoe and front-end loader were used to excavate a series of stratigraphic trenches across Sunshine Wash (Huckleberry *et al.*, 1997). At the base of the alluvial section in one trench (ST3) an approximately 10-cm-thick gravelly sand lens was excavated that contained lithic tools in apparent association with bones of *Camelops hesternus*. Alluvial sediments roughly contemporaneous with those in ST3 and containing artifacts and fauna were

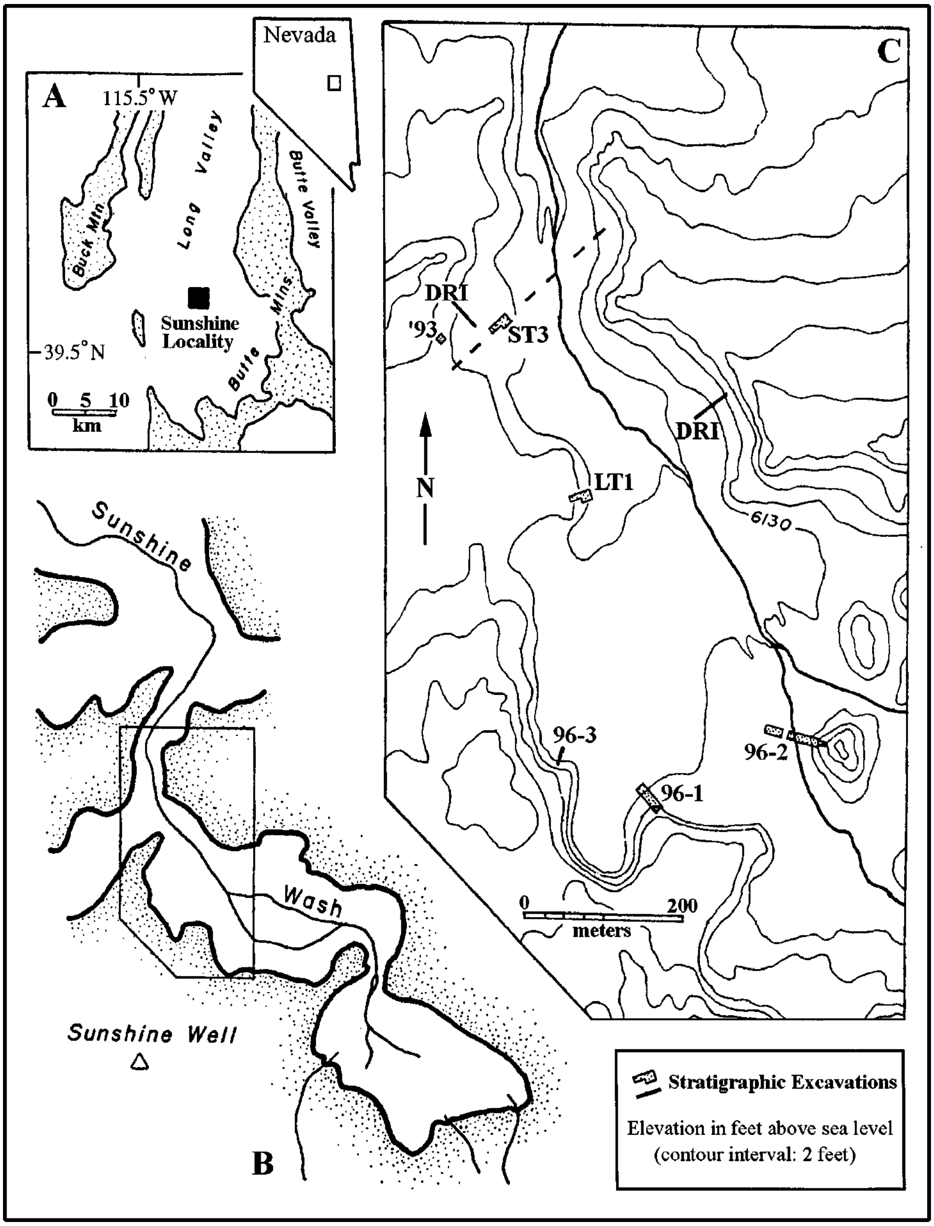

FIG. 1. Location map of Sunshine Locality study area. See text for excavation descriptions.

also excavated at LT1. In 1996 additional bones of *Camelops* and *Equus* were recovered at ST3 together with other faunal remains and artifacts. Finally, in 1997 excavations were extended south, revealing a greater variety of depositional environments (Holmes, 1998).

All artifactual and faunal material recovered from the alluvial sediments are assumed to be redeposited as they are associated with coarse sands and gravels in channel cut and fill sequences (see below), suggesting a relatively high energy fluvial regime. Clearly, these materials are derived from somewhere upstream; but because they show little fluvial abrasion, we believe they are locally derived.

Stratigraphy and Chronology

The Sunshine Locality contains lacustrine, alluvial, and eolian sediments with buried paleosols (Figs. 2 and 3). Surprisingly, the overall stratigraphic sequence varies little over a 1.5 km reach of Sunshine Wash. We recognize seven stratigraphic units (adapted from Jones *et al.* 1996[2]) and subdivide part of the alluvial sequence into channel and distal alluvial fan facies.

[2] Based on chronological and lithological similarity, and in an effort to simplify stratigraphic nomenclature, we combine Jones *et al.*'s (1996) Strata D and E (both sandy alluvium) into Stratum D, and Strata F and G (both gravelly sandy alluvium) into Stratum E.

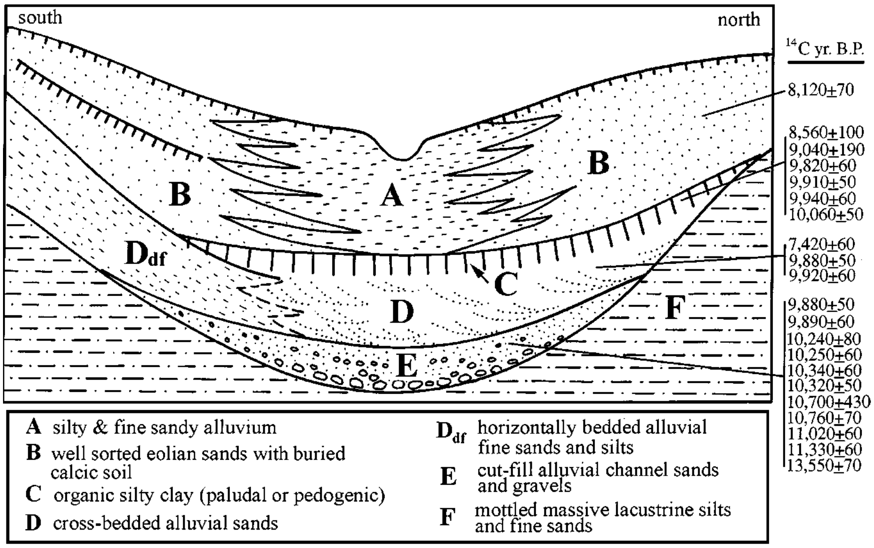

FIG. 2. Schematic stratigraphy at the Sunshine Locality.

The oldest sediments (Unit F) are lacustrine and associated with Pluvial Lake Hubbs (Fig. 2). These deposits consist of indurated fine sands and silts with occasional oblate beach gravels mottled olive and orange, indicative of fluctuating water tables. Unit E is composed of alluvial sands and gravels inset into the lacustrine deposits. These high energy stream deposits record conditions when Sunshine Wash supported a more competent braided channel; sediments are mottled olive and orange and contain fluvially transported bones of *Camelops, Equus,* small mammals, fishes, and birds, as well as artifacts (Jones *et al.*, 1996). Unit D overlies E and has two primary facies. One is a channel facies marked by channel cut and fill stratigraphic boundaries and cross-bedded sands. The other facies occurs in the southern part of the Sunshine Locality where distal alluvial fan deposits interfinger with the channel deposits of Sunshine Wash. Designated D_{df}, these deposits are characterized by fine sand and silty thin beds that extend laterally over several meters. Presumably, they were formed by predominant sheetflow on the distal ends of fans flanking the southern margin of Long Valley. Unit C is a dark brown, silty clay organic-rich zone containing animal bone, artifacts, and algal spores and represents either a shallow pond deposit or wetland soil (Holmes, 1998). Unit C is commonly associated with a whitish marl deposit typical of paludal environments. However, Unit C also contains ped structure and bioturbation features and is traceable upslope onto the banks of Sunshine Wash. Such organic zones in southern Nevada can form by either paludal or pedogenic processes (Quade *et al.*, 1998). Unit C records diminished stream discharge but persistent shallow water tables and phreatophytic vegetation.

The uppermost deposits at Sunshine consist of interfingering well-sorted eolian sands (Unit B) and silty to fine sandy alluvium (Unit A) and reflect drier conditions and ephemeral streamflow. Both deposits are heavily bioturbated, although such mixing is best expressed where a calcic paleosol is preserved within Unit B. Carbonate morphology (Stage II) and biofabric dominated by cicada burrows suggest several thousand years of pedogenesis. Regional soil chronosequences (Harden *et al.*, 1991) suggest a mid-Holocene age (ca. 4,000–8,000 ^{14}C yr B.P.) for this soil. In

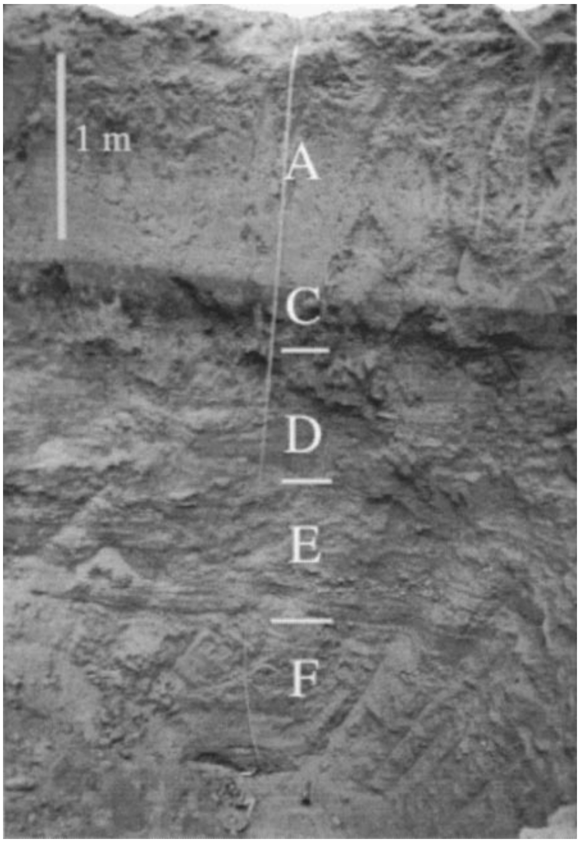

FIG. 3. Photograph of stratigraphy at ST3.

TABLE 1
Radiocarbon Ages from the Sunshine Locality, Nevada

Stratum	Beta lab number	Radiocarbon age[a] (^{14}C yr B.P.; 1 σ)	Calibrated years B.C. (1 σ)[b]	δ^{13}C[c]	^{14}C method	Sample type[d]	Provenience
B	105660	8120 ± 70	7288–7056	−25.0*	Conv.	OS	eolian sands
C	69781	8560 ± 100	7674–7538	—	Conv.	OS	top of organic zone
C	86200	9040 ± 190	8452–7965	−25.0*	Conv.	OS	center of organic zone
C	69782	9820 ± 60	9282–9230	−26.0	Conv.	CH	top of organic zone
C	86202	9910 ± 50	9386–9277	−25.5	AMS	CH	center of organic zone
C	86203	9940 ± 60	9597–9281	−25.9	AMS	OS	center of organic zone
C	86204	10060 ± 50	9948–9392	−28.4	AMS	OS	center of organic zone
D	86199	7420 ± 60	6383–6223	−27.9	AMS	OS	sandy channel fill
D	86201	9880 ± 50	9346–9253	−27.2	AMS	CH	sandy channel fill
D	86198	9920 ± 60	9586–9278	−26.7	AMS	CH	sandy channel fill
E	86206	9880 ± 50	9346–9253	−26.1	AMS	CH	gravelly channel fill
E	105659	9890 ± 60	9384–9253	−26.9	AMS	CH	gravelly channel fill
E	69779	10240 ± 80	10365–9753	−25.2	AMS	CH	gravelly channel fill
E	69780	10250 ± 60	10363–9813	−25.7	AMS	CH	gravelly channel fill
E	83090	10340 ± 60	10620–9999	−27.4	AMS	CH	gravelly channel fill
E	86205	10320 ± 50	10398–9993	−26.6	AMS	CH	gravelly channel fill
E	37515	10700 ± 430	11193–10011	−25.6	Conv.	CH	gravelly channel fill
E	105658	10760 ± 70	10998–10701	−33.0	AMS	CH	gravelly channel fill
E	105657	11020 ± 60	11192–10955	−30.6	AMS	CH	gravelly channel fill
E	105662	11330 ± 60	11487–11207	−21.6	AMS	BC	gravelly channel fill
E	105661	13550 ± 70	14564–14090	−31.5	AMS	CO	gravelly channel fill

[a] All ages are ^{13}C/^{12}C corrected except Beta #69781, which is reported in uncorrected ^{14}C yr B.P. All radiocarbon samples but the camel phalanx received standard acid (HCl)/alkali(NaOH)/acid pretreatment by Beta Analytic prior to analysis. Collagen extraction from the camel phalanx (Beta-105662) was done by first applying cold HCl acid repeatedly until the mineral fraction (bone apatite) was eliminated, and second, by applying alkali (NaOH) to ensure the absence of secondary organic acids.
[b] Calendar ages determined with program CALIB 4.3 for MacIntosh (Stuiver and Reimer, 1993).
[c] * ^{13}C/^{12}C value estimated based on material type.
[d] OS = organic sediment; CH = charred material; CO = calcitic concretion; BC = bone collagen from camel phalanx.

contrast, the surface soil is much more weakly developed and contains only a thin cambic B horizon.

A total of 20 ^{14}C dates have been obtained from the Sunshine Locality (Table 1; Fig. 2). Ten dates are from Unit E, nine of which range between 11,390 and 9860 yr B.P.; the tenth date of 13,450 ± 70 ^{14}C yr B.P. (Beta-105661) was obtained on a hard calcitic concretion that is believed to have been reworked from older lacustrine deposits. Three dates were obtained on organic material from Unit D. Two of these dates, 9840 ± 50 (Beta-86201) and 9920 ± 60 ^{14}C yr B.P. (Beta-86198), suggest that very little time separates the deposits of D from the upper levels of E. The third date of 7380 ± 60 ^{14}C yr B.P. (Beta-86199) was obtained on the humate fraction from organic sediment and is likely contaminated by younger carbon. Six dates were obtained on material from Unit C. Four of these dates range between 10,000 and 9800 ^{14}C yr B.P. The two remaining dates of 8560 ± 100 (Beta-69781) and 9040 ± 190 ^{14}C yr B.P. (Beta-86200) are conventional dates on organic sediment and are also likely too young. A single ^{14}C date of 8120 ± 70 ^{14}C yr B.P. (Beta-105660) comes from the lower part of Unit B and provides a maximum age for the mid-Holocene calcic soil which overlies it. All of the ^{14}C samples except the camel phalanx have measured δ^{13}C values (Table 1) that range from −25 to −31.5‰, indicative of C3 plants (trees, shrubs, tall grasses, and sedges); the camel phalanx has a δ^{13}C value of −21.6‰, suggesting the herbivore had a mixed diet of C3 (summer grasses) and C4 plants.

Artifacts and Fauna

Four seasons of excavation at the Sunshine Locality produced a total of 7,771 artifacts (Table 2). The majority of these artifacts were recovered during the 1993 season from unit A ($N = 5922$), but a substantial number were recovered from Units C, D, and E. Most artifacts are small biface-thinning flakes, pressure flakes, or shatter; retouched tools comprise only a small portion of the overall assemblage. The diversity of these tools, however, is greater than at any other Paleoindian site (surface or subsurface) in eastern Nevada, and perhaps for much of the entire Great Basin (see Beck and Jones, 1997).

In 1993 a point of the Great Basin Stemmed Series was found *in situ*, situated directly on a charcoal lens overlying Unit C. The projectile point appeared to lay conformably upon the upper contact of the lens, and thus we believe the AMS date of 9820 ± 60 ^{14}C yr B.P. (Beta-69782) on the charcoal lens (Table 1)

TABLE 2
Artifacts Recovered from Excavations at the Sunshine Locality, 1993–1997

Stratum	Technological category	*N*	Totals
A	Decortication Flake	64	
	Interior Flake	3403	
	Uniface	3	
	Biface	18	
	Split Pebble	47	
	Shatter/Chunks	2392	
			5927
B	Decortication Flake	5	
	Interior Flake	287	
	Uniface	5	
	Biface	1	
	Shatter/Chunks	326	
			624
C	Interior Flake	29	
	Shatter/Chunks	10	
			39
C–D	Point	1	
			1
D	Interior Flake	13	
	Shatter/Chunks	3	
			16
B–D_{df}	Decortication Flake	1	
	Interior Flake	19	
	Point	1	
	Shatter/Chunks	18	
			39
D_{df}	Decortication Flake	3	
	Interior Flake	32	
	Shatter/Chunks	55	
			90
E	Decortication Flake	54	
	Interior Flake	701	
	Uniface	6	
	Point	14	
	Biface	6	
	Split Pebble	1	
	Shatter/Chunks	253	1035
Total All Strata			7771

provides a very close age estimation for the point (Jones *et al.*, 1996). In 1995 a crescent and fluted point were recovered from Unit E in LT1. Charcoal recovered 12 cm directly above these artifacts in Unit E yielded a date of 10, 340 ± 60 ^{14}C yr B.P. (Beta-83090), providing at least a limiting date for these artifacts at the site. Also in 1995, a stem section of a Great Basin Stemmed Series point, an andesite biface, and a scraper were found adjacent to and directly beneath several large bones, including a scapula, a phalanx, and an unciform of *Camelops hesternus*, with the phalanx directly dated at 11,390 ± 60 ^{14}C yr B.P. (Beta-105662) (see below). As stated above, however, because of the context in which these bones and artifacts occur (i.e., coarse sands and gravels), the association between these remains is equivocal.

A total of 2,679 faunal specimens were recovered during the 1993, 1995, and 1996 excavations at Sunshine, of which 892 are identifiable to the taxonomic level of order or more specific. As is the case with the artifacts, the majority of these specimens were retrieved from Unit A in 1993, but several specimens were also later retrieved from units E through C (Table 3). The most significant of the faunal remains from Sunshine are the *Camelops hesternus* specimens. Seven specimens were recovered in 1995 and an additional five in 1996. Also found was one molar enamel fragment identified as cf. *Camelops hesternus* and a horse (*Equus* sp.) incisor. In addition to these identifiable specimens, 19 unidentifiable bone fragments from very large, camel- or horse-sized mammals were also recovered. All of the 13 *Camelops* specimens could be accounted for by a single animal, although it is by no means certain that only one animal is represented here. *Camelops* remains were also recovered in the 1987 trenching by DRI and the Nevada State Museum (Dansie, 1990). All horse and camel remains with known stratigraphic provenience are from Unit E.

One of the *Camelops* specimens (the phalanx found in 1995) has been directly dated by AMS dating of bone collagen (Table 1). This specimen dates to 11,390 ± 60 ^{14}C yr B.P. (Beta-105662). This date is some 300 radiocarbon years older than the oldest charcoal date from the associated gravels (10,930 ± 60 ^{14}C yr B.P. (Beta-105657)), which suggests that this camel bone may have been redeposited from an older channel or terrace eroded by the stream. However, the condition of most of the camel bones, as well as other bones and artifacts found in this stratum, suggests a limited transport distance. The AMS date on the *Camelops* phalanx is significant from a purely paleontological point of view as it makes this specimen the youngest well-dated *Camelops* from within the Great Basin (see dates in Grayson, 1993). This date is also among the youngest for any extinct Pleistocene taxon in the Basin and is one of the youngest dates on *Camelops* from anywhere in North America.

In addition to the camel and horse specimens, the remains of smaller mammals, fishes, and birds were also recovered from the terminal Pleistocene strata at Sunshine (Table 3) and provide some information about environmental conditions at the time of their deposition that is broadly consistent with the geological record. The bird assemblage is particularly important in that there are very few terminal Pleistocene/early Holocene avian faunal assemblages known from the Great Basin, and none have been excavated from eastern Nevada or adjacent Utah. Bird specimens recovered from Units C, D, and E are indicative of a wetland habitat. Taxa identified include two genera of ducks (*Anas* sp. and *Aythya* sp.), geese (*Branta* sp.), swans (*Cygnus* sp.), grebes (cf. *Podiceps* sp.), and unidentified shorebirds (Scolopacidae). In addition to these waterbirds, the remains of Sharp-shinned Hawk (*Accipiter striatus*) and Black-billed Magpie (*Pica pica*) were also recovered from the lower strata; these birds are typical Great Basin desert species but are usually found in habitats more mesic than Long Valley is today. A total of 25 fish specimens have also been recovered from Unit E, but due to the highly fragmentary nature of these specimens, none could be securely identified below the taxonomic level of family. The

TABLE 3
Identified Faunal Specimens Recovered at the Sunshine Locality, 1993–1996

Taxon	Stratum A	B	C	D	E	n.a.[a]	Total
FISHES							
Salmonidae (Trouts)					1		1
Cypriniformes (Minnows and Suckers)					9		9
Cyprinidae (Minnows)					13		13
Catostomidae (Suckers)					2		2
BIRDS							
Podiceps sp. (Grebes)					2		2
Anatidae (Waterfowl)			1		4		5
Cygnus sp. (Swans)					1		1
Branta sp. (Geese)					3		3
Anas sp. (Dabbing Ducks)				3	7		10
Aythya sp. (Diving Ducks)			2		10	1	13
Accipiter striatus (Sharp-Shinned Hawk)			1				1
Scolopacidae (Shorebirds)					1		1
Passeriformes (Perching Birds)					2		2
Pica pica (Black-Billed Magpie)					1		1
Oreoscoptes montana (Sage Thrasher)	1						1
MAMMALS							
Leporidae (Rabbits and Hares)	30		8	2	26		66
Brachylagus idahoensis (Pygmy Rabbit)	11				8		19
Sylvilagus sp. (Cottontail Rabbits)	4		1		7		12
Lepus sp. (Jackrabbits)	6				6		12
Sciuridae (Squirrels and Allies)	211	29	11		9		260
Tamias sp. (Chipmunks)	1						1
Spermophilus sp. (Ground Squirrels)	16		1				17
Spermophilus townsendii (Townsend's Ground Squirrel)	107	19	14				140
Thomomys sp. (Pocket Gophers)	134	20	25	1	4		184
Thomomys bottae (Botta's Pocket Gopher)	19	1	4				24
Dipodomys sp. (Kangaroo Rats)	5				2		7
Dipodomys ordii (Ord's kangaroo Rat)	3						3
Peromyscus sp. (White-footed Mice)	3		1				4
Neotoma cinerea (Bushy-tailed Wood Rat)				1			1
Arvicolinae (Voles)	18	2	2		11		33
Microtus sp. (Meadow Voles)			1	1	7	1	10
Lemmiscus curtatus (Sagebrush Vole)	6				2		8
Canidae (Coyote, Wolves, and Foxes)					1		1
Canis latrans (Coyote)					1		1
Vulpes vulpes (Red Fox)					1		1
Mustela vison (Mink)					1		1
Equus sp. (Horse)					1		1
Artiodactyla (Even-toed Ungulates)	1				5	2	8
Camelops hesternus (Yesterday's Camel)					11	2	13
TOTAL NISP	576	71	72	8	159	6	892
UNIDENTIFIED	433	52	151	29	1089	33	1787

[a] Stratigraphic provenience is not available for these specimens.

families represented include Cyprinidae (Minnows), Catostomidae (Suckers), and Salmonidae (Trouts, Chars, and Whitefishes). These fauna indicate that the locality supported permanent water, assuming that the bones are not redeposited from lacustrine sediments.

Of the small mammal remains from the terminal Pleistocene strata, two taxa were recovered representing species that inhabit areas more mesic than Sunshine is today. One of these taxa is the genus *Microtus* (Meadow Voles). Although none of these specimens could be identified below the generic level, Meadow Voles in general tend to prefer more mesic conditions than exist at Sunshine today (e.g., Hall, 1946). The only voles recovered from the upper eolian and alluvial strata (Units A and B) were Sagebrush Voles (*Lemmiscus curtatus*), which prefer sagebrush-(Artemesia-) covered areas such as are currently found in the area. The other significant small mammal taxon is the Bushy-tailed Wood Rat (*Neotoma cinerea*) represented by a single specimen. This species today tends to prefer cool habitats and is generally found only at higher elevations within the Great Basin, although a few individuals have been collected or sighted at elevations lower than that of the floor of Long Valley (Hall, 1946; Grayson *et al.*, 1996).

COMPARISON WITH REGIONAL RECORDS

The geological and faunal record at the Sunshine Locality indicates a period of greater effective moisture at the Pleistocene to Holocene transition followed by increased aridity. As Pluvial Lake Hubbs receded during a period of reduced effective moisture prior to 11,300 ^{14}C yr B.P., local alluvial base levels lowered, and streams draining adjacent piedmonts incised into older beach deposits and lake beds. This corresponds to packrat midden evidence in the Bonneville Basin for significant warming approximately 14,000 to 12,000 ^{14}C yr B.P. (Rhode, 2000a). The coarse bedload in Units D and E suggests an ample discharge that was supplied largely by surface runoff, at least during certain times of the year, rather than baseflow. Sunshine Wash downcut and then backfilled with channel and bar deposits that grade upwards from coarse gravels to fine sand. This period of aggradation marked by perennial streamflow dates from 9,800 to 11,300 ^{14}C yr B.P. and appears to mark an episode of increased moisture but without Lake Hubbs rising to previous lake levels. Stream competence and discharge diminished 9,000 to 9,800 ^{14}C yr B.P., but water tables remained shallow, resulting in the formation of Unit C. Water tables thereafter lowered, and after 8,500 ^{14}C yr B.P. deposition became dominated by a combination of ephemeral streamflow and dune activity. Deposition within the floodplain was episodic, allowing for the formation of a middle Holocene (approximately 4,000 to 8,000 ^{14}C yr B.P.) soil, but conditions never returned to the mesic riparian environments of 9,000 to 11,000 ^{14}C yr B.P.

Inferences about the hydrologic regimen at the Sunshine Locality during the terminal Pleistocene/early Holocene conform with regional geological evidence for increased moisture during

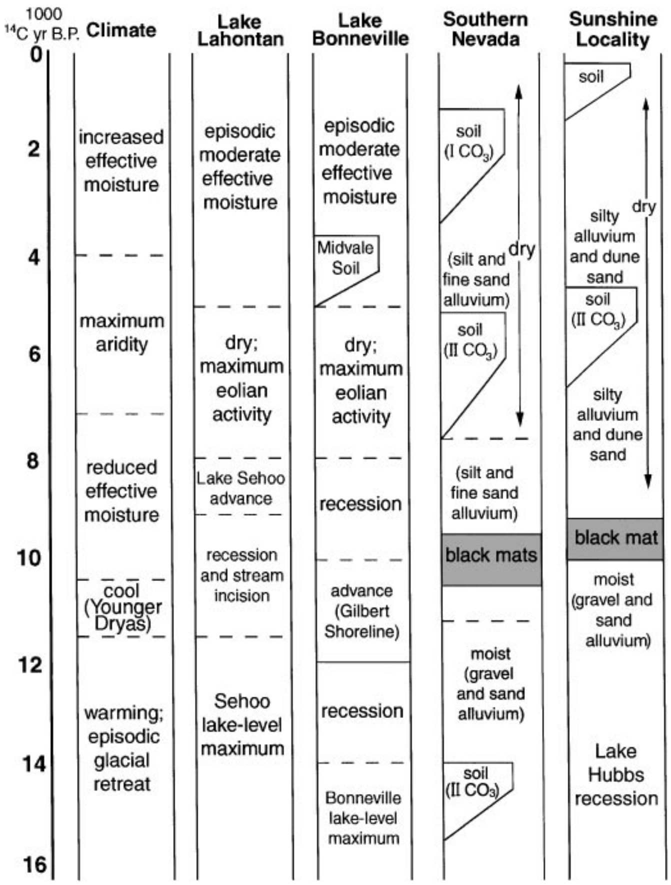

FIG. 4. Correlation of regional geologic–climatic events. Post-glacial climate adapted from Antevs (1948). Lake Lahontan sequence adapted from Benson and Thompson (1987) and Morrison (1991). Lake Bonneville sequence adapted from Currey (1990), Oviatt (1997), and Morrison (1991). Southern Nevada sequence adapted from Haynes (1967), Quade (1986), and Quade *et al.* (1998).

the Younger Dryas and significant drying thereafter (Fig. 4). Long Valley is situated between pluvial lakes Bonneville and Lahontan. Pluvial Lake Bonneville attained its maximum height approximately 15,000 ^{14}C yr B.P. when it broke through Red Rock Pass and flowed into the Snake River drainage (Malde, 1968; Morrison, 1991; Scott *et al.*, 1982). Pluvial Lake Lahontan reached its lake level maximum approximately 13,000 to 15,000 ^{14}C yr B.P (Benson and Thompson, 1987; Currey, 1990; Morrison, 1991; Thompson *et al.*, 1986). Both lakes thereafter recede, but Bonneville's latest Pleistocene recession reversed beginning around 12,000 ^{14}C yr B.P. and continued to do so until approximately 10,000 ^{14}C yr B.P. forming the Gilbert shoreline, a short-lived rise that has been correlated to the Younger Dryas (Oviatt, 1997). In contrast, Lake Lahontan appears to have had a short-lived rise much later, between 8,000 and 9,000 ^{14}C yr B.P. (Morrison, 1991). Aridity peaked in both lake systems 5,000 to 8,000 ^{14}C yr B.P., followed by relatively more yet episodic moist conditions during the late Holocene. A similar sequence is also suggested for pluvial Lake Franklin, located in the Ruby Valley 100 km north of Sunshine. There Thompson (1992) concludes that pluvial Lake Franklin apparently deepened about 10,800 ^{14}C yr B.P., following a possible episode of desiccation. By ca. 10,400 ^{14}C yr B.P. Lake Franklin had become more saline, probably as lake level receded. The shallow lake gave way to a marsh in the next millennium. Following a brief lake expansion about 8,750 ^{14}C yr B.P., shadscale steppe expanded onto the playa surfaces in Ruby Valley.

Alluvial sections in southern Navada basins near Las Vegas (Haynes, 1967; Quade, 1986; Quade *et al.*, 1998) show similarities to the Sunshine Locality (Fig. 4). The latest Pleistocene is characterized by coarse gravel grading upwards to finer sands, rich in aquatic mollusks and ostracods, suggestive of moist conditions with perennial streamflow. After ca. 11,000 ^{14}C yr B.P., sandy and finer alluvial muds commonly contain a dark organic zone or "black mat." These black mats are related to elevated water tables and increased spring activity and cluster in age at 9,500 to 10,500 ^{14}C yr B.P. (Quade *et al.*, 1998). Quade *et al.* (1998) suggest these black mats and associated spring-fed channels formed in response to moister conditions during the Younger Dryas and preserve the last episode of increased spring discharge before substantial drying occurred in the early Holocene.

Although brief periods of increased moisture punctuate the early Holocene (Morrison, 1991), most geologic and vegetational records point to progressively dryer conditions that peak during the mid-Holocene (Mehringer, 1986; Rhode, 2000b). The millennium preceding 10,000 yr B.P., by contrast, was far wetter, and cultural records known from the Younger Dryas suggest a human affinity for wetland habitats (Grayson, 1993). With dryer conditions in the early Holocene and probable restriction of wetlands, human diet breadth likely expanded, resulting in the increased use of a greater variety of environmental zones.

The Sunshine Locality is one of a very few archaeological sites in the Great Basin from which relatively large numbers of fluted points, crescents, and large stemmed points have been collected from the surface, and it is unique in this region of the Basin (Beck and Jones, 1997). In addition to the points and crescents, other tool types, including various forms of scrapers, gravers, burins, and knife-like bifaces, have been recovered by the hundreds, along with thousands of simple retouched flake tools. The assemblage recovered from the Pleistocene alluvial sediments also reflects this diversity and contains almost the full range of tool types comprising the classic Paleoindian toolkit (see Beck and Jones, 1997). The sheer number of tools represented continuously across the surface of this site for over five kilometers suggest fairly heavy use and reuse of this locality during the late Pleistocene/early Holocene interval. The diversity of tools suggests a wider range of activities than represented at other sites of this age in the region, whose assemblages are composed primarily of stemmed point fragments, bifaces in various stages of manufacture, and debitage (see Beck and Jones, 1997). Given the wetland habitat indicated during this period by both the sediments and faunal remains, we believe that Sunshine offered a fairly permanent locality of relatively greater productivity for late Pleistocene/early Holocene peoples whose adaptation is believed to have focused on wetland resources and perhaps large mammals.

SUMMARY AND CONCLUSIONS

Stratified terminal Pleistocene/early Holocene cultural records are rare in the central and eastern Great Basin, particularly those in open basin locations such as the Sunshine Locality. A decade of intermittent geoarchaeological study of the Sunshine Locality has revealed the depositional history and timing of paleoenvironmental change in Long Valley. The locality contains over 12,000 years of lacustrine, alluvial, and eolian deposits marking dramatic environmental shifts. To date, no artifacts of Paleoindian age have been found in primary association with extinct fauna. However, the paleoenvironmental information derived from Sunshine provides further data for understanding the nature of environmental change during the transition from glacial to interglacial in the east-central Great Basin and how this might have affected human use of the locality.

We believe that the Sunshine Locality records a period of increased effective moisture 9,800 to 11,000 ^{14}C yr B.P. that interrupts a period of overall drying during the deglaciation of the Northern Hemisphere. This adds to a growing list of geological evidence for the Younger Dryas affecting the western United States (Benson *et al.*, 1997; Clark and Bartlein, 1995). It also supports Ernst Antev's (1948) hypothesis that the Laurentide ice cap pushed the polar jet stream southward, thus diverting Pacific cyclonic storms over the Great Basin (see Mifflin and Wheat, 1979; Oviatt, 1997). Interestingly, the alluvial sequence at Sunshine is remarkably similar to that approximately 400 km to the south in the southern Great Basin (Quade *et al.*, 1998), suggesting a minimum latitudinal zone (36°–40° N) of enhanced moisture during the Younger Dryas in western North America. However, conditions rapidly became dryer in the northern Great Basin following the Younger Dryas, whereas desiccation was less dramatic to the south, perhaps as a result of summer insolation maxima and incursions of subtropical moisture (Kutzbach and Guetter, 1986; Spaulding and Graumlich, 1986; Thompson *et al.*, 1993). The last 8,000 years in the northern Great Basin has been remarkably dry in comparison to the terminal Pleistocene. Because geomorphic events at Sunshine during the Pleistocene/Holocene transition were driven by regional-scale climatic change, we believe that there are other buried alluvial sites with Paleoindian archaeology and extinct fauna—potentially with *in situ* associations—in the Great Basin in similar lower piedmont locations that have not yet been discovered because of poor exposure. Such areas warrant further scrutiny so we can further understand human adaptation in the Great Basin at the terminal Pleistocene/early Holocene boundary.

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