



ARTICLE

# Great Basin Survivance (USA): Challenges and Windfalls of the Neoglaciation / Late Holocene Dry Period (3100–1800 cal BP)

David Hurst Thomas<sup>1</sup> , David Rhode<sup>2</sup>, Constance I. Millar<sup>3</sup>, Douglas J. Kennett<sup>4</sup>, Thomas K. Harper<sup>5</sup> , and Scott Mensing<sup>6</sup>

<sup>1</sup>Division of Anthropology, American Museum of Natural History, New York, NY, USA, <sup>2</sup>Division of Earth and Ecosystem Sciences, Desert Research Institute, Reno, NV, USA, <sup>3</sup>USDA Forest Service, Pacific Southwest Research Station, Albany, CA, USA, <sup>4</sup>Department of Anthropology, University of California, Santa Barbara, CA, USA, <sup>5</sup>Department of Anthropology, Pennsylvania State University, University Park, PA, USA, and <sup>6</sup>Department of Geography, University of Nevada, Reno, NV, USA  
**Corresponding author:** David Hurst Thomas, Email: [thomasd@amnh.org](mailto:thomasd@amnh.org)

(Received 23 February 2023; revised 5 May 2023; accepted 6 May 2023)

## Abstract

The Late Holocene Dry Period (LHDP) was a one-plus millennial megadrought (3100–1800 cal BP) that delivered challenges and windfalls to Indigenous communities of the central Great Basin (United States). New pollen and sedimentation rate studies, combined with existing tree-ring data, submerged stump ages, and lake-level evidence, demonstrate that the LHDP was the driest Great Basin climate within the last 6,000 years—more extreme than the well-known Medieval Climatic Anomaly. New evidence reported here documents that most Great Basin archaeological sites south of 40° N latitude were abandoned during the long dry phase of the LHDP (3100–2200 cal BP), sometimes reoccupied during a wet interval (2200–2000 cal BP), and abandoned again during the most extreme drought (2000–1800 cal BP). Even in the face of epic drought, this is a story of remarkable survivance by some people who adjusted to their drought-stricken landscape where they had lived for millennia. Some moved on, but other resilient foragers refused to abandon their homeland, taking advantage of glacier-fed mountain springs with cooler alpine temperatures and greater moisture retention at high altitude, a result of early Neoglaciation conditions across many Great Basin ranges, despite epic drought conditions in the lowlands.

## Resumen

El Período Seco del Holoceno Tardío, una megasequía milenaria (3100-1800 cal aP), suministró inesperados desafíos y oportunidades para las comunidades indígenas de la Gran Cuenca Central (Estados Unidos). Nuevos estudios palinológicos y de tasas de sedimentación, junto con datos existentes sobre dendrocronología, las edades de troncos sumergidos y evidencia de niveles de los lagos, demuestran que el Período Seco del Holoceno Tardío fue la peor sequía experimentada en la Gran Cuenca Central dentro de los últimos 6.000 años—más extrema que la famosa Anomalía Climática Medieval. Nueva evidencia presentada aquí demuestra que la mayoría de los yacimientos arqueológicos de la Gran Cuenca al sur de la latitud 40° N fueron abandonados durante la larga sequía del Período Seco del Holoceno Tardío (3100-2200 cal aP), a veces ocupados de nuevo durante un intervalo lluvioso (2200-2000 cal aP), y abandonados otra vez durante la etapa más extrema de la sequía (2000-1800 cal aP). Aun frente a esta épica sequía, esta es una extraordinaria historia de supervivencia. Este paisaje atormentado por sequía nunca fue completamente abandonado, en parte porque recolectores resilientes se aprovecharon de los manantiales alpinos alimentados de glaciares; éstos perduraron debido a temperaturas alpinas más frías que fomentaron una mayor retención de humedad en alta elevación como resultado de condiciones Neoglaciales tempranas a través de muchas cordilleras de la Gran Cuenca, en contraste con las condiciones de sequía épicas en las tierras bajas.

**Keywords:** drought; Neoglaciation; survivance; climate change; cultural resilience; Great Basin archaeology; paleoecology

**Palabras clave:** sequía; Neoglaciación; supervivencia; cambio climático; resiliencia; arqueología de la Gran Cuenca; paleoecología

Beginning in the Middle Holocene, central Nevada foraging communities moved into their upland desert-mountain mosaic, developing subsistence and cosmological practices that persisted—with some significant challenges and transformations considered here—into the ethnohistoric era. Thomas (2023) chronicled this lifestyle in detail, and we summarize the essential elements.

Central Great Basin foragers mapped onto the verticality of their desert-mountain resource base—patchy in time and space—by moving themselves to resources (as opposed to marsh-tethered lacustrine strategies that transported resources to people), with an intrinsic resilience capable of adjusting group size and composition (Simms 2008:32–37). Rarely settling in the semipermanent villages more typical of lacustrine settings, desert-mountain foragers sometimes stayed for months in winter villages located in the piñon-juniper belt, set up camps near lowland fish-driving spots, and often spent weeks at summertime root-collecting places on the valley floors. They periodically aggregated at special-event super-camps to stage pronghorn and jackrabbit drives, with the associated fandangos strengthening kinship ties, regional identities, and resource-specific communication (Thomas 1972).

These foragers engineered the desert-mountain landscapes from top to bottom. Alpine hunters set up thousands of blinds, rock drift fences, and soldier cairns to help channel large game into harm's way. They embellished rock features to mimic fake hunters and pulled up small slabs to corral sage grouse as they mated. Hunters sometimes temporarily left their families to go on alpine expeditions that were staged from logistic camps, the earliest identified at Gatecliff Shelter (6170–6060 cal BP; Thomas 1983). They crafted man caves as redundant personal spaces, building small fire hearths to heat sleeping areas near the cave walls. They carried field-dressed bighorn sheep into these naturally protected spaces to dry meat for transport and lighten the load. Eight similar man cave campsites were stacked vertically inside Gatecliff Shelter, spanning more than three millennia. Indigenous communities also fashioned lowland pronghorn traps across the Great Basin, reusing and refurbishing these facilities for millennia (Hockett and Dillingham 2023; Hockett et al. 2023; Thomas 2023:Chapter 8). Thousands of Northern Side-notched and Gatecliff projectile points still litter the alpine and subalpine catchments of the central Great Basin—mute testimony to the intensity of the high-elevation hunting that began in the Middle Holocene.

Central Mountain Archaic communities experienced millennia of exponential growth, with their population growing more rapidly as it increased in size (Robinson and Thomas 2023). This lifeway was severely challenged 3100 cal BP by the Late Holocene Dry Period (LHDP), the most severe megadrought of the last 6,000 years. What happened to the people in its path?

### Extreme Climate and Cultural Shifts

Archaeologists have long pondered the cultural impacts of natural catastrophic events such as earthquakes, volcanic eruptions, severe droughts, abrupt cooling episodes, changing sea levels, and epidemics. With the contemporary realities of abrupt climate change increasingly apparent, “collapsology” (Middleton 2017:82) came to dominate academic and popular discourse within archaeology, television documentaries, feature films, and novels—highlighted by the 2004 blockbuster movie *The Day after Tomorrow* and the nonfiction bestseller *Collapse: How Societies Choose to Fail or Survive* (Diamond 2005).

Despite the obvious appeals of “collapse archaeology” (Butzer and Endfield 2012), many have become impatient with simplistic tales of past societies overexploiting and overshooting the limitations of their ecosystems, leading to internal and external stresses followed by transformation or outright collapse (Løvschal 2022:197; McAnany and Yoffee 2010; Olsson et al. 2015). Hypotheses directly connecting social “collapses” to abrupt climate change suffer from broadly dated paleoclimatic proxies with uncertain effects on society: such disconnects make it difficult to define causal linkages between human societies and the “megadisturbances” they experience (Kohler and Rockman 2020; Millar and Stephenson 2015). Kintigh and Ingram (2018) statistically assessed and questioned the correspondence between episodes of extreme climate (such as droughts) and cultural events (such as depopulation) that they purported to explain (see also Degroot et al. 2021). Although climate extremes have long been

implicated in large-scale cultural transformations, rarely are they the sole cause (Kennett et al. 2012). In some cases, unexpected and nonlinear relationships connect climate change and human behavior (Kennett 2005; Kennett and Kennett 2000).

### Impacts of the Late Holocene Dry Period (LHDP)

Reflecting O'Brien's (2017:295) "boredom with the apocalypse," we applaud the search for pathways through which external perturbations are mediated by social variables, including subsistence strategies, settlement patterns/mobility, population density, territoriality, infrastructure, technology, and previous experience (Fitzhugh et al. 2019; Mulholland 2021; Nelson et al. 2016). Most collapsology addresses large-scale agricultural societies, and we think it appropriate to explore abrupt climate change impacts on smaller-scale mobile communities.

The LHDP was a one-plus millennial megadrought (3100–1800 cal BP) across the southwestern United States (Mensing et al. 2013). This dry interval is evident in pollen records from eastern to northwestern Nevada (Mensing et al. 2008, 2013, 2023), limber pine (*Pinus flexilis*) dendroclimatology and population histories in the Wassuk Range (Millar et al. 2018), reduced growth in other limber pine dendrochronologies across the Great Basin (Millar et al. 2021), and other records (e.g., Theissen et al. 2019). The LHDP varied in geographic range, duration, and intensity across the Intermountain West. Late Holocene paleoenvironmental chronologies suggest that the LHDP followed a persistent dipole pattern, with wet sites to the north and dry sites to the south (Mensing et al. 2013, 2023). Correlative drought-related shifts in occupation patterns are evident in archaeological sites, including Gatecliff Shelter (Kennett et al. 2014; Thomas 1983), Alta Toquima (Thomas 2020), Bonneville Estates Rockshelter (Goebel et al. 2021), and O'Malley Rockshelter (Fowler et al. 1973).

In this companion article to Mensing and colleagues (2023), we report the first systematic test of the LHDP hypothesis in a cultural context. Beginning in 2016, our interdisciplinary team pursued paleoecological and archaeological studies in Nevada along a north–south transect between 39° N and 42° N latitude, designed to span the dipole pattern of El Niño / Southern Oscillation (ENSO)–associated precipitation (Figure 1). Paleoecological results confirm previous assessments and partition the LHDP into three phases: an initial 900-year dry period, 200 years of wetter climate, and two final centuries of extreme drought. New pollen and radiocarbon evidence from four wet-meadow sites (presented in Mensing et al. 2023) demonstrates a sedimentation hiatus (or significant slowdown) during the period about 2000–1800 cal BP, interpreted as a severe drought signal across the central Great Basin. The geographical extent of the LHDP remained stable between 39° N and 40° N latitude, which is similar to the latitude boundary of the ENSO dipole (Wise 2010), with sites to the north remaining wet and dry climate prevailing in the south. At its maximum (2000–1800 cal BP), the LHDP was the driest Great Basin climate of the last 6,000 years, its severity and duration more extreme than the well-documented megadroughts of the Medieval Climatic Anomaly (Stine 1994). The extreme and extended aridity of the LHDP south of 40° N latitude is explained via ENSO processes (Mensing et al. 2013, 2023), particularly a long-lasting La Niña state. Such La Niña oceanic conditions are associated with dry climates in the American Southwest and with wetter conditions in mid-latitudes farther north, though anomalously wet La Niña phase winters can also occur in northern California / Great Basin; for example, in 2022 and 2023 (Guirguis et al. 2015). Notably, documentation of such droughts came primarily from low-elevation sites, with few conclusions about mountain conditions.

We expand the synthesis by Mensing and colleagues (2023) with new archaeological results detailing the diverse cultural responses to these regionally differentiated impacts. Collapsology fails to capture the pivotal importance of human agency: the ability of individuals to act freely and make their own choices. To do this, we draw instead on "survivance," a concept developed by Anishinaabe scholar Gerald Vizenor (1998:15): "Survivance [is] more than survival, more than endurance or mere response; the stories of survivance are an active . . . repudiation of dominance, tragedy, and victimry." So viewed, survival is about getting through the present in a hurry, without much thought for the future. Survivance is survival with attitude, combining endurance, resistance, and planning ahead. The survivance concept embraces agency rather than passivity, harnessing aggressive ways beyond merely staying alive but also flourishing in the future (Silliman 2014; Wieskamp and Smith 2020:72)

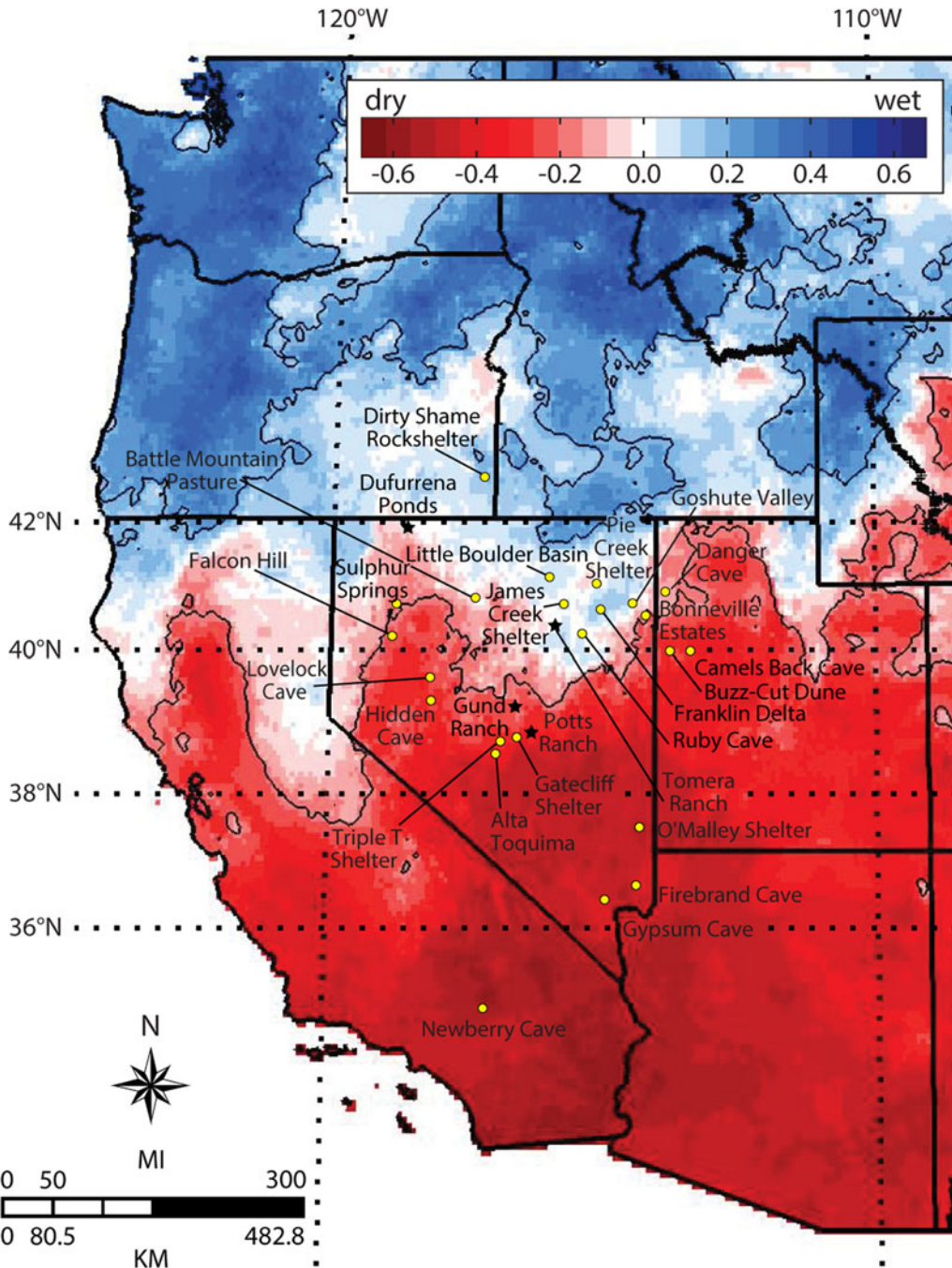
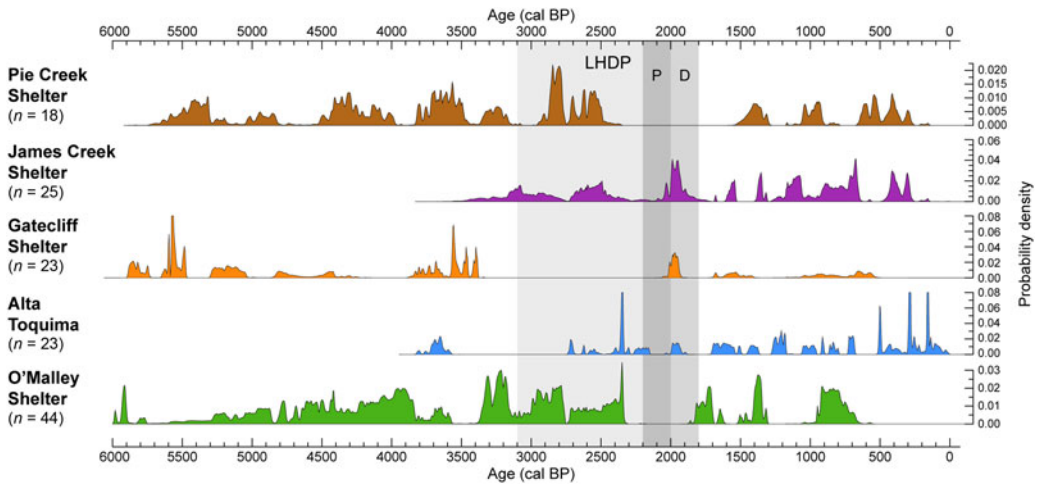


Figure 1. Map of correlation coefficients between June to November Southern Oscillation Index (SOI) and October through March precipitation (1892–2007) showing the north-south antiphasing dipole pattern of precipitation associated with ENSO (adapted from Wise 2010, with permission). Black stars represent paleoenvironmental sites; circles represent archaeological sites.

Combined with insights from resilience theory and behavioral ecology, survivance helps contextualize the broad-scale adjustments and decisions made by affected Indigenous communities, which reflect cultural attachments to landscapes and ancestral places under duress (see also Fitzhugh et al. 2019; Riris and de Souza 2021; Scheffer et al. 2021). We marshal new evidence regarding



**Figure 2.** Summed probability distribution of the available  $^{14}\text{C}$  dates from five archaeological sites in the Great Basin distributed from north to south (top to bottom) across the  $42^{\circ}$ – $40^{\circ}$  N latitude dipole as a proxy for occupation intensity: Pie Creek Shelter ( $41.3^{\circ}$  N lat), James Creek Shelter ( $40.8^{\circ}$  N lat), Gatecliff Shelter ( $39.0^{\circ}$  N lat), Alta Toquima ( $38.8^{\circ}$  N lat), and O'Malley Shelter ( $37.5^{\circ}$  N lat). The LHDP is shown with gray shading between 3100 and 1800 cal BP with the dark-gray P (pluvial) indicating a wetter period of the LHDP and the D indicating the driest part of the LHDP. Sites north of the dipole remained occupied for much of the LHDP; significant disruptions in occupation occurred at some sites south of the dipole. Other sites south of the dipole remained occupied and demonstrated resilient foraging adaptations in the face of drought (after Mensing et al. 2023:Figure 9).

high-elevation Great Basin climates and explore likely impacts of simultaneous Neoglacial advances throughout the LHDP and beyond—a perspective not previously incorporated in LHDP studies. We propose that these insights help understand survivance to the challenges and possible windfalls of the LHDP across the Great Basin's altitudinal range.

### *New Archaeological Evidence*

High-precision chronologies from Gatecliff Shelter and Alta Toquima (Kennett et al. 2014, 2020:401–410) anchor the southern end of our north–south transect (Mensing et al. 2023:Figure 9). To further historicize human responses, we redated James Creek Shelter (Elston and Budy 1990) and Pie Creek Shelter (McGuire et al. 2004), both located toward the northern end of the dipole transect (Figure 1). We processed 18 new AMS radiocarbon dates from previously undated plant remains in key stratigraphic sections (Supplemental Table 1) and developed Bayesian chronological sequences for both sites (Supplemental Texts 1 and 2), with model results yielding good agreement indices.

We conclude that James Creek Shelter was occupied episodically during the LHDP, documented in a cluster between about 2725–2400 cal BP, followed by a gap lasting around 250 years, followed by another cluster about 2105–1890 cal BP, with additional occupation episodes at about 1570 and 1355 cal BP. The newly dated sequence for Pie Creek Shelter generates two possible scenarios for LHDP occupations, depending on the age of a major rock fall event. If Rock Fall I occurred about 2300 cal BP, it likely rendered Pie Creek Shelter effectively uninhabitable until around 1,500 years ago. Alternatively, if the rock fall happened about 1,500 years ago (McGuire et al. 2004), the LHDP represents a long interval of sparse and sporadic occupation from around 2400–1500 cal BP. Under this scenario, the negligible use of Pie Creek Shelter might be attributable to LHDP effects, despite its northerly location. We do not know which scenario is correct but suspect that Pie Creek Shelter provided a well-watered northerly refuge during the LHDP until Rock Fall I cut short its habitability.

Figure 2 plots these new results against five well-dated Great Basin archaeological sites. Grading from north to south across the  $42^{\circ}$ – $40^{\circ}$  N dipole, these combined findings demonstrate that sites north of the dipole remained occupied for much of the LHDP, whereas significant disruptions were

common south of the dipole. A notable exception is Alta Toquima, which demonstrates the reverse pattern, with significant high-elevation human occupations in the face of extreme lowland drought.

### *Confronting LHDP Neoglaciation*

New evidence regarding high-elevation Great Basin climates helps explain these behavioral responses. Prior ecological studies (Mensing et al. 2008, 2013, 2023; Millar et al. 2021; Miller et al. 2001; Tausch et al. 2004) focused on the multiple proxies demonstrating the varied effects of the prolonged drought during the LHDP. But the role of temperature in modulating or exacerbating those effects is poorly understood, particularly in different LHDP phases (Mensing et al. 2008:87, 2013:277). The substantial literature on Great Basin Neoglaciation has yet to be comprehensively incorporated into studies addressing mountain climatic conditions during the LHDP, and this evidence provides important insights on responses of Great Basin communities to LHDP impacts.

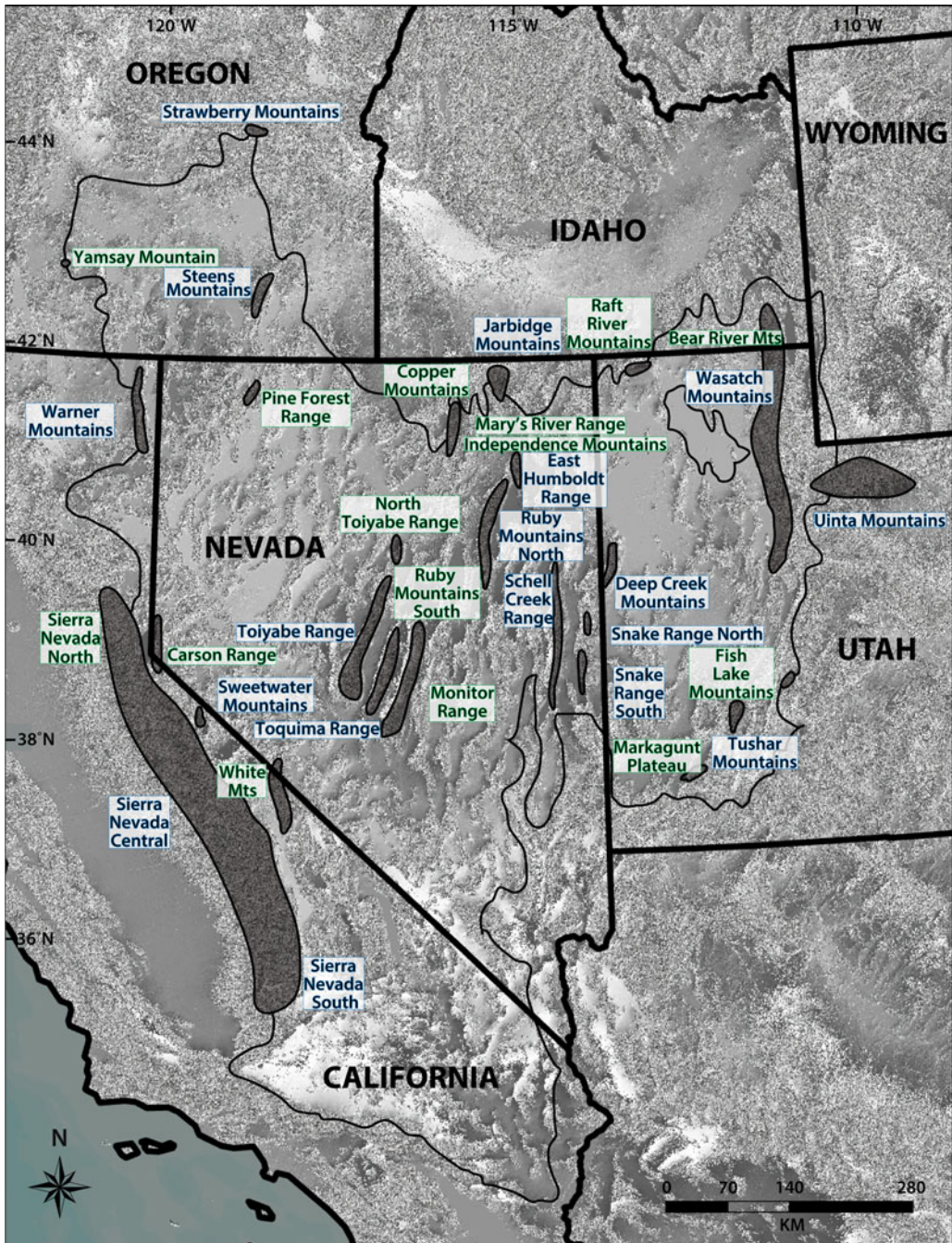
Millar and Thomas (2023) directly tackle early Neoglaciation in the Great Basin—what they term the “800-pound gorilla in the room”—by documenting its extent, timing, and implications for high-elevation temperature and precipitation. Neoglaciation (NG) is defined as a worldwide geoclimatic (time- and space-transgressive) unit characterized by the rebirth and growth of alpine glaciers following their maximum shrinkage during the warm, dry Middle Holocene (Porter and Denton 1967). Broadly, Porter and Denton (1967) recognized the NG as extending from 4,000 to 5,000 years ago to the early twentieth century, with dates and duration varying by latitude and region. Despite variability, glacial advances across global alpine regions clustered into two major periods, the “early NG” extending from about 3,500–4,000 to about 1,600 years ago and the “late NG,” widely recognized as the Matthes advance or Little Ice Age (LIA; Grove 1988) dating about 700 years ago to the early 1900s AD. An approximately 900-year interval of no or mild/short glacial advances is commonly documented between these bookends.

### *Dating Early Neoglacial Advances in the Great Basin*

Before the mid- to late 1980s, glacial geologists in the Great Basin assumed that the Neoglacial was restricted to the recent LIA interval, without earlier advances. This conclusion resulted from the absence of moraines typical of ice glacier deposits that dated older than the LIA in mountains of the Great Basin (Clark and Gillespie 1997; Munroe 2002). Increasing recognition of the role of rock glaciers (Barsch 1996; Martin and Whalley 1987) triggered a reevaluation of early NG advances in the Great Basin. Although rock glaciers had been described in the Great Basin (Osborn and Bevis 2001)—especially in the Sierra Nevada (Millar and Westfall 2008), the Snake Range (Davis 1988), and the Uinta Range (Munroe 2005)—no systematic inventory or assessment was available until Millar and Westfall (2019) documented the widespread distribution of Late Holocene-age rock glaciers throughout high mountains of the Great Basin. Analyses of sediment cores taken from high-elevation cirque lakes provided secure dates for early NG advances in the western and eastern Great Basin (Bowerman and Clark 2011; Munroe 2002). The upshot is that the early Neoglacial is now recognized as a period of prominent glacial advance widely expressed throughout western North America (Davis et al. 2009), with dates extending through most of the LHDP. The analysis of locations and ages developed in Millar and Thomas (2023) is summarized next.

The most accurately dated glacial advances in the Great Basin (GB) derive from the central and southern Sierra Nevada in California, the Ruby Mountains and East Humboldt Range in Nevada, and the Uinta Mountains in Utah (Figure 3). These studies define early NG advances as early as 3800–3700 cal BP, with multiple subsequent advances estimated (Bowerman and Clark 2011; Clark and Gillespie 1997; Konrad and Clark 1998; Munroe 2002, 2005; Munroe et al. 2013, 2018; Reinemann et al. 2009), documenting that the Neoglaciation persisted throughout the entire LHDP.

New evidence from a GB-wide inventory of rock glaciers and persistent ice fields (Millar and Westfall 2019), combined with published studies, documents early NG expression in 33 Great Basin ranges extending from 36.5° N to 44.3° N and from 110.7° W to 121.4° W (Figure 3; Millar and Thomas 2023). The implication is that all high mountain regions of the “cold GB”—excluding



**Figure 3.** Map of Great Basin mountain ranges showing evidence for early Neoglaciation. Blue labels are ranges where published records document early Neoglacial advances. Green labels are additional ranges assessed by Millar and Thomas (2023) from the rock-glacier inventory of Millar and Westfall (2019) to have had early Neoglacial advances. Base map modified from Esri, USGS, and NOAA.

southern desert ranges and a few high ranges without early NG evidence—likely experienced early NG glacial advances without any apparent latitudinal dipole.

Most published studies on Neoglacial temperature and precipitation thresholds in the GB focus on conditions under which ice glaciers grow. Synthesizing previous thermal relations of GB rock glaciers

with new estimates from the rock-glacier inventory, Millar and Thomas (2023) estimate high-elevation climatic conditions for early NG advances in several ranges, including the Toiyabe Range. Winter precipitation and summer temperature threshold values are critical for glaciers to grow, and various combinations of cool summers and wet winters allow rock glacial development. For temperature/precipitation combinations feasible for LHDP aridity at low elevations, rock-glacier growth in the early Neoglacial high Toquima Range cirques would require a summer temperature depression of about 1.3°C to about 4.3°C.

### **Neoglacial Impacts during the LHDP**

Millar and Thomas (2023)—recognizing that the LHDP was an extreme and long period of aridity south of 40–42° N latitude (Mensing et al. 2023)—concluded that summer temperature depressions in the range noted earlier could enable rock glaciers to grow. Although it might seem surprising that glaciers would develop with decreased precipitation, Plummer (2002) developed water-balance models to explain precipitation–temperature relationships between glacier growth in the Sierra Nevada uplands and water relations—using Owens Lake level as a proxy—in the lowlands. With temperature depressions in the range of about 1°C–4°C, rock glaciers would have been capable of growing during the LHDP even with decreased precipitation (Plummer and Phillips 2003).

Cooler summers and slight increases in winter precipitation, as suggested by the growth of rock glaciers, would have sustained GB mountain ecosystems in vibrant, healthy condition. Drainage from ice-embedded rock glaciers would not lead to significant downstream flow; instead, water from these features would be retained in the uplands with abundant glacier-fringed springs (Brighenti et al. 2021). Cool temperatures in the uplands would reduce evaporation, enhance soil moisture, and reduce the transpiration/water needs of plants. Thus, conditions at alpine elevations likely supported diverse and healthy plant growth, distributed springs, persistent snow patches, and sufficient conditions in summer for human residence, even while in the lowlands streams/lakes desiccated and vegetation withered as a result of extreme drought.

To accurately describe climatic conditions and avoid the implication that the Neoglacial period ended at the start of the LHDP, we identify this millennial interval as the “early Neoglaciation / Late Holocene Dry Period.”

### **Archaeological Implications of Early Neoglaciation / LHDP Climatic Diversity**

The early NG/LHDP disrupted multiple millennia of exponential human population growth across the Great Basin (Robinson and Thomas 2023), and these communities demonstrated varied responses that sorted geographically along a latitudinal dipole of persistent ENSO variability (Mensing et al. 2013; Thomas 2023; Wise 2010). The most extreme lowland aridity was largely restricted to south of the 40° N latitude, with a transition zone (about 40°–42° N latitude) separating an arid southern Great Basin from the more mesic northern GB (Figure 1).

The term “Late Holocene Dry Period” remains something of a misnomer north of 42° N latitude because this interval effectively extended the previous mesic conditions. Between 4500 and 2000 cal BP, the Owyhee Desert and Snake River Plains remained cooler and substantially wetter than before, with winter precipitation increasing relative to summer rainfall (Mensing et al. 2008:Figure 5; see also Mensing et al. 2013). Consistent with projections, radiocarbon proxies along the northern tier continued to track exponential growth expectations throughout the early NG/LHDP (Robinson and Thomas 2023:Figure 12.3).

### **Initial NG/LHDP (3100–2200 cal BP)**

The post-Middle Holocene lifestyle fell apart during the multi-centennial aridity of the early NG/LHDP for which Mensing and colleagues (2023) document a three-part record of abrupt climate change in the lowland central Great Basin: a multi-century period of below-average precipitation (3100–2200 cal BP), two centuries of wet climate (2200–2000 cal BP), and a two-century intense drought period (2000–1800 cal BP). South of 42°–40° N, the early NG/LHDP confronted foraging communities with extreme and prolonged drought (Mensing et al. 2023). Decreased discharge from



mountain streams into wetlands reduced primary production (and thus the harvestable biomass of wetland plants of the floodplains). Drinking water became harder to find, and many streams ceased flowing altogether. The highest-ranking habitats south of 40° N latitude rapidly became drought-degraded: these severe impacts are reflected in statistically significant gaps in the summed <sup>14</sup>C probability profiles, with early NG/LHDP population proxies falling below exponential expectations (Robinson and Thomas 2023). The new sequences reported here for James Creek and Pie Creek Shelters record early NG/LHDP reductions in sedimentation rates consistent with the pollen records (Figure 1). After three millennia of man-cave occupations, bighorn hunters abruptly abandoned Gatecliff Shelter (3000–2760 cal BP) and the other man caves, reflecting the disrupted alpine and sub-alpine logistical bighorn sheep hunting (Figure 2).

A wholly different environmental and behavioral scenario played out in the neighboring higher mountains. Despite epic lowland drought, early Neoglacial advances in Great Basin ranges are documented throughout this phase of the early NG/LHDP, from 3400 to 2200 cal BP, fostering glacier-fringed springs in the mountains with cooler alpine temperatures dampening evaporation and creating greater moisture retention (Davis et al. 2009; Millar et al. 2006, 2013). Neoglaciation at altitude likely resulted in ample surface water, well-watered alpine vegetation, and tolerable summer temperatures. Not coincidentally, the alpine residential site of Alta Toquima (3,350 m) was first occupied about 2500–2200 cal BP during the lowland early NG/LHDP drought (Figure 2).

#### *Intermediate NG/LHDP (2200–2000 cal BP)*

The tripartite early NG/LHDP is clearly reflected in the associated archaeological record (Figure 2). Gatecliff Shelter and James Creek Shelter, both abandoned during the initial LHDP aridity, were reoccupied during the two-century mesic interval, with a cluster of <sup>14</sup>C dates about 2050–1900 cal BP demonstrating a lag that likely reflected the time it took to reestablish local vegetation. The picture at Pie Creek Shelter is complicated by a rockfall episode, with an apparent habitational lacuna in the middle LHDP around 2400–1900 cal BP (Supplemental Text 2). Neoglacial conditions continued through this mesic period. O'Malley Shelter, near the southern end of the latitudinal transect, was apparently first abandoned around 2500 cal BP and not reoccupied during this intermediate interval.

#### *Terminal NG/LHDP (2000–1800 cal BP)*

The two centuries of intense drought that terminated the early NG/LHDP mark the driest climate in the Great Basin over the 4,000-year span of the Wassuk limber pine record (Millar et al. 2018). Age models from four paleoecological sites (Mensing et al. 2023) reflect a sediment hiatus and slowdown that began 2270–2040 cal BP and ended 1850–1450 cal BP. The sites span a north–south transect of >300 km (Figure 1), suggesting that synchronicity in changing rates of sedimentation is likely a widespread regional phenomenon. Alpine Neoglacial conditions appear to have persisted through this intense drought period, at least in eastern GB mountains.

The majority of dated archaeological sites south of 40° N latitude in the central Great Basin (including Gatecliff and James Creek shelters) show long periods of abandonment during the dry phase of the early NG/LHDP (3100–2200 cal BP); some were reoccupied during the wet interval (2200–2000 cal BP) and then abandoned again during the most extreme drought (2000–1800 cal BP). Similar early NG/LHDP impacts extended well beyond the narrow north–south transect detailed here (Figure 1). The radiocarbon sequence of cultural materials in the Lahontan Basin and Sulphur Springs “essentially goes dark” between 2800 and 1500 cal BP (McGuire et al. 2018:197, Figure 51). This also happened in the Bonneville Basin (Madsen and Berry 1975), where the cultural <sup>14</sup>C sequence began considerably earlier than in Gatecliff Shelter but remained similar over the past seven millennia (Thomas 2023: Chapter 9). Bonneville Estates Rockshelter experienced an early NG/LHDP hiatus from 2815 to 2230 cal BP followed by a largely continuous pulse of occupation from 2100 to 1550 cal BP (Goebel et al. 2021). Similar early NG/LHDP abandonments south of 40° N latitude are documented at Triple T and O'Malley shelters; Ruby, Danger, Camel's Back, Lovelock, Hidden, Gypsum, Firebrand, Newberry, and the Falcon Hill caves; Buzz Cut Dunes; and parts of the northern Mojave Desert (Thomas 2020, 2023).

The mid-latitudes were never totally abandoned during the early NG/LHDP because multiple sites, including Alta Toquima, were first occupied during the megadrought. Why were there such widespread yet diverse human responses to the landmark challenges (and perhaps windfalls) of the early Neoglaciation / Late Holocene Dry Period?

### Coping with Abrupt Climatic Change

The human toll is impossible to calculate, but the early NG/LHDP framed a tipping point that doomed the man-cave era. Although massive numbers of archaeological sites south of 40° N latitude were abandoned in the early NG/LHDP, foragers in Monitor Valley established many alpine residences at Alta Toquima and elsewhere. As the LHDP severely degraded the highest-ranking lowland habitats south of 40° N latitude, landscapes immediately north persisted largely unchanged or somewhat improved.

With the unfolding of the millennium of climate change, central Nevada communities faced life-changing decisions: Should we stay and eke it out or flee to wetter territories just a few days' walk away?

### Those Who Left

For more than 150 generations, the peaks and passes of the central Great Basin became origin places for communities living there, tied through birthright connections to specific landscapes in a mosaic of ritualized cartographies (Stoffle et al. 2004). This homeland contained long-established power places for ceremonies, such as those for balancing and healing the world or for expressing the influence that a shaman possesses in rites of passage and vision quests. By 5500 cal BP, foragers were ritually emplacing hundreds of incised prayerstones at proven power places like Gatecliff Shelter and Ruby Cave (Stoffle et al. 2021; Thomas 2019). Because power is cumulative, such power places were “made” by human interactions and experiences with nature, attracting other powerful elements and becoming even more powerful as people lived and relived those experiences (Zedeño 2000). Some so-called storied rocks at pictograph and petroglyph sites doubtless held power (*puha*) long before the paintings and other embellishments came along.

These shared vested interests must have made it painful to walk away. But some did just that. As they watched their ancestral homeland abruptly turn unfriendly, relocating to water elsewhere must have seemed best, with the gastric realities of epic LHDP aridity convincing them to abandon a status quo that was no longer working.

### Sunk Cost Considerations

Such survival decisions can be delayed by rigidity traps involving beliefs, rituals, and social practices that discourage people from abandoning the established way of doing things, even though dropping such practices might have been best (Arkes and Ayton 1999; Hegmon et al. 2008; Janssen et al. 2003:727; Kennett and Beach 2013). Sunk costs of community cohesion were tied to places where people created their own lived histories—not only through labor investments in hunting blinds and pronghorn drive corrals but also when social and cosmological beliefs created landscapes of ritual practice on a regional scale (Spielmann 2002:203; Thomas 2019, 2023). Despite such stabilizing mechanisms, radical transformations can (and do) happen when a society—or segments of it—decide that change is necessary (Scheffer et al. 2021). Notable transformations can be driven by a growing mistrust in older ways of doing things (including ritual, social, and physical trappings) that self-propagates and cascades contagiously through a society (Scheffer and Carpenter 2003).

### Relocation Costs

Those seeking to relocate to moister habitats found places that somehow carried over mesic climates after 2800 cal BP. Suddenly, many of these patches became more appealing than the desiccating mountain-desert homeland they left behind to the south. Singleleaf piñon pine did not (and does not) grow north of the Humboldt River, so communities relocating from the south forfeited the high return rates of piñon procurement and benefits conferred by seasonally enhanced population densities (Allee [1938] effects), including the fall pine nut harvests that for millennia

had underwritten fandangos and communal jackrabbit and pronghorn hunts (Hockett and Dillingham 2023).

Refugee communities transplanting northward to escape LHDP aridity may have become unwelcome intruders. The ideal despotic distribution (IDD) provides a first-order heuristic to help conceptualize mobility into previously occupied areas, likely promoting a concern for resource defense. The most productive or highest-ranked patches or habitats would have likely been already occupied, potentially leading to stiff competition in the form of defense by existing populations (Codding and Bird 2015; Codding et al. 2019; Giovas and Fitzpatrick 2014; Kennett et al. 2009; Winterhalder et al. 2010). Communities whose descendants initially settled in the previously lower-ranking, piñon-free northern end of the ENSO precipitation dipole likely came to view their increasingly sought-after residential bases and homelands in defensible terms, and unsettled newcomers from the south may have experienced less-than-free access to the now higher-ranking habitats under less-than-ideal conditions.

### *Those Who Stayed*

Some resilient communities refused to abandon their ancestral homeland, electing instead to weather the early NG/LHDP drought in place. A few miles from then-abandoned Gatecliff Shelter, Monitor Valley foragers pioneered ways to make the most of their drought-degraded landscape, establishing Alta Toquima as the first alpine residential site recorded in North America (Thomas 2020).

### *The Syncopated Settlements of Monitor Valley*

Still-resident Monitor Valley communities downsized during the early NG/LHDP into smaller households better suited to living on arid land, crafting strategies of high residential mobility among multiple shorter-term, water-tethered, extended-family encampments. They abandoned millennia of upland bighorn hunting grounds in favor of more intensive family foraging in the alpine reaches and neighboring piñon-juniper woodland. They broadened their diets to include plants and animals considered too costly before the LHDP, spending less time searching for things and more effort processing what they found.

Rather than fleeing northward to wetter territory, these resilient foragers found that ongoing neoglaciation—even during extreme drought—created ample vegetation and surface water in the alpine zone. Located at exactly 11,000 feet (3,353 m), the 31 domestic structures of Alta Toquima remain an exemplar of early NG/LHDP survivance (Thomas 2020). Families lived at Alta Toquima almost exclusively during the driest parts of the early NG/LHDP, moving downhill to repurpose sites like Gatecliff Shelter when the landscape became sufficiently watered to support patches of seeds and geophytes. They remained free to return to elevation when the extreme aridity resumed (2000–1800 BP).

### *Low Population Density Risks*

Those who stayed in homelands south of the 40° N dipole—now a drought-degraded lowland landscape abandoned by many neighbors—exposed themselves to greater extinction risks (Kramer et al. 2018) because low-density population levels can negatively affect fertility and survivorship; they may lead to unbalanced sex ratios, inbreeding, reduced cooperative foraging (Steele 2009:126–127), and possibly catastrophic consequences of random accidents or injuries. Risks of lower densities can be offset when foragers split into autonomous groups of different sizes, enhancing the average number of potential partners available to each reproductively fertile female. Offsetting Allee (1938) effects are density-dependent phenomena in which population growth or individual components of fitness increase as population density increases (Codding et al. 2019; Kramer et al. 2009; Robinson et al. 2019).

These resilient, smaller-sized Great Basin communities countered potential genetic hazards through larger-scale, short-term encampments, including fandangos (often financed by piñon surpluses) and a host of other supra-village festivals and gatherings, such as sweat house events, mass pronghorn capture, and jackrabbit drives. Fandangos created temporary residential camps much larger than individual winter villages, significantly expanding the localized gene pool (Freeman et al. 2019; McDonald and Hewlett 1999). In addition to their social and ritual importance,

fangangos helped disperse critical ecological information to adjust regional population densities. Given the inevitable information spread at supra-village gatherings, foragers facing intensifying LHDP lowland aridity doubtless understood that cooler, wetter settings persisted to the north and at high mountain elevations of the south.

### *Neoglaciation/LHDP Survivance*

Alta Toquima remains a dramatic example of early NG/LHDP survivance and of similar resilience playing out elsewhere. In Big Smoky Valley and Goshute Range to the east, subsistence practices shifted to more intensified plant harvesting, especially geophytes and wild grass seeds (Thomas 2023:Chapter 9). By 2500 cal BP, communities established start-up settlements in southeastern Oregon (Dirty Shame Rockshelter), central Nevada (Little Boulder Basin, Calcareous Mountains, Pahute/Rainier mesas), and southeastern California (White Mountains and Owens Valley lowlands). Leaving the piñon-zone man caves behind, residential intensification at alpine Alta Toquima, Franklin Delta, Little Boulder Basin, and Battle Mountain Pasture reflects the end of logistical mobility, with downsizing into family bands that would characterize Great Basin Shoshonean populations into the ethnohistoric era.

Following the early NG/LHDP, the pooled  $^{14}\text{C}$  record again exceeded exponential growth expectations in the Great Basin until the megadrought of the Medieval Climatic Anomaly (MCA) once more challenged communities across the Intermountain West (Robinson and Thomas 2023). Although resilient communities persisted in the central Great Basin, the MCA directly contributed to the demise of the lacustrine Lovelock culture by 700 cal BP and the dissolution of farming communities of the Virgin Branch of Ancestral Puebloans by 750–700 BP and the Fremont Complex by 600 BP (Thomas 2023).

### **Moving Forward**

Fine-grained behavioral and paleoenvironmental chronologies available today underscore the degree to which communities were capable of coping with the extreme spatial and temporal variability of the early NG/LHDP. Such abrupt environmental impacts played out differently by elevation, and these settlement strategies reflect a flexibility that ensured community sustainability without requiring significant internal structural change.

Survivance during the early NG/LHDP is unexpected and revealing, an example of what Leone (2007:127) called “surprising, counter-intuitive archaeological discoveries” with the potential to challenge and replace conventional understandings (Kasper and Handsman 2015). Although the survivance concept has been specifically grounded in the context of decolonization (Atalay 2006), Vizenor (2008:1) carefully left “survivance” loosely defined as “elusive, obscure, and imprecise,” and we argue that clear-cut survivance transcends archaeology’s indisputable colonial origins (Thomas 2000).

The essence of survivance lies in creative decision-making in the face of crisis (Vizenor 1998). Archaeology’s ability to recover and represent long-ago Indigenous histories demonstrates how Great Basin communities maintained their cultural identities in a world of always-changing landscapes. Western Shoshone (Newe) scholars Ned Blackhawk and Steven Crum herald the continuation of a “resilient and . . . triumphant character of Nevada and Idaho Shoshones to endure” (Blackhawk 2006:287). Despite Euro-American intrusions, Western Shoshoneans long maintained a “strong sense of place . . . deeply attached to particular valley areas and the nearby mountain ranges” (Crum 1994:8). By adapting traditional seasonal economies to the necessities of wage labor, many Western Shoshone rejected reservation life to remain in familiar ritualized landscapes, continuing to gather for celebrations, socializing at both traditional and new locations, and still resisting the ways of state formation.

Such long-term demographic survivance invites us to revisit conventional archaeological perceptions of abandonment and migration. The recognition of multiple structural poses and the emergence of fine-grained cultural chronologies enable archaeologists to distinguish between a short-term site hiatus and regional abandonment. Merely because some large, readily recognizable archaeological sites were left behind no longer requires archaeologists to posit overarching, regional abandonments that dominated the broader social and economic landscape. Survivance experiences are always diverse within a community—varying by generation, household, family, and gender—and this reality

complicates both research and representation (Kasper and Handsman 2015). Great Basin foraging communities intentionally switched strategies of residential mobility by temporarily abandoning some sites and intensifying subsistence at others across the variable Great Basin cultural landscape—playing out multiscale structural poses across the years, decades, and centuries as they responded to significant lowland drought impacts of the early Neoglaciation / Late Holocene Dry Period and the windfalls of the cool, wet high elevations.

**Acknowledgments.** We acknowledge the generous collaboration and insights from numerous tribal members from the Northern Paiute, Western Shoshone, and Southern Paiute communities regarding the *puha* reflected in the incised prayerstones that help document their long-term survivance in the Great Basin. We particularly thank the Shoshone Paiute Tribes of Duck Valley who graciously showed us potential core sites and gave us permission to obtain sediment cores on their land. Maria Nieves Zedeño had significant input, with Fred Phillips, Christopher Jazwa, and three anonymous reviewers making noteworthy contributions that improved this article. We are grateful to our collaborators in this project, including Wei Wang, Adam Csank, Cedar Briem, Brendan J. Culleton, Richard J. George, and John Southon. We thank Gene Hattori and Rachel Delovio at the Nevada State Museum, and Carolyn White and Geoff Smith at the University of Nevada-Reno, for assistance in obtaining suitable materials for radiocarbon dating. We are extremely grateful to Diana Rosenthal-Roberson for assistance in preparing this manuscript, with help from Lorann S. A. Pendleton, Caitria O’Shaughnessy, and Olganydia Plata Aguilera, all from the American Museum of Natural History.

**Funding Statement.** This study was supported by Grant 1636519, “Magnitude, Extent, and Impact of a Pre-Historical Multi-Century Drought in the Western US,” from the National Science Foundation.

**Data Availability Statement.** All data used as the basis for this analysis are included in Thomas (2020, 2023), Mensing and colleagues (2023), and Millar and Thomas (2023).

**Competing Interests.** The authors declare none.

**Supplemental Material.** For supplemental material accompanying this article, visit <https://doi.org/10.1017/aaq.2023.37>.

Supplemental Table 1. Radiocarbon Dates.

Supplemental Text 1. Bayesian Chronology of James Creek Shelter.

Supplemental Text 2. Bayesian Chronology of Pie Creek Shelter.

## References Cited

- Allee, Warder Clyde. 1938. *The Social Life of Animals*. W. W. Norton, New York.
- Arkes, Hal R., and Peter Ayton. 1999. The Sunk Cost and Concorde Effects: Are Humans Less Rational than Lower Animals? *Psychological Bulletin* 125(5):591–600.
- Atalay, Sonya. 2006. No Sense of the Struggle: Creating a Context for Survivance at the NMAI. *American Indian Quarterly* 30(3/4):597–618.
- Barsch, Dietrich. 1996. *Rockglaciers: Indicators for the Present and Former Geocology in High Mountain Environments*. Springer Series in Physical Environments Vol. 16. Springer, Heidelberg.
- Blackhawk, Ned. 2006. *Violence over the Land: Indians and Empires in the Early American West*. Harvard University Press, Cambridge, Massachusetts.
- Bowerman, Nicole D., and Douglas H. Clark. 2011. Holocene Glaciation of the Central Sierra Nevada, California. *Quaternary Science Reviews* 30(9–10):1067–1085.
- Brighenti, Stefano, Scott Hotaling, Debra S. Finn, Andrew G. Fountain, Masaki Hayashi, David Herbst, Jasmine E. Saros, Lusha M. Tronstad, and Constance I. Millar. 2021. Rock Glaciers and Related Cold Rocky Landforms: Overlooked Climate Refugia for Mountain Biodiversity. *Global Change Biology* 27(8):1504–1517.
- Butzer, Karl W., and Georgina H. Endfield. 2012. Critical Perspectives on Historical Collapse. *PNAS* 109(10):3628–3631.
- Clark, Douglas H., and Alan R. Gillespie. 1997. Timing and Significance of Late-Glacial and Holocene Cirque Glaciation in the Sierra Nevada, California. *Quaternary International* 38/39:21–38.
- Codding, Brian F., and Douglas W. Bird. 2015. Behavioral Ecology and the Future of Archaeological Science. *Journal of Archaeological Science* 56:9–20.
- Codding, Brian F., Ashley K. Parker, and Terry L. Jones. 2019. Territorial Behavior among Western North American Foragers: Allee Effects, Within-Group Cooperation, and Between-Group Conflict. *Quaternary International* 518:31–40.
- Crum, Steven J. 1994. *The Road on Which We Came – Po’i Pentun Tammen Kimmappéh: A History of the Western Shoshone*. University of Utah Press, Salt Lake City.
- Davis, P. Thompson. 1988. Holocene Glacier Fluctuations in the American Cordillera. *Quaternary Science Reviews* 7(2): 129–157.
- Davis, P. Thompson, Brian Menounos, and Gerald Osborn. 2009. Holocene and Latest Pleistocene Alpine Glacier Fluctuations: A Global Perspective. *Quaternary Science Reviews* 28(21–22):2021–2033.
- Degroot, Dagomar, Kevin Anchukaitis, Martin Bauch, Jakob Burnham, Fred Carnegy, Jianxin Cui, Kathryn de Luna, et al. 2021. Towards a Rigorous Understanding of Societal Responses to Climate Change. *Nature* 591:539–548.
- Diamond, Jared. 2005. *Collapse: How Societies Choose to Fail or Succeed*. Viking, New York.

- Elston, Robert G., and Elizabeth E. Budy (editors). 1990. *The Archaeology of James Creek Shelter*. University of Utah Anthropological Papers No. 115. University of Utah Press, Salt Lake City.
- Fitzhugh, Ben, Virginia L. Butler, Kristine M. Bovy, and Michael A. Etnier. 2019. Human Ecodynamics: A Perspective for the Study of Long-Term Change in Socioecological Systems. *Journal of Archaeological Science Reports* 23:1077–1094.
- Fowler, Don D., David B. Madsen, and Eugene M. Hattori. 1973. *Prehistory of Southeastern Nevada*. Desert Research Institute Publications in the Social Sciences No. 6. Desert Research Institute, University of Nevada, Reno.
- Freeman, Jacob, John M. Anderies, Raymond P. Mauldin, and Robert J. Hard. 2019. Should I Stay or Should I Go? The Emergence of Partitioned Land Use among Human Foragers. *PLoS ONE* 14(7):e0218440.
- Giovas, Christina M., and Scott M. Fitzpatrick. 2014. Prehistoric Migration in the Caribbean: Past Perspectives, New Models and the Ideal Free Distribution of West Indian Colonization. *World Archaeology* 46(4):569–589.
- Goebel, Ted, Bryan Hockett, David Rhode, and Kelly Graf. 2021. Prehistoric Human Response to Climate Change in the Bonneville Basin, Western North America: The Bonneville Estates Rockshelter Radiocarbon Chronology. *Quaternary Science Reviews* 260:106930.
- Grove, Jean M. 1988. *The Little Ice Age*. Methuen, New York.
- Guirguis, Kristen, Alexander Gershunov, and Daniel R. Cayan. 2015. Interannual Variability in Associations between Seasonal Climate, Weather, and Extremes: Wintertime Temperature over the Southwestern United States. *Environmental Research Letters* 10(12):124023.
- Hegmon, Michelle, Matthew A. Peebles, Ann P. Kinzig, Stephanie Kulow, Cathryn M. Meegan, and Margaret C. Nelson. 2008. Social Transformation and Its Human Costs in the Prehispanic U.S. Southwest. *American Anthropologist* 110(3): 313–324.
- Hockett, Bryan, and Eric Dillingham. 2023. *Large-Scale Traps of Nevada, Eastern California, and Western Utah*. Texas A & M University Press, College Station.
- Hockett, Bryan, Ted Goebel, Kelly E. Graf, and Edward Stoner. 2023. A Latest-Paleoindian-Aged Pronghorn Trap in the Goshute Valley, Eastern Great Basin, USA. *PaleoAmerica* 9(1):25–47.
- Janssen, Marco A., Tim A. Kohler, and Marten Scheffer. 2003. Sunk-Cost Effects and Vulnerability to Collapse in Ancient Societies. *Current Anthropology* 44(5):722–728.
- Kasper, Kimberly, and Russell G. Handesman. 2015. Survivance Stories, Co-Creation, and a Participatory Model at the Mashantucket Pequot Museum and Research Center. *Advances in Archaeological Practice* 3(3):198–207.
- Kennett, Douglas J. 2005. *The Island Chumash: Behavioral Ecology of a Maritime Society*. University of California Press, Berkeley.
- Kennett, Douglas J., and Timothy P. Beach. 2013. Archeological and Environmental Lessons for the Anthropocene from the Classic Maya Collapse. *Anthropocene* 4:88–100.
- Kennett, Douglas J., Sebastian F. M. Breitenbach, Valorie V. Aquino, Yemane Asmerom, Jaime Awe, James U. L. Baldini, Patrick Bartlein, et al. 2012. Development and Disintegration of Maya Political Systems in Response to Climate Change. *Nature* 338:788–791.
- Kennett, Douglas J., Brendan J. Culleton, Jaime Dexter, Scott A. Mensing, and David Hurst Thomas. 2014. High-Precision AMS <sup>14</sup>C Chronology for Gatecliff Shelter, Nevada. *Journal of Archaeological Science* 52:621–632.
- Kennett, Douglas J., Brendan J. Culleton, Thomas Kelley Harper, and David Hurst Thomas. 2020. Dating Alta Toquima: The Third Iteration. In *Alpine Archaeology of Alta Toquima and the Mt. Jefferson Tablelands (Nevada): The Archaeology of Monitor Valley*, Contribution 4, edited by David Hurst Thomas, pp. 401–410. Anthropological Papers No. 104. American Museum of Natural History, New York.
- Kennett, Douglas J., and James P. Kennett. 2000. Competitive and Cooperative Responses to Climatic Instability in Coastal Southern California. *American Antiquity* 65(2):379–395.
- Kennett, Douglas J., Bruce Winterhalder, Jacob Bartruff, and Jon M. Erlandson. 2009. An Ecological Model of the Emergence of Institutionalized Social Hierarchies on California's Northern Channel Islands. In *Pattern and Process in Cultural Evolution*, edited by Stephan Shennan, pp. 297–314. University of California Press, Berkeley.
- Kintigh, Keith W., and Scott E. Ingram. 2018. Was the Drought Really Responsible? Assessing Statistical Relationships between Climate Extremes and Cultural Transitions. *Journal of Archaeological Science* 89:25–31.
- Kohler, Timothy A., and Marcy Rockman. 2020. The IPCC: A Primer for Archaeologists. *American Antiquity* 85(4):627–651.
- Konrad, Sarah K., and Douglas H. Clark. 1998. Evidence for an Early Neoglacial Glacier Advance from Rock Glaciers and Lake Sediments in the Sierra Nevada, California, USA. *Arctic and Alpine Research* 30(3):272–284.
- Kramer, Andrew M., Luděk Berec, and John M. Drake. 2018. Editorial: Allee Effects in Ecology and Evolution. *Journal of Animal Ecology* 87:7–10.
- Kramer, Andrew M., Brian Dennis, Andrew M. Liebhold, and John M. Drake. 2009. The Evidence for Allee Effects. *Population Ecology* 51:341–354.
- Leone, Mark P. 2007. The Foundations of Archaeology. In *Ethnographic Archaeologies: Reflections on Stakeholders and Archaeological Practices*, edited by Quetzil E. Castañeda and Christopher N. Matthews, pp. 119–137. AltaMira Press, Lanham, Maryland.
- Løvshol, Mette. 2022. Retranslating Resilience Theory in Archaeology. *Annual Review of Anthropology* 51:195–212.
- Madsen, David B., and Michael S. Berry. 1975. A Reassessment of Northeastern Great Basin Prehistory. *American Antiquity* 40(4):391–405.
- Martin, H. Elizabeth, and W. Brian Whalley. 1987. Rock Glaciers: Part 1: Rock Glacier Morphology: Classification and Distribution. *Progress in Physical Geography: Earth and Environment* 11(2):260–282.

- McAnany, Patricia A., and Norman Yoffee (editors). 2010. *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*. Cambridge University Press, New York.
- McDonald, Douglas H., and Barry S. Hewlett. 1999. Reproductive Interests and Forager Mobility. *Current Anthropology* 40(4):501–524.
- McGuire, Kelly R., Michael G. Delacorte, and Kimberley Carpenter. 2004. *Archaeological Excavations at Pie Creek and Tule Valley Shelters, Elko County, Nevada*. Anthropological Papers No. 25. Nevada State Museum, Carson City.
- McGuire, Kelly R., William R. Hildebrandt, D. Craig Young, Kaely Colligan, and Laura Harold. 2018. *At the Vanishing Point: Environment and Prehistoric Land Use in the Black Rock Desert*. Anthropological Papers No. 103. American Museum of Natural History, New York.
- Mensing, Scott, Saxon E. Sharpe, Irene Tunno, Don W. Sada, Jim M. Thomas, Scott Starratt, and Jeremy Smith. 2013. The Late Holocene Dry Period: Multiproxy Evidence for an Extended Drought between 2800 and 1850 cal yr BP across the Central Great Basin, USA. *Quaternary Science Reviews* 78:266–282.
- Mensing, Scott A., Jeremy Smith, Kelly Burkle Norman, and Marie Allan. 2008. Extended Drought in the Great Basin of Western North America in the Last Two Millennia Reconstructed from Pollen Records. *Quaternary International* 188(1):79–89.
- Mensing, Scott, Wei Wang, David Rhode, Douglas J. Kennett, Adam Csank, David Hurst Thomas, Cedar Briem, et al. 2023. Temporal and Geographic Extent of the Late Holocene Dry Period in the Central Great Basin, USA. *Quaternary Science Reviews* 300:107900.
- Middleton, Guy D. 2017. The Show Must Go On: Collapse, Resilience, and Transformation in 21st-Century Archaeology. *Reviews in Anthropology* 46:78–105.
- Millar, Constance I., David A. Charlet, Robert D. Westfall, John C. King, Diane L. Delany, Alan L. Flint, and Lorraine E. Flint. 2018. Do Low-Elevation Ravines Provide Climate Refugia for Subalpine Limber Pine (*Pinus flexilis*) in the Great Basin, USA? *Canadian Journal of Forest Research* 48:663–671.
- Millar, Constance I., Diane L. Delany, John C. King and Robert D. Westfall. 2021. Growth Response of Great Basin Limber Pine Populations to Climate Variability over the Past 4002 years. *Quaternary Research* 102:1–22.
- Millar, Constance I., John C. King, Robert D. Westfall, Harry A. Alden, and Diane L. Delany. 2006. Late Holocene Forest Dynamics, Volcanism, and Climate Change at Whiting Mountain and San Joaquin Ridge, Mono County, Sierra Nevada, CA, USA. *Quaternary Research* 66(2):273–287.
- Millar, Constance I., and Nathan L. Stephenson. 2015. Temperate Forest Health in an Era of Emerging Megadisturbance. *Science* 349(6250):823–826.
- Millar, Constance I., and David Hurst Thomas. 2023. Confronting Neoglacial Climates during the Late Holocene Dry Period, Great Basin, Southwestern USA. Manuscript on file, Division of Anthropology, American Museum of Natural History, New York.
- Millar, Constance I., and Robert D. Westfall. 2008. Rock Glaciers and Related Periglacial Landforms in the Sierra Nevada, CA, USA; Inventory, Distribution and Climatic Relationships. *Quaternary International* 188(1):90–104.
- Millar, Constance I., and Robert D. Westfall. 2019. Geographic, Hydrological, and Climatic Significance of Rock Glaciers in the Great Basin, USA. *Arctic, Antarctic, and Alpine Research* 51(1):232–249.
- Millar, Constance I., Robert D. Westfall, and Diane L. Delany. 2013. Thermal and Hydrologic Attributes of Rock Glaciers and Periglacial Talus Landforms: Sierra Nevada, California, USA. *Quaternary International* 310:169–180.
- Miller, Jerry R, Dru Germanoski, K. Waltman, Robin Tausch, and Jeanne C. Chambers. 2001. Influence of Late Holocene Hillslope Processes and Landforms on Modern Channel Dynamics in Upland Watersheds of Central Nevada. *Geomorphology* 38:373–391.
- Mulholland, Bernard. 2021. Can Archaeology Inform the Climate Change Debate? *Academia Letters*, Article 4385.
- Munroe, Jeffrey S. 2002. Timing of Postglacial Cirque Reoccupation in the Northern Uinta Mountains, Northeastern Utah, USA. *Arctic, Antarctic, and Alpine Research* 34(1):38–48.
- Munroe, Jeffrey S. 2005. Glacial Geology of the Northern Uinta Mountains. In *Uinta Mountain Geology*, edited by Carol M. Dehler, Joel L. Pederson, Douglas A. Sprinkel, and Bart J. Kowallis, pp. 215–34. Publication No. 33. Utah Geological Association, Salt Lake City.
- Munroe, Jeffrey S., Matthew F. Bigl, Annika E. Silverman, and Benjamin J. C. Laabs. 2018. Records of Late Quaternary Environmental Change from High-Elevation Lakes in the Ruby Mountains and East Humboldt Range, Nevada. In *From Saline to Freshwater: The Diversity of Western Lakes in Space and Time*, edited by Scott W. Starratt and Michael R. Rosen, pp. 33–52. Special Paper No. 536. Geological Society of America, Boulder.
- Munroe, Jeffrey S., Catherine M. Klem, and Matthew F. Bigl. 2013. A Lacustrine Sedimentary Record of Holocene Periglacial Activity from the Uinta Mountains, Utah, U.S.A. *Quaternary Research* 79:101–109.
- Nelson, Margaret C., Scott E. Ingram, Andrew J. Dugmore, Richard Streeter, Matthew A. Peeples, Thomas H. McGovern, Michelle Hegmon, et al. 2016. Climate Challenges, Vulnerabilities, and Food Security. *PNAS* 113(2):298–303.
- O'Brien, Stephen. 2017. Boredom with the Apocalypse: Resilience, Regeneration, and their Consequences for Archaeological Interpretation. In *Crisis to Collapse: The Archaeology of Social Breakdown*, edited by Tim Cunningham and Jan Driessen, pp. 295–303. Presses Universitaires de Louvain, Louvain-la-Neuve, Belgium.
- Olsson, Lennart., Anne Jerneck, Henrik Thorén, Johannes Persson, and David O'Byrne. 2015. Why Resilience Is Unappealing to Social Science: Theoretical and Empirical Investigations of the Scientific Use of Resilience. *Science Advances* 1(4):e1400217.
- Osborn, Gerald, and Ken Bevis. 2001. Glaciation in the Great Basin of the Western United States. *Quaternary Science Reviews* 20(13):1377–1410.

- Plummer, Mitchell A. 2002. Paleoclimatic Conditions during the Last Deglaciation Inferred from Combined Analysis of Pluvial and Glacial Records. PhD dissertation, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro.
- Plummer, Michael A., and Fred M. Phillips. 2003. A 2-D Numerical Model of Snow/Ice Energy Balance and Ice Flow for Paleoclimatic Interpretation of Glacial Geomorphic Features. *Quaternary Science Reviews* 22(14):1389–1406.
- Porter, Stephen C., and George H. Denton. 1967. Chronology of Neoglaciation in the North American Cordillera. *American Journal of Science* 265(3):177–210.
- Reinemann Scott A., David F. Porincho, Amy M. Bloom, Bryan G. Mark, Jason E.Box et al. 2009. A Multi-Proxy Paleolimnological Reconstruction of Holocene Climatic Conditions in the Great Basin. *Quaternary Research* 72(3):347–358.
- Riris, Philip, and Jonas Gregorio de Souza. 2021. Formal Tests for Resistance-Resilience in Archaeological Time Series. *Frontiers in Ecology and Evolution* 9:740629.
- Robinson, Erick J., and David Hurst Thomas. 2023. Intermountain Demography. In *Defining the Central Mountains Archaic: Natural and Cultural Great Basin Biographies*, by David Hurst Thomas, in press. Anthropological Papers. American Museum of Natural History, New York.
- Robinson, Erick J., Jabran Zahid, Brian F. Coddling, Randall Haas, and Robert L. Kelly. 2019. Spatiotemporal Dynamics of Prehistoric Population Growth: Radiocarbon “Dates as Data” and Population Ecology Models. *Journal of Archaeological Science* 101:63–71.
- Scheffer, Marten, and Stephen R. Carpenter. 2003. Catastrophic Regime Shifts in Ecosystems: Linking Theory to Observation. *Trends in Ecology and Evolution* 18(12):648–656.
- Scheffer, Marten, Egbert H. van Nes, Darcy Bird, R. Kyle Bocinsky, and Timothy A. Kohler. 2021. Loss of Resilience Preceded Transformations of Pre-Hispanic Pueblo Societies. *PNAS* 118(18):e2024397118.
- Silliman, Stephen W. 2014. Archaeologies of Indigenous Survivance and Residence: Navigating Colonial and Scholarly Dualities. In *Rethinking Colonial Pasts through Archaeology*, edited by Neal Ferris, Rodney Harrison, and Michael V. Wilcox, pp. 57–75. Oxford University Press, Oxford.
- Simms, Steven R. 2008. *Ancient Peoples of the Great Basin and Colorado Plateau*. Left Coast Press, Walnut Creek, California.
- Spielmann, Katherine A. 2002. Feasting, Craft Specialization, and the Ritual Mode of Production in Small-Scale Societies. *American Anthropologist* 104:195–207.
- Steele, James. 2009. Human Dispersals: Mathematical Models and the Archaeological Record. *Human Biology* 81(3):121–140.
- Stine, Scott. 1994. Extreme and Persistent Drought in California and Patagonia during Mediaeval Time. *Nature* 369: 546–549.
- Stoffle, Richard W., Fletcher Chmara-Huff, Kathleen Van Vlack, and Rebecca Toupal. 2004. *Puha Flows from It: The Cultural Landscape Study of the Spring Mountains*. US Forest Service, Humboldt Toiyabe National Forest. Bureau of Applied Research in Anthropology, University of Arizona, Tucson.
- Stoffle, Richard W., Kathleen A. Van Vlack, Sean M. O’Meara, Richard W. Arnold, and Betty Cornelius. 2021. Incised Stones and Southern Paiute Cultural Continuity. *Journal of California and Great Basin Anthropology* 41(1):19–36.
- Tausch, Robin J., Cheryl L. Nowak, and Scott A. Mensing. 2004. Climate Change and Associated Vegetation Dynamics during the Holocene: The Paleoeological Record. In *Great Basin Riparian Ecosystems: Ecology, Management and Restoration*, edited by Jeanne C. Chambers and Jerry R. Miller, pp. 24–48. Island Press, Washington, DC.
- Theissen, Kevin M., Thomas A. Hickson, Ashley L. Brundrett, Sarah E. Horns, and Matthew S. Lachniet. 2019. A Record of Mid-and Late Holocene Paleohydroclimate from Lower Pahrangat Lake, Southern Great Basin. *Quaternary Research* 92(2):352–364.
- Thomas, David Hurst. 1972. Western Shoshone Ecology: Settlement Patterns and Beyond. In *Great Basin Cultural Ecology: A Symposium*, edited by Don D. Fowler, pp. 135–153. Publications in the Social Sciences No. 8. Desert Research Institute, University of Nevada, Reno.
- Thomas, David Hurst. 1983. *The Archaeology of Monitor Valley: 2. Gatecliff Shelter*. Anthropological Papers 59, No. 1. American Museum of Natural History, New York.
- Thomas, David Hurst. 2000. *Skull Wars: Kennewick Man, Archaeology, and the Battle for Native American Identity*. Basic Books, New York.
- Thomas, David Hurst. 2019. A Shoshonean Prayerstone Hypothesis: Ritual Cartographies of Great Basin Incised Stones. *American Antiquity* 84(1):1–25.
- Thomas, David Hurst. 2020. *Alpine Archaeology of Alta Toquima and the Mt. Jefferson Tablelands (Nevada)*. Anthropological Papers No. 104. American Museum of Natural History, New York.
- Thomas, David Hurst. 2023. *Defining the Central Mountains Archaic: Natural and Cultural Great Basin Biographies*, in press. Anthropological Papers. American Museum of Natural History, New York
- Vizenor, Gerald. 1998. *Fugitive Poses: Native American Indian Scenes of Absence and Presence*. University of Nebraska Press, Lincoln.
- Vizenor, Gerald. 2008. Aesthetics of Survivance: Literary Theory and Practice. In *Survivance: Narratives of Native Presence*, edited by Gerald Vizenor, pp. 1–24. University of Nebraska Press, Lincoln.
- Wieskamp, Valerie N., and Cortney Smith. 2020. “What to Do When You’re Raped”: Indigenous Women Critiquing and Coping through a Rhetoric of Survivance. *Quarterly Journal of Speech* 106(1):72–94.
- Winterhalder, Bruce, Douglas J. Kennett, Mark N. Grote, and Jacob Bartruff. 2010. Ideal Free Settlement of California’s Northern Channel Islands. *Journal of Anthropological Archaeology* 29(4):469–490.



- Wise, Erica K. 2010. Spatiotemporal Variability of the Precipitation Dipole Transition Zone in the Western United States. *Geophysical Research Letters* 37(7):L07706. <https://doi.org/10.1029/2009GL042193>.
- Zedeño, María Nieves. 2000. On What People Make of Places—A Behavioral Cartography. In *Explorations in Social Theory*, edited by Michael B. Schiffer, pp. 97–111. University of Utah Press, Salt Lake City.

---

**Cite this article:** Thomas, David Hurst, David Rhode, Constance I. Millar, Douglas J. Kennett, Thomas K. Harper, and Scott Mensing. 2023. Great Basin Survivance (USA): Challenges and Windfalls of the Neoglaciation / Late Holocene Dry Period (3100–1800 cal BP). *American Antiquity* 88(3):402–418. <https://doi.org/10.1017/aaq.2023.37>.