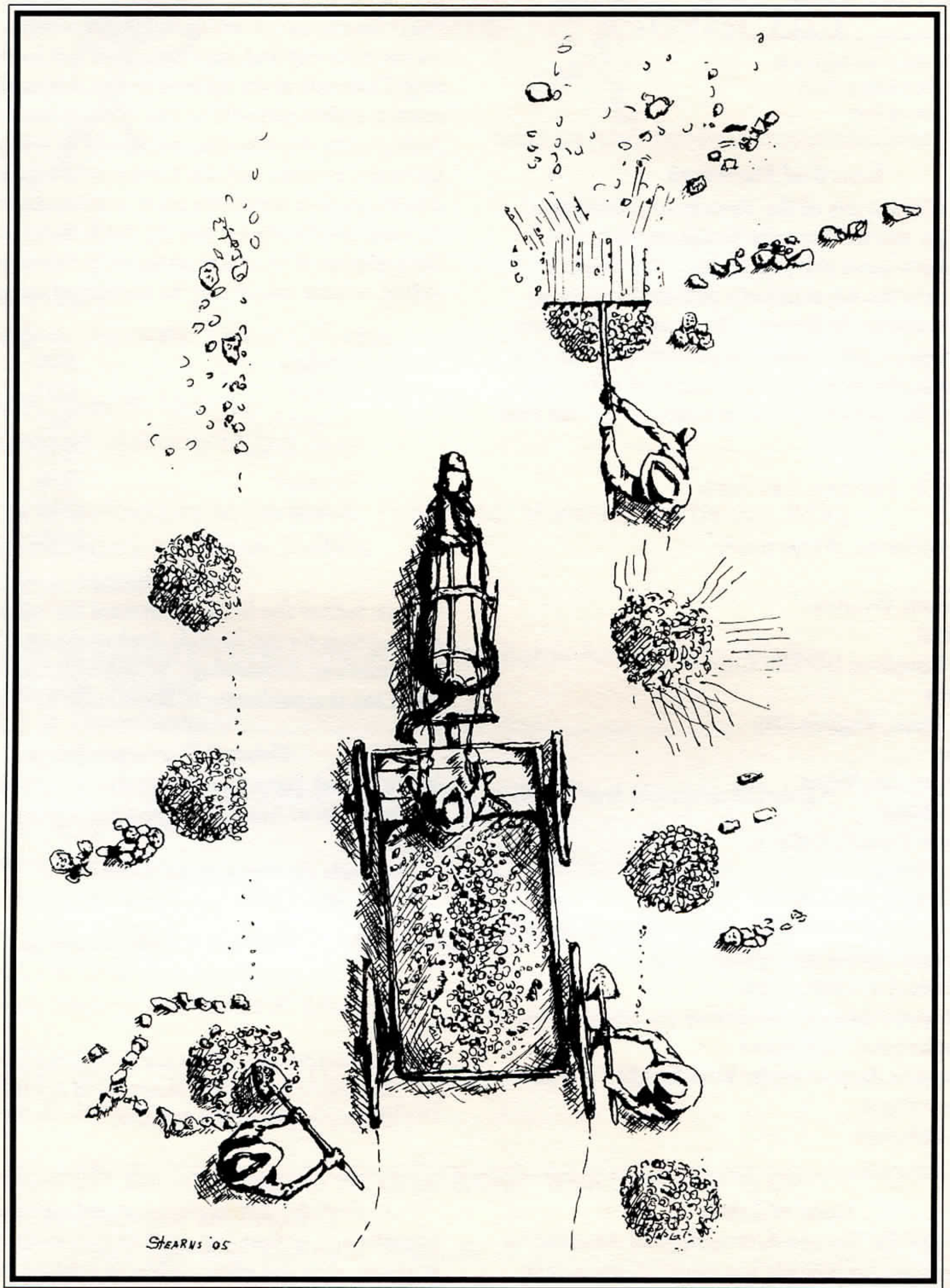
# NEVADA ARCHAEOLOGIST

VOLUME 22, 2007 NORTHERN NEVADA ACROSS TIME




**NEVADA ARCHAEOLOGICAL ASSOCIATION**

# Nevada Archaeological Association

The design for the NAA logo was adapted by Robert Elston from a Garfield Flat petroglyph.

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**Cover:**

Method of railroad ballast collection/harvesting as suggested by Steven Stearns and Alvin R. McLane in their paper in this volume.

## Code of Ethics

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1. Uphold the purpose and intent of the NAA.
2. Adhere to all antiquities laws.
3. Seek the advice, consent and assistance of professionals in archaeology and/or history in dealing with artifacts, sites and other materials relating to antiquities.
4. Assist professionals and educators in accomplishing the objectives of the NAA.
5. Be a personal envoy of the NAA and responsible for conducting themselves in a manner so as to protect the integrity of the artifacts, sites, or other material.

# Table of Contents

# *Editors' Corner*

*Geoffrey Smith and Linsie Lafayette*

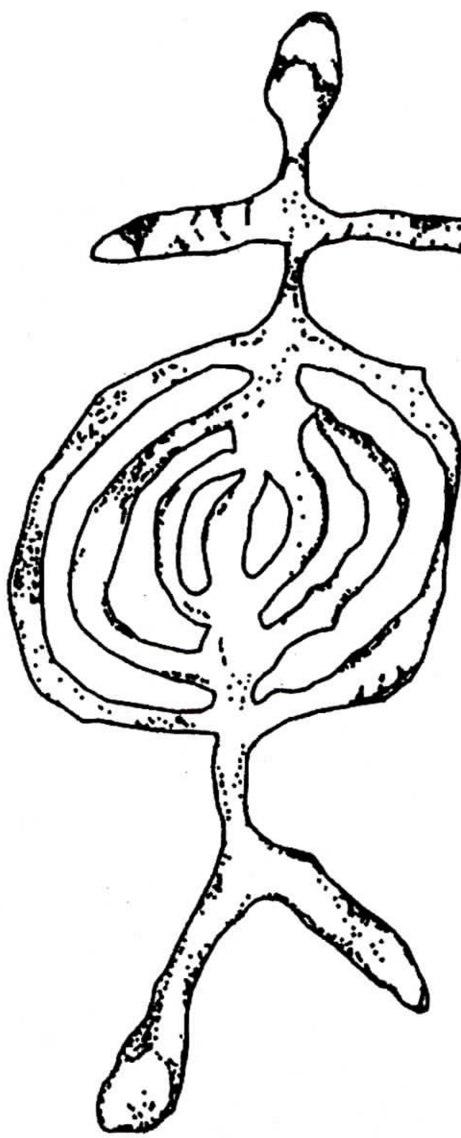
At long last, here is Volume 22 of the *Nevada Archaeologist*. Graduate school, a first-time home purchase and subsequent remodeling, graduation, fieldwork, report writing, and a myriad of other factors together conspired to delay its completion, but somehow we overcame these obstacles and managed to wrap things up a mere two years after it was due. For that, we apologize.

Despite the long wait, we believe that the final product is a good one. The quality of this volume is due foremost to the interest, efforts, and patience of the contributors themselves. We would like to sincerely thank all those who submitted articles, including Ron Reno and Gene Hattori, whose thoughtful reflections on the life of Alvin McLane are especially poignant given that Mr. McLane is one of the contributors to this volume. A great deal of gratitude is also owed to Anne McConnell, who turned a motley collection of formats, graphics, and tables into a beautifully crafted, professional quality publication. Additionally, she gently urged us to move forward with the editing and production process when we needed it the most. Finally, we would like to thank the NAA Board of Directors for answering our many questions and providing helpful suggestions.

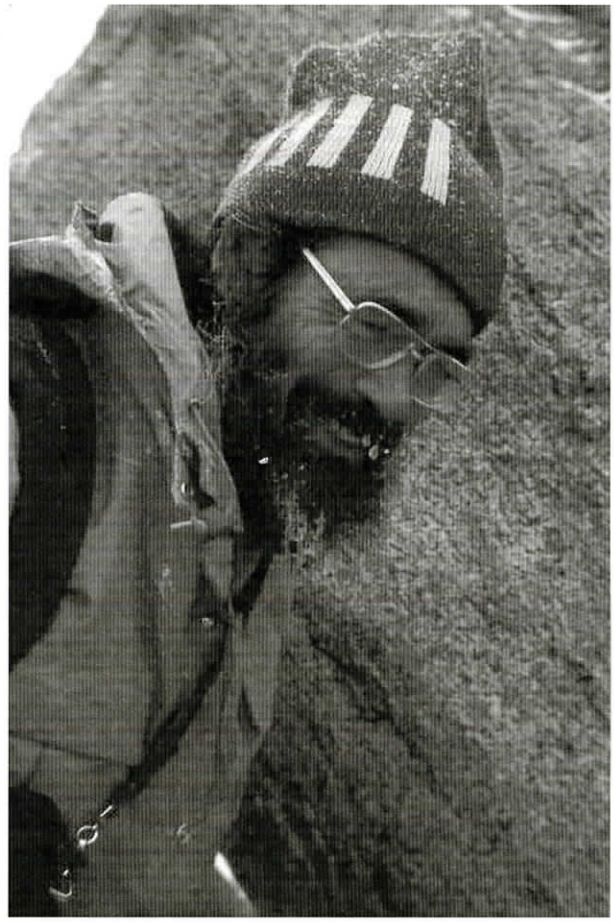
The articles contained within this volume encompass a broad range of topics and periods that generally reflect the theme of this issue, "Northern Nevada Across Time." Although, as you will see, our definitions of the terms "northern" and "Nevada" are somewhat flexible (for example, one of the articles deals with the archaeology of the Hawthorne Army Depot, which is decidedly more central than northern, while another deals with climate change in the Bonneville Basin, which is decidedly more Utah than Nevada), we feel that each article directly contributes to our understanding of how humans adapted to this place that many of us call home.

To stay true to our theme, we have arranged the articles in a roughly chronological order so that the reader can begin with discussions of the prehistory of the region and conclude with overviews of more recent aspects of Nevada history. Leach opens the volume by using obsidian data and artifact assemblages to move beyond basic issues of chronology and considers if it is possible to address more subtle aspects of human behavior including population dynamics and gender roles via the archaeological record. Next, Giambastiani's article truly reflects our theme "Northern Nevada Across Time" by presenting an overview of data related to several millennia of human occupation near the Hawthorne Army Depot. It provides a clear example of what many archaeologists working in the region face when conducting cultural resource inventories in terms of placing the artifacts they find into the appropriate time and space. In contrast, Thomas' article addresses a very specific research topic: the effects of charcoal production on the landscape surrounding the Ward Historic Mining District in eastern Nevada between 1872 and 1878. His work questions the assumption that clear-cutting of trees for fuel wood took place and provides an alternative scenario regarding the effects that charcoal production may have had on the environment surrounding historic mining locales. Stearns and McLane also address a very specific aspect of the archaeological record of the region and provide a plausible explanation for the creation of some of Nevada's most enigmatic cultural features—pebble mounds. Mires and Kimball undertake the task of defining some of the lesser known ephemeral architectural features found in Nevada and illustrate their importance in Nevada history—in particular, their relevance to both on-the-ground archaeologists attempting to make sense of historic artifact scatters as well as those asking broader questions about cultural landscapes. Finally, Patrickson and Brunelle provide a concise overview of climate change in the Bonneville Basin. This article will serve as an important reference to individuals working in Eastern Nevada and elsewhere, as it is clear that environmental change and cultural change often go hand-in-hand—a pattern that has not gone unnoticed by those with an interest in the prehistory of northern Nevada.

We sincerely hope that you enjoy this volume of the *Nevada Archaeologist*. Again, we apologize for the delay in its completion and want to thank all those who contributed to its content and production.



# *Alvin R. McLane*



*Alvin on a winter ascent of Stoneman Peak, Nevada. Photo courtesy of Ron Reno.*

A good friend and colleague to many of us, Alvin R. McLane, died on October 18, 2006, after a valiant struggle precipitated by leukemia. Alvin was unique. Despite being a first-rate scholar, Alvin was intentionally oblivious to the separation of knowledge and experience into separate "fields." He was freed from a single focus, whether archaeology, history, mountaineering, spelunking, or natural history. When Alvin went rock climbing in the upper Truckee River Canyon he not only navigated an "easy" 5.9 route, he also envisioned antecedent, Pleistocene rivers cutting through tertiary volcanics, emigrant observations during their struggles along the Truckee River Route, and Central Pacific Railroad travelers' descriptions of the area.

Guided by his innate enthusiasm and remarkable natural abilities, he retraced the paths of great nineteenth-century explorers/scientists/humanists such as Fremont, Simpson, King, Wheeler, and Powell. As an explorer and naturalist, Alvin would have been entirely at home on any of these earlier expeditions. The core of his formidable library contained reports and journals of these expeditions, and his archives contained associated field notes, annotated topo maps, slides, and clippings. The contents of any one of the Great Surveys makes up an accurate inventory of Alvin's broad interests, including physiography, geology, plants and animals, ancient peoples, ethnography, and history. Simultaneously, Alvin's many exploration adventures rival hair-raising exploits recorded in the narratives of Powell or King. The valleys were well known by the time Alvin reached the Great Basin, but undiscovered frontiers awaited him in mountain ranges and caverns. He collected information about every locality in the region, but it was these extremes he reserved for particular attention, and where he clearly obtained the most intense experiences of the physical world. Alvin whooped and literally jumped for joy upon discovery or accomplishment.

Alvin's approach toward everything was totally direct. He utilized every possible form of transportation from technical rock and ice climbing, to extreme hiking, to Jeeps, to rides in airplanes and helicopters in order to directly experience the local environment. He immediately translated this experience into maps by using all of those (both historic and modern) available for the area, or where these did not exist (as in caves), proceeded to make them for himself. It is no accident that one of Alvin's personal heroes is the famed cartographer Carl I. Wheat. For his own purposes, a nearly photographic memory of locality served as the main repository for his knowledge, supplemented by scores of photographs, trip reports, and occasionally a more formal publication. He gradually found that archaeological site recording (particularly petroglyph sites) was perfectly suited to his needs, although not the IMACS forms. Here again we see the classic scientific explorer. While no one could have had more fun exploring, Alvin was constantly organizing and recording this knowledge in relation to other previous explorers, Native Americans, emigrants, settlers, miners, etc.

As time passed, he was increasingly called upon to share this immense personal database, which he did in innumerable ways, provided sharing would not endanger the resource. He mentored and instructed hundreds of people through time on techniques of archaeology, spelunking, climbing, and backcountry skiing. He did the same regarding his particular use of sources, many of which were not commonly consulted by local historians or other scholars until recently. He was frequently sought out to identify particular natural or historical landscapes for other scholars, or act as a guide for tours, professional photographers, or more recently, for a television series. Alvin sold books regarding his favorite topics, authored technical and popular articles, and even started his own press, Camp Nevada, to publish works emphasizing geographically-based local history.

*Eugene M. Hattori and Ron Reno*

# *Three Brief Reflections on Obsidian: Population, Mobility, and Gender Roles in the Massacre Lake Basin, Nevada*

*Melinda Leach*
*Department of Anthropology*
*University of North Dakota*

*Decades of hydration analysis and geochemical characterization of obsidian artifacts from western North American sites have yielded enormous archives of dates and provenances. Armed with these data, many researchers in the Great Basin have now moved beyond mere chronology-building to the exploration of important behavioral questions about long-term mobility, raw material transport and exchange, and changing patterns of land use. Here, I wish briefly to explore those and other questions, including population dynamics and gender roles, in the Massacre Lake Basin of northwestern Nevada.*

## OBSIDIAN STUDIES IN THE GREAT BASIN

The Great Basin (Figure 1) is a volcanically active region with thousands of surface deposits of obsidian and an extraordinary potential for obsidian hydration dating and geochemical sourcing studies. The complexities of deriving source- and site-specific hydration rates have been acknowledged (Amick 1999; Beck and Jones 1992a; Byrum 1995; Friedman and Long 1976; Hughes 1984; Jackson 1984; Michels and Tsong 1980) and their resolution is an on-going pursuit (see, for example, Beck 1999; Beck and Jones 1994; Hutchins and Simons 2000; Jones and Beck 1990; Stevenson et al. 2000). Geochemical characterization, a well established technique for identifying volcanic source localities of obsidian tools and flaking debris, is not only required for controlling variation in hydration rates, but is now central for addressing key questions in prehistory. With the ever-expanding number of sourcing studies accumulating in its research base, the Great Basin is becoming a leader in the development of both method and theory, generating sophisticated models of prehistoric social, ecological, economic, and political systems.

For example, ecological models that emphasize geography, landscape, and mobility have dominated Great Basin archaeological hunter-gatherer studies of the last several decades. And increasingly, identifying the movements of peoples across space has relied upon the tracking of chemically distinctive raw materials transported from volcanic source to base camp, village, hunting locale, or foraging station (see Basgall and McGuire 1988; Beck and Jones 1992b; Bettinger 1980; Delacorte and McGuire 1993 among many others). And some investigators have argued, using longitudinal patterns of source use, for the continuity of prehistoric territorial ranges into the ethnographic period (for example, Jenkins and Connolly 1990).

Resource patch use and subsistence intensification models have also been developed through the mapping of obsidian sources vis-a-vis the local settlement pattern. In a number of studies, variable source profiles at different types of sites have suggested intricate temporal and spatial patterning in settlement systems (see Basgall 1988; Connolly and Jenkins 1997; Delacorte et al. 1994; Leach 1988, 1992).

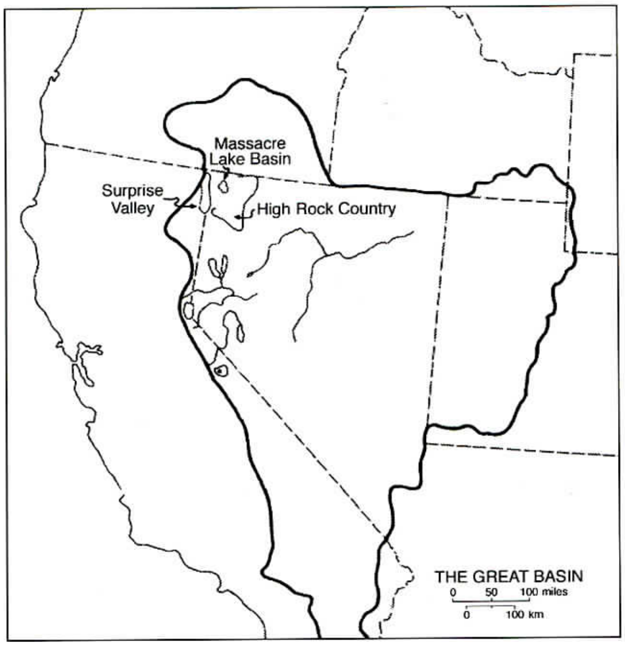



***Figure 1.*** *Map of the Great Basin.*

Using site-specific obsidian source profiles, archaeologists also have modeled the organization of lithic technology, long-term patterns of quarry use, strategies for collecting/processing/transporting raw material and tool-specific exploitation of resource procurement areas (Basgall 1989; Jones, et al. 2003; Leach 1992; Lyons et al. 2001; Smith 2004).

Finally, some Great Basin researchers have attempted to define entire settlement systems, identify social group boundaries, and specify territorial limits with obsidian sourcing (Delacorte et al. 1994; Hughes 1983; Hughes and Bettinger 1984). Sourcing analysis also has been used to illuminate inter-group communication, trade, and formalized exchange networks (Basgall 1989; Hughes 1984, 1986, and others).

## THREE BRIEF APPLICATIONS IN THE MASSACRE LAKE BASIN, NORTHWESTERN GREAT BASIN

The northwestern Great Basin, with its abundant volcanic sources, is ideally suited for obsidian hydration dating and sourcing applications. Through chemical characterization of obsidian from the northwestern Great Basin, Hughes (1983, 1986) has identified over 40 distinct volcanic sources (or chemical groupings) in that region. The Massacre Lake Basin (see Figure 1), subsuming some 432 km$^2$ in northwestern Nevada, is rich in surface obsidian scatters of "float" and "bomb" nodules that occur primarily in the southern half of the Massacre Lakes region (Raven 1981:10). The Massacre Lake/Guano Valley chemical grouping dominates the area and subsumes a large aggregation of discrete obsidian flow localities ranging over a 200 km$^2$ area, from the southern Massacre Lake Basin into southern Oregon (Hughes 1983).

Obsidian is the dominant lithic material on virtually all archaeological sites in this region. And more than 80 prehistoric quarry sites recorded in the Massacre Lake Basin testify to the prolific use of the area's volcanic resources. Some of these surface quarries range in size from a few hundred square meters to several square kilometers, displaying dense fields of assayed cobbles, cores and core fragments, blanks, and early stage reduction debris and bifaces (Leach 1988, 1994, 1995; Raven 1981).

In the Massacre Lake Basin, an extensive archaeological survey (conducted with an 8 percent stratified, random sample designed by the author) recovered 279 archaeological sites and over 260 isolated artifacts (Leach 1988). Obsidian tools and debitage were collected from site surfaces and an initial sample was submitted for volcanic sourcing (77 projectile points, 34 pieces of debitage) and obsidian hydration analysis (77 projectile points, 447 pieces of debitage) (Leach 1988, 1996; Leach and Russell n.d., 1988).[1] The Massacre Lake Basin surface artifacts, when sourced, revealed use of obsidian from at least 12 chemically distinct volcanic sources (described in Table 6). Of the initial sample of debitage, however, over 85 percent was produced from the local Massacre Lake/Guano Valley chemical group, while just over 50 percent of the projectile points were identified with this source.

With a demonstrated preference for Massacre Lake/Guano Valley obsidian for lithic production, it was useful to develop a source-specific hydration rate using projectile points (Leach and Russell 1988) and employing a best-fit power function

[1]Glenn Russell, formerly of the UCLA Obsidian Hydration Laboratory, conducted hydration analysis on 77 projectile points and 447 pieces of debitage. All measurements were made to an accuracy of +/- 0.2 microns. Some artifacts (77 projectile points and 34 pieces of debitage) also were submitted to Richard Hughes, Geochemical Research Laboratory, California, for volcanic sourcing analysis (energy dispersive x-ray fluorescence spectrometry).

***Table 1.*** *The Massacre Lake/Guano Valley Projectile Point Sample Used to Establish an Absolute Hydration Rate: Time Ranges and Mean Hydration Values.*

| Projectile Point Series[a] | Time Range (in years BP)[b] | Time Range Midpoint | n | Mean Hydra-tionValue (microns Φ) | Std. Dev. | Range of Hydration Values (Φ) |
|---|---|---|---|---|---|---|
| Cottonwood/DSN | 450–100 | 275 | 2 | 2.4 | .2 | 2.3–2.6 |
| Rosegate | 1450–450 | 950 | 8 | 3.4 | 1.6 | 1.5–6.4 |
| Elko | 2950–1450 | 2200 | 5 | 4.9 | 1.0 | 4.1–6.5 |
| Pinto | 4450–2950 | 3700 | 7 | 5.6 | 1.5 | 3.9–8.5 |
| NSN | 6450–4450 | 5450 | 5 | 6.3 | 1.2 | 4.7–7.6 |
| GB Stemmed | 10950–7950 | 9450 | 1 | 7.5 | - | - |

[a]DSN = Desert Side-notched; Elko = Elko Eared or Elko Corner-notched; NSN = Northern Side-notched; GB Stemmed = Great Basin Stemmed.

[b]References: Bedwell (1973); Hester 1973; O'Connell (1971; 1975); Thomas 1981; Tuohy and Layton (1977)

model proposed by Jackson (1984).[2] This rate was derived from the statistical regression of mean hydration values for 28 time-sensitive projectile points against the midpoint values of their time ranges (Table 1).

Using this absolute hydration rate, I established hydration measurement ranges which corresponded to accepted dates for the Paleoarchaic (*sensu* Jones et al. 2003), and Early, Middle and Late Archaic periods (Table 2). Accordingly, the debitage hydration readings (presumed to be heavily skewed toward the Massacre Lake/Guano Valley source) were then assigned to these four discrete time periods. Thus, the debitage, clustered by time period, could be examined for both chronological and other kinds of information (see below).

## Dates as "Data": Using Obsidian Hydration Dates as Indicators of Relative Population Density and Occupational Intensity

Archaeological dates traditionally are interpreted as discrete, chronological signatures for associated artifacts and sites. Yet several researchers have argued that the dates themselves, when viewed in the aggregate, present substantially more information. Indeed, dates can be viewed as data that might reveal important regional patterning, especially in population dynamics or occupation intensity (Kuzmin and Keates 2005; Layton 1972, 1973; Leach and Russell 1988; Rick 1987; Ritter 1966, and others).

***Table 2.*** *Ranges of Hydration Values for Cultural Periods, Massacre Lake Basin.*

| Period | Years BP | Range of Hydration Values (Φ) |
|---|---|---|
| Late Archaic | 100–1500 | 1.0–4.1 |
| Middle Archaic | 1500–3000 | 4.2–5.1 |
| Early Archaic | 3000–6500 | 5.2–6.6 |
| Paleoarchaic | 6500–11000 | 6.7+ |

A key assumption, of course, is that increased occupation intensity should be reflected in greater production of tools and debitage which, in turn, should be revealed in the relative magnitude of the obsidian hydration date record. The age distribution of obsidian artifacts, therefore, should reflect relative occupation intensity within a discrete region. For the Massacre Lake Basin, then, the substantial obsidian hydration date record can reveal relative occupation intensity across time.

## The Distribution of Hydration Dates

The obsidian hydration sample, which provides the date record used here, was constructed with artifacts selected from numerous site types (residential sites, temporary camps, task sites, quarries, etc.) and locales (Leach 1988). Because site age was unknown at the time of selection, the distribution of hydration readings ought to be free from any particular date bias in sampling. The debitage hydration readings (476 hydration readings, including multiple hydration bands, on 447 pieces of debitage) are contiguous, revealing no major gaps in occupation. Indeed, the date record suggests

[2] Using a non-linear, best-fit regression exercise (SAS procedure NLIN (SAS 1982), an absolute rate was derived for the Massacre Lake/Guano Valley Source of <years BP = 14.81(microns$^{3.20}$) with ($r^2$) of .99 >.

***Table 3.*** *Standardized Frequency of Debitage Obsidian Hydration Values across Time Periods, Massacre Lake Basin.*

| Time Period | Hydration values (ϕ) | Standardized Frequency[1] |
|---|---|---|
| Late Archaic 1500–100 BP | 143 | 143.0 |
| Middle Archaic 3000–1500 BP | 107 | 97.3 |
| Early Archaic 6500–3000 BP | 111 | 44.4 |
| Paleoarchaic 11000–6500 BP | 115 | 35.9 |

[1]A one-sample Kolmogorov-Smirnov test conducted on the proportions of standardized hydration dates falling into Archaic age classes shows a significant difference between the cumulative proportions and those expected, if obsidian artifact production was equivalent in all time periods. $\underline{D}_{crit,.05}$ = .076; $\underline{D}$ = .25; denotes a statistically significant result.

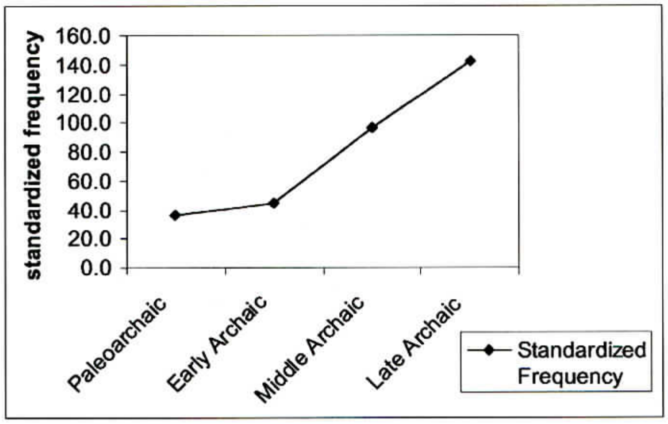



***Figure 2.*** *Standardized frequencies of obsidian hydration values across time periods.*

virtually continuous habitation in the Massacre Lake Basin.[3]

In order to examine relative population changes in the Massacre Lake Basin, however, it is more instructive to view the distribution of obsidian dates among established time intervals for the Great Basin Archaic. The hydration value frequencies shown in Table 3 have been standardized to remove the effect of unequal time periods on the accumulation of obsidian hydration dates. Each cluster of hydration dates within a time period is divided by a factor which represents the number of 1400 year-long periods in each Archaic interval. Thus, the rounded Paleoarchaic standardizing factor is 4500/1400 years=3.2; the Early Archaic factor is 3500/1400=2.5; the Middle Archaic factor is 1500/1400=1.1; and the Late Archaic factor is 1400/1400=1.0. Any significant rise in the number of dates within Archaic periods should indicate a relative increase in occupation intensity.

The distribution of hydration values shown in Table 3 and in Figure 2 reveals a burgeoning of obsidian hydration dates, particularly in the Middle and Late Archaic. The Early, Middle and Late Archaic populations contributed relatively greater proportions of obsidian hydration dates to the Massacre Lake surface deposits over time. Given that much of the Paleoarchaic record might be subsurface, the pattern of greatest significance in terms of behavior is revealed by the data for the Early, Middle and Late Archaic. For these time periods, then, I suggest that populations produced relatively greater amounts of debitage over time, triggered by rises in relative occupation intensity.

The rise in standardized obsidian hydration dates, however, is just one indicator of changing population density during these time periods. Very similar patterns in the numbers of sites, levels of tool reuse and resharpening of tools, and quantities of projectile points (see Leach 1988) support a proposition of increased occupational intensity in the Massacre Lake Basin, particularly during the Middle and Late Archaic.

This consideration of obsidian hydration dates as data can be applied fruitfully in other regions of the Great Basin where even larger databases of hydration readings have been obtained and where chemical sourcing programs have established the range of volcanic sources used prehistorically.

## Mobility and Subsistence Intensification

The significant shifts in population density/ occupation intensity that I have specified above can be expected to have had a profound influence on prehistoric decisions about where settlements were located and how resources were exploited (see Bettinger and Baumhoff 1982; Earle and Christenson 1980; Elston 1982; Jones et al. 2003; Kelly and Todd 1988; O'Connell et al. 1982). That

[3]This observation is particularly interesting in light of arguments for an "Altithermal abandonment" which have been advanced for several regions of the Great Basin (Antevs 1948; Baumhoff and Heizer 1965; Bedwell 1973; but see Grayson 1993: 216), including the nearby High Rock Country (Layton 1972, 1973; McGonagle 1974).

***Table 4.*** *A General Model of Mobility, Population Density, and Subsistence Intensification for the Great Basin.*

| Paleoarchaic 11000 BP | Early Archaic 6500 BP | Middle Archaic 3000 BP | Late Archaic 1500 BP |
|---|---|---|---|

<continuum>

| | |
|---|---|
| Low, but increasing population density. | Increasing population density. |
| Little competition for resources. | Resource competition is high. |
| Relatively high environmental productivity. | Relative productivity has declined as patch marginal value has dropped. |
| Intra-patch stays are brief. | Foragers stay longer in patches of declining output. Intensification of food exploitation within patches results. |
| Narrow diet breadth (largely high-ranked game). | Diet breadth widens to include lower ranked, seasonal foods (roots, tubers, grass seeds) [note that these are also <u>storable</u> foods]. |
| Dietary emphasis on high ranked big game (available year round), means seasonality is less stressful. | Seasonality keenly felt. |
| Little or no storage. | Storage is required to survive winter resource scarcity; higher population densities not supportable on dispersed game. |
| Narrow range of habitat types occupied. | Occupation in wide range of habitats. |
| Frequent, short-term logistical moves by special task groups (e.g. hunting parties). | Longer-distance logistical moves by special parties, especially during winter. |
| Frequent residential moves. | Reduced mobility of residence groups (especially during winter, as group is tied to storage facilities), and longer time spent in low quality patches = increasing sedentariness. |
| High inter-birth intervals maintained by mobility requirements. | Lower mobility allows/triggers shorter birth intervals and positively affects population growth rates. |

is, relative occupation density could be argued to have affected both settlement patterning and foraging behavior in the Massacre Lake Basin (Leach 1988; 1995). Coupled with well-documented Holocene environmental fluctuations during the Archaic (see Elston 1982; Grayson 1993; O'Connell 1975), increasing occupational intensity and/or population density should have triggered changes in foraging logistics, resource patch use and mobility in the region (Table 4).

In this intensification model, culture change is represented as a continuum from the Paleoarchaic/ Early Archaic to the Middle/Late Archaic. Populations experiencing long term resource stress (through climate or population changes or both) will organize their foraging activities over the landscape differently than populations experiencing resource stability. Groups living at low population density with stable resource bases should be able to maintain highly mobile foraging groups, small residential groups, and minimize storage. As the diet breadth diversifies under conditions of resource fluctuation and population density increases, residential groups will become more sedentary, possibly larger, and foraging should become more logistically organized (involving pre-planned forays to target zones by special task groups)

By the Middle/Late Archaic, there should be intensification of foraging effort as competition, a growing population, and diminishing resource returns reduce the relative productivity of habitats. Further, there should be a trend toward a broader diet, with increasing use of high-cost, low ranked small game and storable plant foods (for example, grass seeds). This broadening of the diet should be expressed in a trend toward occupation of more diverse habitats over time: as diet breadth widens, sites should be placed to give access to new resource patches so that settlement locations (particularly those of specialized procurement sites) should appear more diverse over time. Populations should have begun a shift toward more sedentary residential behavior. While settling down for longer periods in certain seasons, such residential sedentism should have been punctuated by more frequent, and more distant logistical moves in the Middle/Late

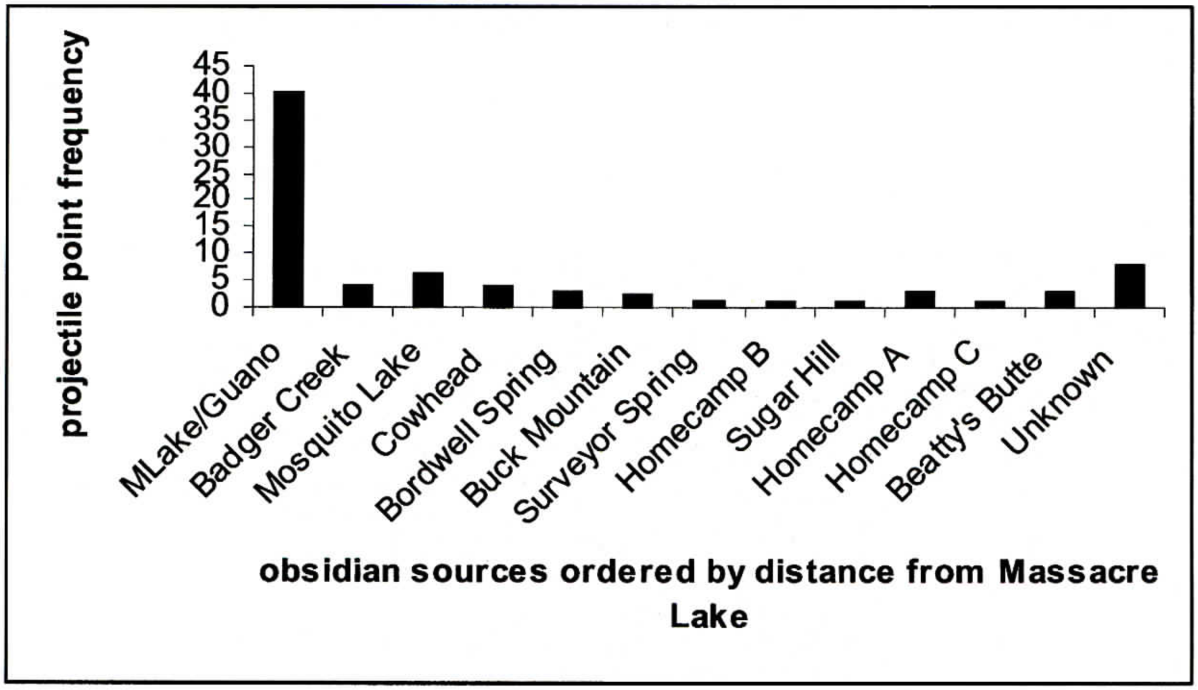



***Figure 3.*** *Obsidian source origins for projectile points (n=77).*

Archaic. Logistical groups should be going farther afield and bringing back raw materials that they pick up in the course of longer-distance foraging trips (Binford 1979:259).

Thus, by the Middle Holocene, Massacre Lake populations may well have been experiencing some degree of food stress, increasing competition, and diminished residential mobility. And the breadth of habitats exploited (and the intensification of resource use within these habitats) should have shifted in response to this stress, corresponding to different, less efficient foraging choices and increased storage needs (Leach 1988).

At the heart of this model of culture change, lies a pattern of declining residential mobility and increasing logistical mobility during the Middle to Late Archaic (*sensu* Binford 1980; R. Kelly 1983, 1990:262). Can the Massacre Lake Basin obsidian sourcing record offer any insight into this issue?

**Obsidian Source Use**

At least 14 of the distinct volcanic sources identified by Hughes (1983) for the northwestern Great Basin would have been accessible within 100 km of the prehistoric Massacre lakeshore settlements (Leach 1994). Twelve of these (along with one or more unknown sources) were revealed in the sourced projectile point sample (Leach 1988). As shown in Figure 3, a significant preference for the local Massacre Lake/Guano Valley obsidian was manifested in point production, but more distant sources, up to 70 km away, were also exploited.

An examination of source use over time, however, reveals some temporal variation, even in this small sample. In Table 5, projectile point counts have been collapsed into two larger time periods and one can see that some sources used in the Paleoarchaic/Early Archaic fall out of use in later times. Some sources appear for the first time only in the Middle/Late Archaic. Indeed, the most distant sources were used by Middle/Late Archaic groups, suggesting an expanded logistical range (increased logistical mobility) during these time periods.

Projectile points were often highly curated, refurbished, and maintained, with the result that they were carried in finished form across large territories. The proportion of projectile points manufactured from Massacre Lake/Guano Valley obsidian relative to all other sources is significantly greater in the Paleoarchaic/Early Archaic; while all other sources become relatively more important in later assemblages. Indeed, use of other sources exceeds the use of Massacre Lake/Guano Valley obsidian in the Middle/Late Archaic (Figure 4). It appears that the social units (perhaps logistical

*Table 5. Obsidian Source Origins of Massacre Lake Projectile Points (n=76)[a], by Time Period.*

| Obsidian Source (ranked by distance from Massacre Lake) | Distance from Massacre Lake | Paleoarchaic/ Early Archaic | Middle/Late Archaic |
|---|---|---|---|
| 1. Massacre Lake/Guano Valley, NV | 0-60 km | 22 | 18 |
| 2. Badger Creek, NV | 16 km | 1 | 3 |
| 3. Mosquito Lake, NV | 30 km | 4 | 2 |
| 4. Cowhead, NV | 45 km | C | 4 |
| 5. Bordwell Spring, NV | 48 km | C | 3 |
| 6. Buck Mountain, CA | 51 km | 2 | C |
| 7. Surveyor Spring, OR | 56 km | C | 1 |
| 8. Homecamp B, NV | 56 km | 1 | C |
| 9. Sugar Hill, CA | 56 km | 1 | C |
| 10. Homecamp A, NV | 56-65 km | 1 | 2 |
| 11. Homecamp C, NV | 65 km | C | 1 |
| 12. Beatty's Butte, OR | 72 km | C | 3 |
| 13. Unknown Sources | C | 4 | 3 |

[a]one point was removed from the sample of 77 for this analysis because of inconclusive temporal information.

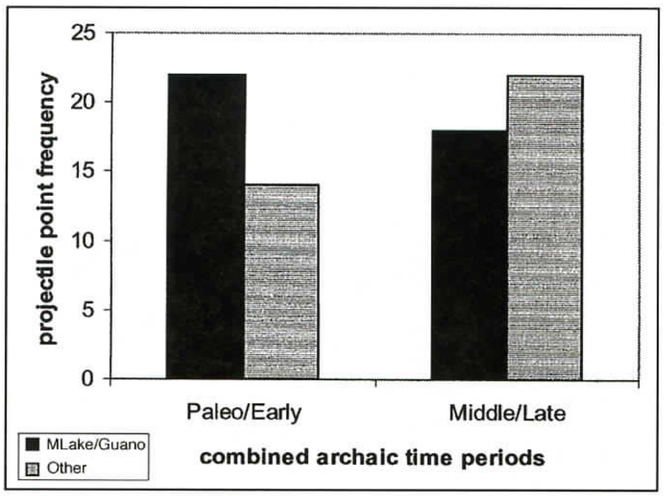



*Figure 4. Obsidian source origins of projectile points by Archaic time periods.*

parties) responsible for transporting projectile points were exploiting more distant obsidian sources during these later times.

With a larger sample size, data revealing such variability might firmly demonstrate differential use of the landscape over time by logistically mobile parties. The presence of exotic, or non-local, obsidian on sites might reflect the dispersion patterns of foraging groups during the seasonal round. Evidence of shifting annual territories and long-term mobility (including logistical and residential) patterns might be shown, then, in the temporal distribution of obsidian types in offsite and site assemblages.

If this projectile point source pattern contrasts strongly with on-site tool production (which generates copious debitage) where more generalized, less formal tools might be fashioned expediently, then we must be looking at different lithic production systems. Could variation between debitage and projectile points suggest deeper organizational, even gendered activities?

## Gender Roles and Variability in Toolstone Procurement and Use

In the last several decades, the inattention paid to the roles and activities of women in prehistory has been called into question by a number of archaeologists (Brumfiel 1992; Conkey and Gero 1991; Conkey and Spector 1984; Spector 1993; Wylie 1992). Archaeologists now recognize that men, women, and children were working together to create the archaeological record. And an increasing number of studies are turning to analyses of data sets that re-focus our attention on the actions, interactions, and behaviors of all members of the population (e.g., Gero 1991; Leach 1996, 1999; McGuire and Hildebrandt 1994; Sassaman 1998; Zeanah et al. 1995). Thus, Great Basin archaeology, once dominated by analyses that focused on the material record traditionally regarded as most visible (e.g., male foraging and formalized tool production), can now turn its attention to archaeological analyses of sites with few elaborately retouched tools and assemblages dominated by the

***Table 6.*** *Site Type Classification for Massacre Lake Basin Sourcing Study.*

| Site Type | Classification Criteria |
|---|---|
| Large groundstone site | Area > 1000 m²; presence of groundstone and chipped stone artifacts |
| Small groundstone site | Area ≤ 1000 m²; presence of groundstone and chipped stone artifacts |
| Offsite finds | Artifacts occurring in a concentration of fewer than 10 objects |
| Large lithic scatters | Area > 1000 m²; chipped stone artifacts; no groundstone artifacts |
| Small lithic scatters | Area ≤ 1000 m²; chipped stone artifacts; no groundstone artifacts |

by-products of manufacture (cores and debitage) in order to "view" other forms of production.

Early Great Basin ethnographers observed that women and men sometimes collected food and raw materials in discrete task groups that varied seasonally and locationally (I. Kelly 1932, 1964; Steward 1938, 1970; Stewart 1941). It appears that this pattern of sex-differentiated foraging likely originated in the late Pleistocene, according to sophisticated behavioral ecology models that retrodict habitat use and site distributions (e.g., Elston and Zeanah 2002; Zeanah et al. 1995).

If raw material procurement patterns, like foraging patterns, can be extended back into prehistory, then we should see differentiation of the obsidian record that women and men left behind. If we acknowledge that women, as well as men, could have been stone tool producers (Gero 1991), then it is likely that both functional and gender differences in stone tool procurement might have been at work. Did men and women use the same sorts of tools for their daily tasks? Did they procure the raw material for those tools from the same sources or locations? Might small task sites, where gendered groups might sometimes have been segregated, most clearly reflect such patterning (see Chartkoff 1995)?

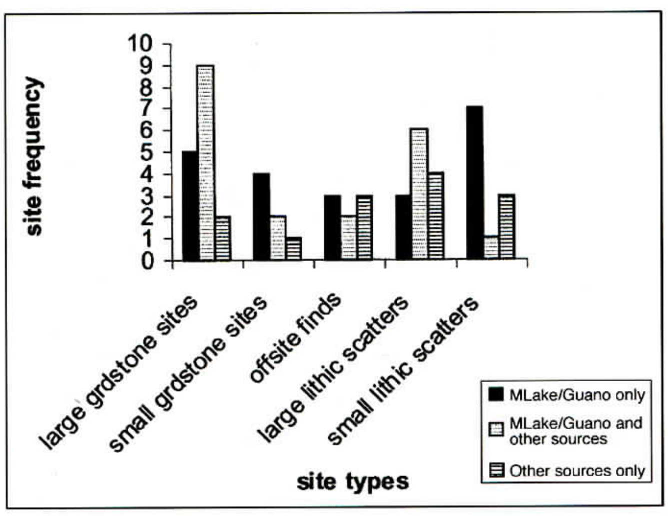



***Figure 5.*** *Distribution of obsidian sources across site types (n=55).*

In a second sourcing study (Leach 1996), I submitted an additional 120 flakes for profiling, bringing the total Massacre Lake Basin sourcing sample to 154 flakes from 55 sites. For analytical purposes, these sites have been classified according to the criteria shown in Table 6. Site area and the presence/ absence of groundstone are critical variables that might distinguish sites by both function and gender (presuming the close ethnographic association between women and plant processing activities).

When viewed as discrete collections of source occurrences in differentiated site types, the use of Massacre Lake/Guano Valley and "other" obsidians varies considerably (Figure 5). The local source, alone or in combination with other sources, dominates the profiles of all site types. But the disparity between the source profiles for these assemblages suggests that they were products of different obsidian procurement systems.

Similarly, the contrast in source occurrences between projectile point assemblages and groundstone sites (both large and small) is also striking (Figure 6). Projectile points, perhaps more often made by men, were more likely than chipped stone artifacts on groundstone sites to have been fashioned from other, non-local obsidian. As shown earlier, obsidian for these points was obtained from locales as distant as 50 to 70 km. In contrast, debitage, the by-product of stone tool manufacturing and maintenance by women and men, was more likely to be fashioned from sources closer to the Massacre Lake Basin. I suggest here that the production of projectile points and on-site debitage was carried out in at least two very different contexts of mobility: one involving transport of obsidian over long distances, the other its expedient collection and reduction. These scenarios may have involved different genders or multi-gendered groups completing functionally different tasks.

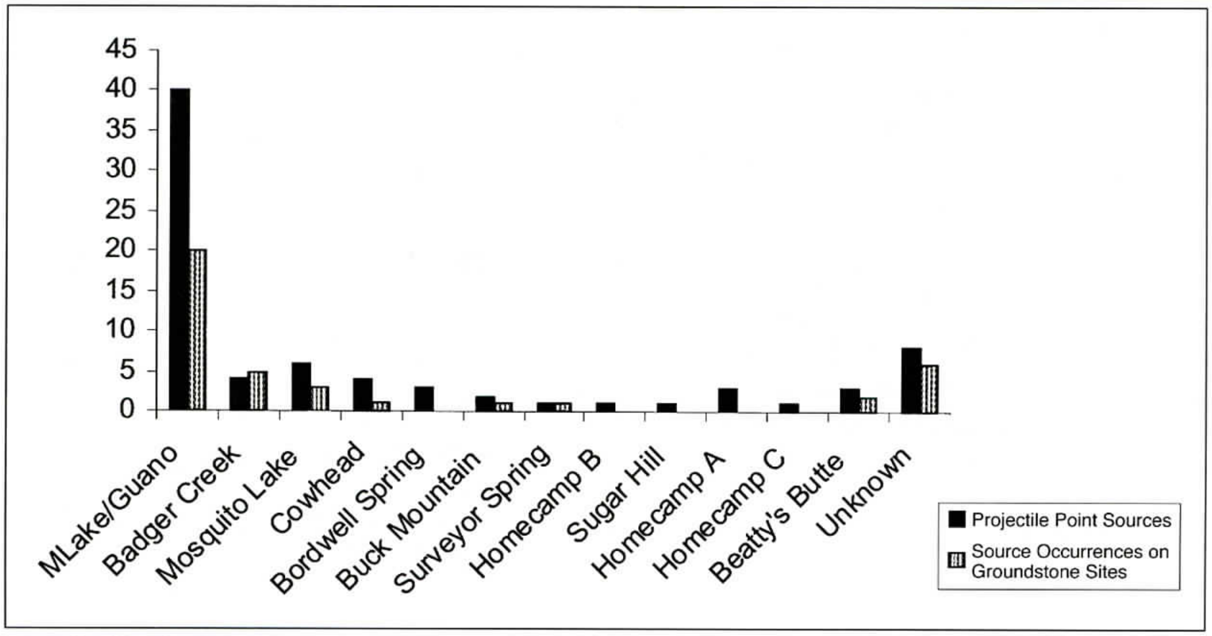



***Figure 6.*** *Obsidian source occurrences in projectile points and debitage from small and large groundstone sites.*

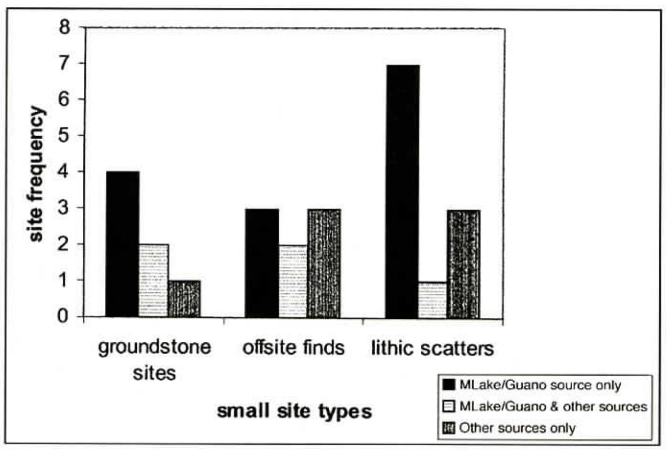



***Figure 7.*** *Obsidian source distribution across small site types.*

It is the attention to *small* archaeological sites, in particular, with few elaborately retouched tools and assemblages dominated by the by-products of manufacture (cores and debitage), that should best reveal a picture of gendered small group logistical tasks. Small groundstone sites (possibly representing women's plant procurement and processing locales), small lithic scatters that lack groundstone (possibly single-gender or multi-gender task sites), and offsite remains are examined here for differences in volcanic source profiles (Figure 7).

Lithic scatters that lack groundstone are somewhat more likely than small groundstone sites to be characterized by other, non-local obsidians. In a gendered scenario, women working with groundstone may have expediently picked up their own obsidian, as it lay readily nearby, to produce the flake tools they needed. It hardly makes sense that women would carry raw material with them to special task sites when Massacre Lake/Guano Valley obsidian was lying at their feet. Men, participating in single- or multi-gender task sites, on the other hand, might well be carrying a variety of materials or formalized tools, including obsidian from more distant sources collected during long-distance forays.

To understand how gender might have operated in the past, we have to cast the same critical eye on all components of the lithic production system that we have in the past cast on visible aspects of the archaeological record. It was not my aim, here, to identify "women's" vs. "men's" sites. Rather, I hoped to raise the issue of how we can ask more of our obsidian assemblages by modeling the expected patterning of single-gender/single-task and multi-gender/multi-task groups.

## CONCLUSIONS

We in the Great Basin are poised to ask increasingly sophisticated questions of our obsidian assemblages. Such evidence represents a means by which we can reconstruct population dynamics and complex patterns of cultural behavior, including foraging and mobility strategies, procurement, transport and exchange of raw materials, technology, modes of prehistoric land use, group organization, and gendered work and social interactions (see Andrefsky 1994; Elston and Zeanah 2002; R. Kelly 1985; Leach 1988; Thomas 1988; Zeanah et al. 1995).

To answer such behavioral questions, however, we need to continue to build large data sets of volcanic sourcing and obsidian hydration data. Equally important, we must develop theoretical models and methodological approaches that help us understand how those complex patterns of behavior are embedded in highly complex social systems. Finally, we must seek to illuminate how obsidian production and use patterns shift in response to changes in natural and social environments over time.

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# *Prehistoric and Historic Occupations at the Hawthorne Army Depot, Walker Lake Valley, Nevada*

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*A recent Class III survey by ASM Affiliates, Inc. at the Hawthorne Army Depot identified 42 archaeological sites including prehistoric lithic quarries, small to large lithic scatters, and a variety of historic deposits. Analytical results pertain to several major research themes, including regional patterns of prehistoric lithic procurement, historic period transportation, and pre-military Euroamerican settlement and land-use.*

In August of last year, crews from ASM Affiliates in Reno, Nevada, conducted a Class III cultural resources inventory at the Hawthorne Army Depot (Giambastiani 2005). The survey was done in conjunction with seismic testing to be completed by the U. S. Navy Geothermal Program and was intended to identify cultural resources that lay in the paths of proposed source and receiver lines. The inventory totaled 407 miles of linear Area of Potential Effect (APE) on lands owned and administered by the Army Depot, the BLM, and private interests. All told, ASM identified 42 archaeological sites and 211 isolate finds that demonstrate long-term prehistoric and historic use of the Hawthorne area.

The project area lies in the lower Walker Lake Valley south of Hawthorne at the foot of Mount Grant and the Wassuk Range at elevations ranging from 4,200–5,200 feet (Figure 1). Most of the landscape consists of mildly sloping, sandy terrain, but patches of incipient desert pavement occur on the upper reaches of alluvial fans in the southwestern part of the study area. Lower sagebrush vegetation emerges at highest elevations, transitioning to a shadscale scrub community between 4,900–5,100 feet. Several perennial drainages enter the study area from the Wassuk Range, including Alum Creek, Little Squaw Creek, and Corey Creek. Since well before historic times, the Hawthorne area has been part of the prescribed territory of the Pagwi-Dikita Northern Paiute (Cleland et al. 1984; Johnson 1975).

Sites found during the inventory include 21 prehistoric and 21 historic deposits. The former include four lithic quarries and 17 lithic scatters. Quarries are clustered at the south end of the survey area; all but one in its extreme southeastern corner. These sites are places where chert boulders and cobbles were assayed and reduced for export, taken off-site as large cores and bifaces. Raw chert at all quarries is consistent in composition, being grayish white to greenish gray in color and having slightly coarse-grained texture. Finished tools are absent from these sites. Debitage occurs in discrete clusters of large cortical flakes and medium-size interior flakes, some having assayed cobbles or boulders in association. Despite lots of stone-working at quarry sites, natural chert deposits are only partly depleted and many suitable boulders and cobbles remain unused. This is likely due to an abundance of raw chert in the immediate area, such material being common across an extensive series of pavement terraces located immediately to the east.

Lithic scatters are distributed more widely across the survey area. Most are dominated by obsidian and only a few are composed largely or exclusively of chert. In general, obsidian waste

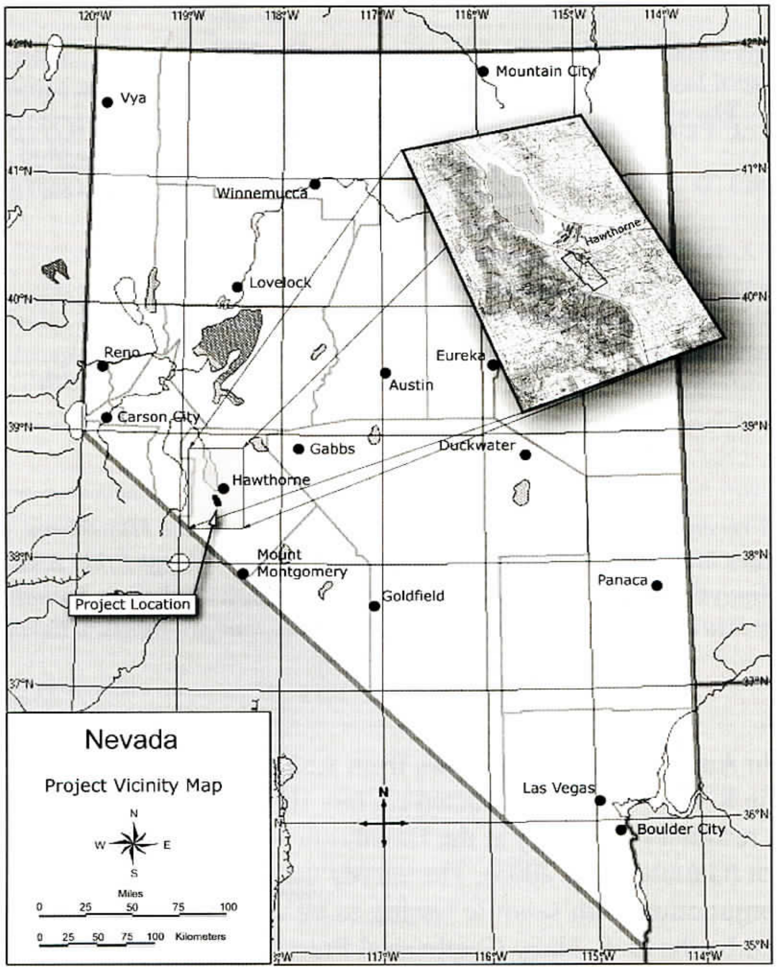


*Figure 1. Project vicinity map for the HWAD survey.*

derives from the resharpening, reworking, and finishing of various tools, while chert debris was produced through extensive bifacial reduction. Bifaces are the only common tool form at lithic scatters; projectile points and simple flake tools being present in smaller but consistent numbers. All projectile points found during the inventory are obsidian. These included two possible stemmed forms, Elko and Gatecliff types, and a Rose Spring variant. Only two groundstone artifacts were identified, one at a lithic scatter and the other within a historic trash dump.

Looking to historic sites, some 20 trash dumps were identified, most of them small, dense accumulations but a few being extensive, sparse scatters that have been well dispersed by sheetwash erosion. In general, trash dumps consist primarily of domestic refuse—mostly cans, bottles, and tins—but including dishware, utensils, and cookware like stove parts, kettles, pans, and pots. Several sites contain auto parts, building materials such as milled wood, wire, framing, bricks, and nails, while others contain assorted items like mule shoes, bicycle parts, clothing hardware, and wind-up toys. Some dumps contain a mixture of debris spanning several decades but most debris looks to date between 1910–1930, judging by maker's marks and diagnostic artifacts like solarized amethyst glass, matchstick filler cans, tobacco tins with striker plates, license plates, etc. Still other sites might date to the late 1900s, while a few are possibly of late 1940s vintage.

Not surprisingly, most historic trash scatters are probably simple roadside dumps. A group of them is spread in a linear fashion just south of Hawthorne along State Route 359, a road that approximates the alignment of the old Hawthorne-Bodie Toll Road. This historic road was built just prior to 1880 by the Walker Lake and Bodie Toll Road Company (Cleland et al. 1984; Kasso 1981; Maule 1938). It allowed for travel between Hawthorne and Bodie but also intersected the

Aurora-Bodie Toll Road that served the Esmeralda County seat in Aurora, Nevada. The exact route of the Hawthorne-Bodie Toll Road through the project area is not known, but southwest of town the road once followed the current route of Lucky Boy Pass Road (Hawthorne 1911 Quadrangle). South of town the toll road ran a bit east of the current alignment of State Route 359 on lands now occupied by the Army Depot. As it happens, one of the roadside dumps found south of Hawthorne (26MN1559) is flanked by a narrow, revegetated track that closely parallels the course of the toll road. This track is not wide or deeply rutted and has small berms on either side; thus, it does not seem a good candidate for the well-traveled Bodie toll road. While it is possible that long-term sedimentation has concealed its original, more substantial dimensions, the road could simply be an old military route that fell into disuse some decades ago.

One historic feature was also discovered, a section of the Corey Creek water pipeline now exposed by erosion beneath an overhead telephone line. The pipeline was built sometime in the late 1890s to early 1900s to bring water from Corey Creek to Hawthorne. Historic accounts claim the pipeline had a wooden interior that was wrapped by riveted iron strapping, but no wooden lining was seen during our inspection. This segment of pipeline does, however, closely follow the course of a pipeline shown on the 1911 Hawthorne quadrangle, running from Corey Creek directly into town.

Considering the inventory results, there are several archaeological patterns we can point to regarding land-use in the Hawthorne area. Starting with prehistoric sites, quarries are restricted to the south end of the study area. This is largely a function of surface geology, as such sites occur where large boulders and cobbles of raw chert are common but nowhere else on the installation. Prior research indicates that the quarries we identified lie at the extreme northwestern end of a large quarrying district where a variety of raw materials, including Garfield Hills obsidian, are plentiful (Blair and Kimball 1991; Blair et al. 1995). No doubt there are many other undocumented lithic quarries south and southeast of the study area. Lithic scatters, in contrast, are fairly spread out across the landscape at lower elevations. Some are situated adjacent to major drainages but many are not, implying such sites were not established only in accordance with seasonal water availability. Beyond this, however, it is difficult to know what the distribution of lithic scatters really means lacking a better idea of their relative ages. One site in particular, 26MN1550, illustrates this problem well. Its surface assemblage contains two possible Great Basin Stemmed points amongst a fairly dense scatter of obsidian tools and debitage. Nearby to the east, a previously recorded deposit with stemmed points (26MN1208) lies at almost the exact same elevation as this site (4,710 ft). At first glance this seemed more than coincidence, perhaps indicating that both sites lie along a relict shoreline of Pleistocene Walker Lake. Unfortunately, this is probably not the case. First, topographic and geologic data do not indicate the lake ever held a shoreline at this elevation in the vicinity of the Army Depot. Second, upon closer examination of surface artifacts it was determined the points are probably of different age than the rest of the site deposit. Both have been retouched and are heavily weathered on original and reworked surfaces, but no other artifacts are weathered at all. One can only conclude the points had been discarded prior to genesis of the site or, more likely, had been culled by site occupants from an older deposit for intended reuse. Whichever scenario is true, site 26MN1550 is typical of lithic scatters on the Depot in lacking firm depositional and temporal contexts.

Nonetheless, lithic scatters do contribute some data regarding local and regional patterns of lithic procurement and use. In general, chert artifacts at lithic scatters appear to be made of material available at local sources. Most chert artifacts look to have been heat-treated, but some sites have a mix of treated and untreated items and others are composed largely of untreated artifacts. Some heat-treated artifacts probably derive from extralocal sources, judging mainly by uniqueness in color, but untreated artifacts likely originate from local sources found to the southeast or from secondary (alluvial) contexts in other parts of the Depot. The presence of heat-treated and untreated chert at certain sites implies that some groups moving across the Depot carried stone they had obtained and treated elsewhere, but had also collected local chert somewhere along the way.

***Table 1**. Visual obsidian source profiles for lithic scatters at the Hawthorne Army Depot.*

| State Trinomial | Casa Diablo | Bodie Hills | Truman-Queen | Other Sources |
|---|---|---|---|---|
| 26MN1534 | 100% | - | - | - |
| 26MN1535 | 45% | 45% | 10% | - |
| 26MN1536 | 70% | 25% | 5% | - |
| 26MN1537 | 80% | 15% | - | 5% |
| 26MN1538 | 75% | 20% | - | 5% |
| 26MN1540 | 45% | 45% | 5% | 5% |
| 26MN1541 | - | - | 100% | - |
| 26MN1542 | 80% | 10% | 5% | 5% |
| 26MN1543 | 80% | 10% | 5% | 5% |
| 26MN1544 | - | 70% | - | 30% |
| 26MN1545 | 10% | 10% | 80% | - |
| 26MN1547 | - | 40% | 60% | - |
| 26MN1548 | 50% | 45% | 5% | - |
| 26MN1550 | 45% | 45% | 10% | - |
| 26MN1551 | 55% | 40% | 5% | - |

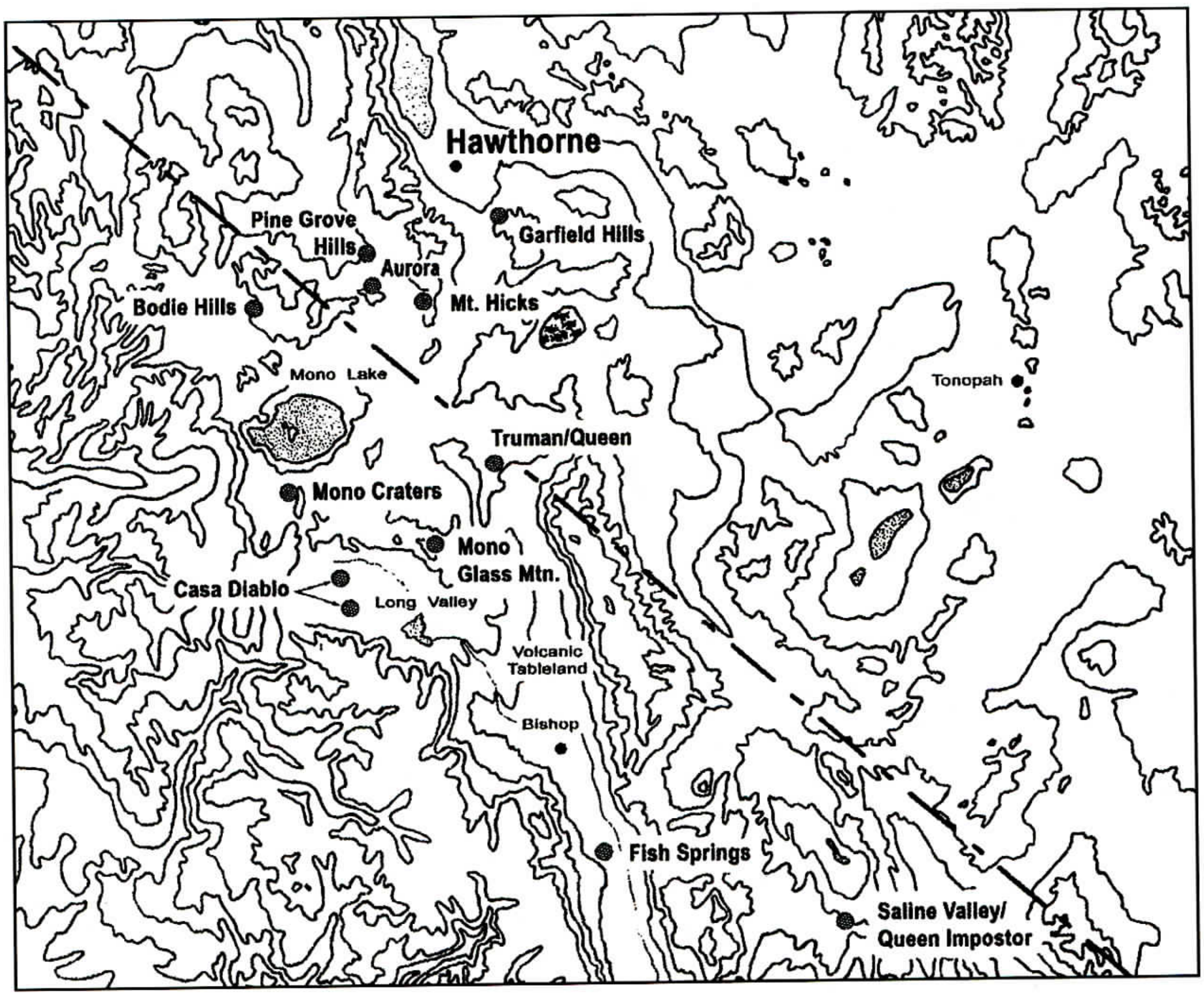


***Figure 2.** Major obsidian sources in eastern California and west-central Nevada. Modified from Basgall (1989).*

In broader context, obsidian artifacts shed some light on regional lithic procurement. At each lithic scatter, visual estimates were made as to the relative abundance of major obsidian types thought common in the Walker Lake area. Sparing the details of visual sourcing, suffice it to say the method works well in places near (but not at) major obsidian sources that, relative to each other, offer stone with distinctive visual properties (Bettinger et al. 1984; Delacorte and McGuire 1993; Giambastiani 2004). Under such conditions, success rates in visual sourcing can be quite high if the analyst is familiar with the range of variability in several different glasses. For instance, in Giambastiani's (2004) dissertation research on the Volcanic Tableland north of Bishop, California, visual sourcing proved capable in the source analysis of more than 10,000 artifacts and was about 90 percent accurate when tested against a program of x-ray fluorescence sourcing. Given that Hawthorne is located fairly near several major, distinct obsidian sources, but not adjacent to any, it was expected that visual sourcing might prove useful in developing some gross source profiles for comparison.

To this end, samples of 20 obsidian flakes were randomly selected from site surfaces and visually sourced in the field (Table 1). Results indicate that most obsidian derives from three main sources: Bodie Hills, Casa Diablo, and Truman-Queen. As the crow flies, Bodie Hills is the nearest of these, some 50 km distant, followed by Truman-Queen at 60 km and Casa Diablo at 85 km (Figure 2). The prominence of these glasses is interesting, given that other sources in the Mono Basin like Aurora, Mono Craters, and Mono Glass Mountain are more proximal to the Hawthorne area. Of 15 lithic scatters sampled, six are dominated by Casa Diablo, three by Truman-Queen, and one by Bodie Hills, while each remaining site contains a mixture of Casa Diablo and Bodie glasses. Obsidians not traced to any of these sources were placed in an indeterminate category. At certain sites this unknown group contains some Mt. Hicks glass, but indeterminates are generally assumed to include other Mono Basin sources, more distant Nevada sources, and possibly local Garfield Hills obsidian. This glass is available in the hills south of the Depot and in secondary alluvial deposits east of the study area, but its visual properties were unfamiliar to ASM analysts. While it is presumed to exist at project lithic scatters, Garfield Hills obsidian cannot yet be pinpointed without further study.

To provide a brief context of regional obsidian procurement, several researchers (Giambastiani 2004; Hughes 1983, 1985; Jones et al. 2003) have argued that Truman-Queen obsidian was primarily moved north and east during prehistoric times, unlike other eastern California sources. Truman-Queen glass is dominant at most sites on the Volcanic Tableland, but it was never moved into Owens Valley in any significant quantities. Its prevalence at Hawthorne supports evidence for prehistoric ties spanning the California-Nevada border, and, taken together with the prominence of Casa Diablo and Bodie Hills obsidians, is reflective of frequent and regular settlement movements between Mono and Walker Lake basins. The fact that Casa Diablo, being the most distant source from the Army Depot, is so plentiful indicates that factors other than proximity influenced modes of lithic procurement.

As for historic site distributions, these have implications for patterns of Euroamerican transportation and land-use. As noted earlier, most historic sites appear to be roadside dumps. They are generally aligned parallel to SR 359 and are dominated by domestic refuse. However, a few sites might contain debris related to early military activities on the installation. The Army Depot was opened in 1928, and at present there is little known about the activities, food consumption habits, and discard patterns of early military personnel. One project site, 26MN1553, contains a group of wooden boxes that once housed large artillery shells. Another site, 26MN1564, contains artifacts that together might attest to food preparation on a large scale: items like a two-gallon coffee pot; half a dozen Log Cabin syrup tins; a stove door and piping; metal roasting pans; an enamelware pitcher and two kettles; large utensils; and two iron frying pans. While it is tempting to see these artifacts as refuse from a military mess, one presumes the Army served military rations to its men during the 1930s. They could also be associated with 1933 Civilian Conservation Corps activities, which were common across the base at that time, or with a more recent surveyor's camp; a Navy benchmark was established at the site in 1953 and many such markers were installed across the Depot at that time.

Unfortunately, the nature and conditions of early military life at the Army Depot remains a key research issue to be pursued in the future.

Perhaps more curious is the disposition of a historic townsite that supposedly lay within the bounds of our inventory area. Though short-lived, the town of McKenzieville evidently contained an ore mill and a brick kiln that served mining camps in Corey Canyon (Cleland et al. 1984; McInnis 1983). Bricks from the kiln were apparently used to construct the original Esmeralda (now Mineral) County courthouse. Unfortunately, previous researchers plotted the site in two different locations near SR 359. The first is on the Depot proper east of the highway, the second west of the highway at a location now hosting several private residences. The townsite was not discovered during a thorough search of its potential location on the Depot. The private parcel is now covered by homes, outbuildings and facilities, and a variety of refuse, and for these reasons was not examined. However, even if the town was present in either location, it is likely to have been intentionally demolished and stripped of raw materials after abandonment, as were other historic townsites on the Depot like Oro City (Blair et al. 1995). Searches at the Nevada Historical Society and at the University of Nevada, Reno (UNR) library turned up no information about McKenzieville's fate, and its ultimate disposition remains an interesting question for future research.

To conclude, as a result of this inventory we now have a much better idea of site distributions on the Army Depot and can begin to comprehend what they might mean in terms of prehistoric and historic land-use patterns. Results indicate that prehistoric occupations on the Depot likely date back to the early Holocene but were most regular and frequent during late Holocene times. Groups clearly had economic and/or social ties to groups inhabiting the Mono Basin, but it is not yet clear whether the two regions were parts of the same, extended settlement system. Historic civilian inhabitants evidently used the subject portion of the Depot as a travel corridor and dumping ground, discarded refuse being of domestic nature and unrelated to mining activities occurring in the surrounding foothills and mountains. Beyond these general statements, there is little more to be said until more data become available. Much remains to be done, particularly with obsidian study and dating efforts, if we are to really understand the timing of prehistoric occupations, the role of local lithic procurement modes within regional settlement systems, and the ages of historic transportation routes and trash deposits. ASM is hoping to do more work at Hawthorne in the near future in order to address some of the interesting questions discussed in this paper.

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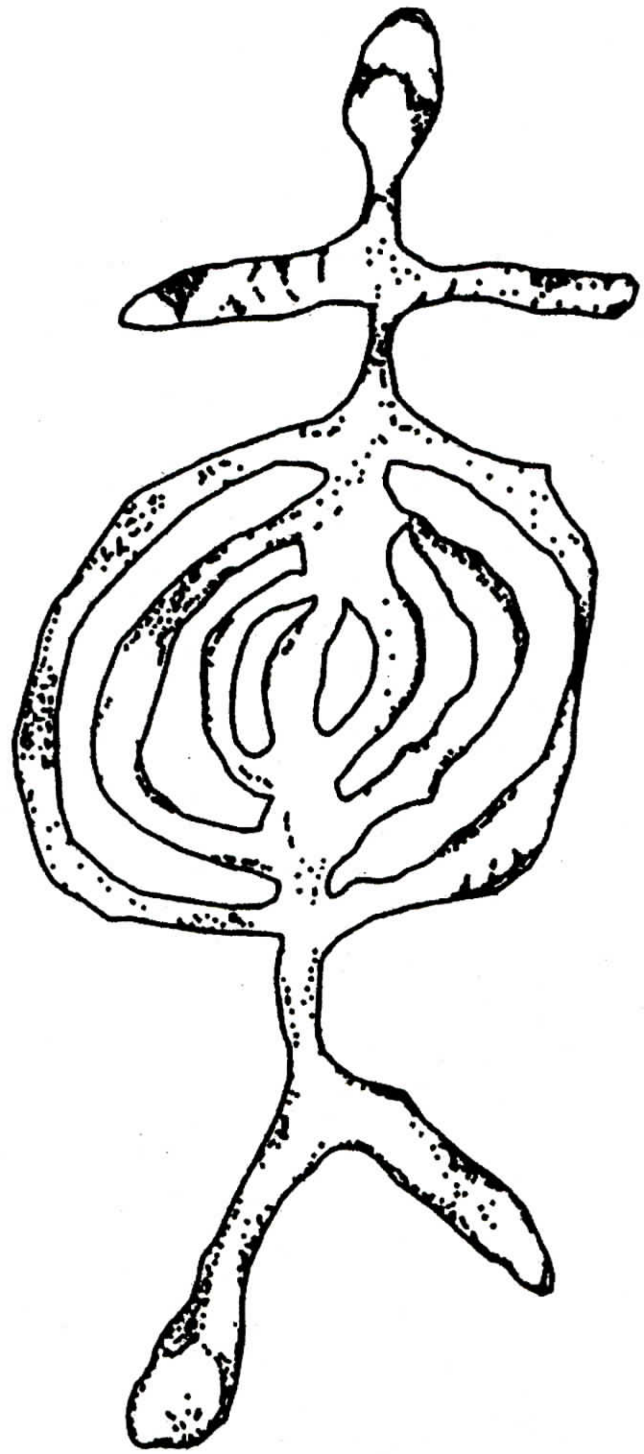

# *Pinyon-Juniper Woodland Resource Depletion at the Ward Historic Mining District, 1872–1888*

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*During the 1860s and 1870s several million bushels of charcoal were produced annually in the northeastern United States for the production of iron (Hough 1878). At the same time, in the western United States, woodcutting for charcoal was taking place at astonishing rates in Virginia City, Eureka, and other mining districts in Nevada (Young and Budy 1987:23–24). The question for many archaeologists has been "to what extent did the demand for charcoal production affect the pinyon-juniper woodlands around each Nevada mining community?"*

*This "woodland resource depletion" question also applies to the Ward Historic Mining District (referred to hereafter as Ward), especially since it is the home to six well constructed and preserved charcoal ovens. These charcoal ovens remain as witnesses to the importance of charcoal at Ward and appear as perpetrators of massive pinyon-juniper woodland depletion. Was this the case or was the depletion rate much smaller? My focus here is to answer this question by looking at the history of Ward, to determine how much charcoal was needed to process the silver ore and how much fuel wood the community used for domestic needs. Similar studies have been conducted by Zeier (1987), Hattori and Thompson (1986), and others. This paper is different in that it looks at industrial charcoal consumption as well as domestic fuelwood consumption. These combined provide a picture of pinyon-juniper woodland depletion around Ward.*

## LOCATION AND DESCRIPTION

Ward is located on Ward Mountain in the Egan Range and Steptoe Valley (Figure 1). The vegetation zones at Ward are typical to the Great Basin (Grayson 1993:32-33). At Ward, three vegetation zones are present: the Sagebrush-Grass Zone, Pinyon-Juniper Zone, and the Upper Sagebrush Zone. The town site of Ward, industrial area, charcoal ovens, and many of the roads are located inside the Pinyon-Juniper Zone. The mines are higher up in the Upper Sagebrush Zone.


***Figure 1.*** *Landscape view of Ward Mountain, showing vegetation zones and key features. This plate shows the Sagebrush-Grass Zone in the foreground, the Pinyon-Juniper Zone at the middle elevation of Ward Mountain and the Upper Sagebrush Zone with snow covering some of the sagebrush.*

## HISTORY

Like many ghost towns in Nevada, Ward ran a common "boom/bust" pattern for a mining boomtown. Hattori summarizes this pattern as:

> Prospectors search for ore, ore discovered, influx of miners, mining camp established, mines established, ore production continues, mill established, town develops, farms, ranches and support sites develop, ore production/yield declines, reduced mine and mill labor force,

> town declines, principal mine closes, town and surrounding area depopulated or abandoned [Hattori 1992:12.10].

The rate of woodland consumption/depletion parallels this pattern. Woodland resource depletion would start slow as mining begins. For example, from the discovery of ore and the early days of a mining area, there would be fewer residents that require fuelwood for domestic uses such as cooking food, heating homes, doing laundry, and heating water. Industrial demands for fuelwood or charcoal would also be minimal as most of the ore is processed elsewhere until a mill is established. During the "boom" time, the population would require higher amounts of fuelwood and industrial demand would be at its highest driven by the need for charcoal for milling or smelting ore. Eventually, the demand on the woodlands would slow down as the productive ore runs out, as mines and mills shut down and people start to move out of the area. Finally, as the area is abandoned the demand or resource depletion would cease. The following sections describe the history of Ward in more detail.

**The Early Days of Ward (1872-1875)**

In 1872, two freighters on the Pioche to Toano freight route named John Henry and William Ballinger found silver ore on what would become Ward Mountain while searching for resting oxen. This ore assayed well in Cherry Creek and the two men returned and started mining (Miller 1924:341-345). By the fall of 1873, Henry and Ballinger had sunk a 45-foot shaft at their mining claim (now called the Paymaster). With good ore in sight, they sold the Paymaster to Judge Frizzell, B. F. Ward, George Tyler, and Ben Mitten. These men named the town after B. F. Ward (Miller 1924:345–346).

Miller reports that Ward had a small population of 12 to 15 people in December of 1874. Then, with the success of the early miners, the population grew to approximately 150 by May of 1875 (1924:347-349). During these early days, the ore was processed outside of the district either at Mineral City, Nevada, or San Francisco, California (Plate 1907:281). This also lowered the rate of woodland depletion, since charcoal for ore processing was not needed at Ward.

During 1872–1875, a total of $301,957 was made from the ore at Ward. Exactly how much ore was mined is unknown (Smith 1976:80); however, Plate (1907:281) reports that each ton of ore that contained less than $50 was discarded. During the early days of Ward, this rich ore led to "gouging" the first ca. 46 to 61 m (150 to 200 feet) below the surface, exposing the more complex ore bodies that contained higher percentages of sphalerite, pyrite, and galena, which made the silver ore difficult to smelt or leach (Lincoln 1923:257; Plate 1907:281). After mining most of the rich ore from the surface, I suspect Frizzell made a shrewd business deal by selling the Paymaster to the Martin White Company in April of 1875 (Miller 1924:347).

**The Middle or "Boom" Years**

The Martin White Company came with great interest in expanding on the previous mining efforts. With their investment, a "boom" in population occurred and by 1877, Ward had a post office, two breweries, numerous businesses, two newspapers, 1,500 residents, and 680 registered voters who controlled many of the White Pine County elections (Paher 1970:260). One of the main investments from the Martin White Company were the six large conical charcoal ovens or "Cameron kilns." The Mining and Scientific Press documents the importance of their construction:

> Furnaces in Nevada had fuel problems since inception of base metal smelting. Ever since the White Pine excitement charcoal had been burned in heaps. The result was an inferior fuel full of stones and dirt. To the west at Ward in White Pine County, the Martin White Company, which had two furnaces, seized upon the Cameron kiln as an answer to contaminated fuel. In July 1876, the company brought in a Mr. Morrison from Hilliard, Wyoming Territory. Reputed to have had a life long experience in the coal business, this gentleman contracted to build six Cameron kilns of a capacity of 800 bushels of charcoal daily. Morrison agreed to run the two furnaces at 13 cents per bushel at the kilns. Haulage of charcoal from the kilns to the furnaces cost two cents per bushel more. The result was superior fuel for smelting purposes [July 15, 1876 quoted by Bailey 2002:169].

*Figure 2. The Ward charcoal ovens. Each oven is approximately seven meters tall and nine and a half meters in diameter.*

With these ovens, the Martin White Company would have received excellent charcoal at a low cost and in vast quantities. Each of the six ovens (Figure 2) would hold a total of 35-40 cords of wood; however, charcoal production slowed as historic accounts indicate that the furnace and mill built by the Martin White Company were not able to process the complex ore (Angel 1881:664; Plate 1907:281). Then, in the Ward Reflex, it states that the problems at the furnace created a large supply of charcoal at the ovens and this prompted the Martin White Company to stop taking charcoal from other charcoal vendors (Musgrove 1877:3). In this "boom" time the woodland depletion slowed, when it theoretically should have been increasing constantly. A visit to either the mill or furnace sites confirms their brief use by an almost total lack of tailings, slag, and historic debris around the sites. During the boom at Ward, charcoal production and woodland depletion should have been the greatest and in fact it was, but not at the levels it could have been if the mills and furnaces were in full production over a sustained amount of time.

## The Demise of the District

As expected with all boomtowns, success at the Ward District started to fail. By 1878, the quality of ore was starting to decline. According to William Wilson (personal communication 2004), a geologist at the Paymaster in the 1960s, the first 250 feet of the mines were naturally weathered, creating a

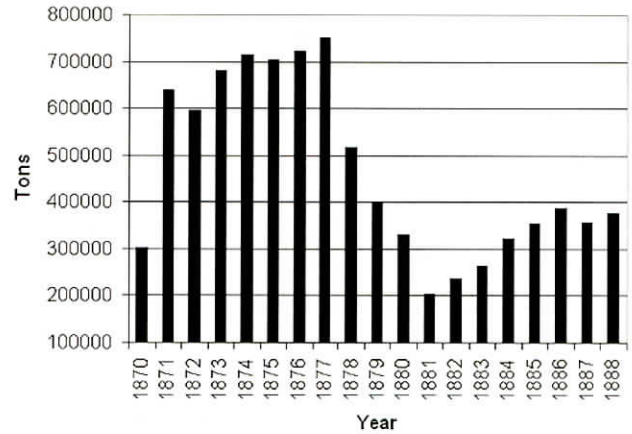


*Figure 3. Tons of precious metal ore produced in Nevada from 1870–1888 showing a decrease starting in 1878 (Couch and Carpenter 1943).*

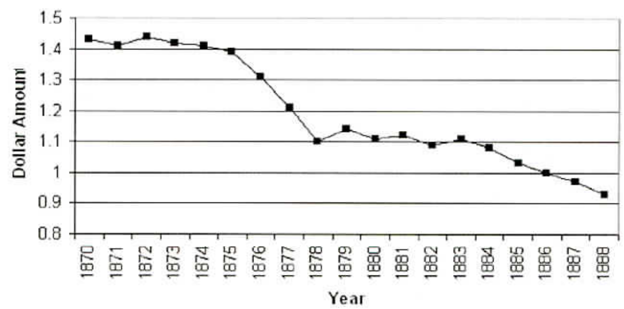


*Figure 4. U. S. dollars for an ounce of silver from 1870–1888. This chart shows a decrease in dollar amount starting in 1875 and a low point in 1878 (Kitco 2004).*

rich silver lead ore that was easily mined and processed. Also in the first 250 feet of earth were strands of wire silver and silver nuggets. Thus, the surface was exploited leaving the complex and rebellious ore below which was difficult to smelt or leach (Lincoln 1923:257; Paher 1970:259; Plate 1907:281).

The decline in production at the district mirrored what was happening in the rest of Nevada. For example, mineral production in all of Nevada had been steadily climbing from 595,141 tons in 1872, to a maximum of 750,241 tons in 1877 (see Figure 3). In 1878, ore production dropped to 518,617 tons, then below 400,000 tons in the next nine years (Couch and Carpenter 1943:13). This figure is connected with the price of silver (see Figure 4). Silver prices started to decline in 1873, dropping significantly from 1875 to 1878. The price of silver continued to be low for the remaining years of the district (Kitco 2004). By 1878,

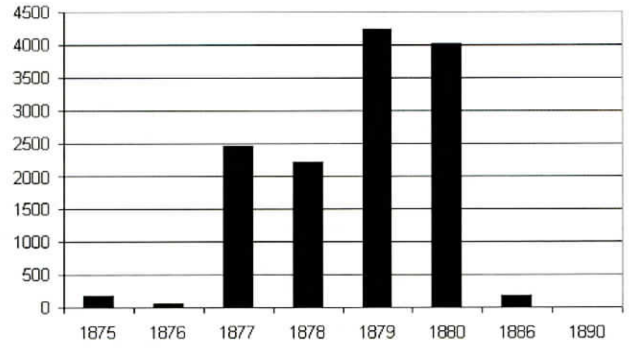


***Figure 5.*** *Tons of ore produced at the furnaces or mills at the Ward Mining District. This chart shows that the district had only four years of substantial production. Before 1875, ore was processed outside of the Ward Historic Mining District (Couch and Carpenter 1943:152).*

Ward was faced with the lowest price of silver in years, ore processing problems, and an ever-decreasing quality of ore as the mines went deeper into the mountain.

By 1878, two-thirds of the population had left the town and by 1882 active mining ceased (Lincoln 1923:256-257; Smith 1976:80). In the final years of Ward, woodland resource depletion would have slowed with the decline in population and the end of mining. In 1883, the situation continued to get worse with a large fire destroying one-third of the town. This disaster, along with the success of other mining "boom towns" such as Cherry Creek (approximately 96 km [60 miles] north) and Taylor (16 km [10 miles] east) in the early 1880s, led even more people out of the district (Lincoln 1923:256; Paher 1970:259).

By 1887, most of the residents had moved to Taylor, which included taking some of their homes and buildings with them. In 1888, the United States Post Office closed (Paher 1970:259). This was the final chapter of the boom times at Ward. In total, Smith reports 15,459 tons of ore, old tailings, or treated tons during 1875–1890, adding up to $657,854 dollars when sold—a small amount considering the $301,957 earned between 1872–1875 before the Martin White Company moved in and the $21,400,000 earned at Hamilton and the rest of the White Pine District from 1876 to 1886 (Smith 1976:Table 24-25). Couch and Carpenter (1943:152) report a smaller total of 13,347 tons produced at Ward from 1875–1880 and 1886 (see Figure 5).

## WOODLAND DEPLETION CAUSED BY ORE PRODUCTION

The importance of charcoal and, more specifically the pinyon-juniper woodlands, to remote nineteenth century Nevada mining districts is without question (Lanner 1981:116–118; Young and Budy 1987:23–24). Bailey (2002:147) stated that prior to coal mines opening up in the western United States, charcoal was the primary fuel for the smelting industry, restaurants, laundries, assay shops, and homes. Even though charcoal was very important, the devastating affects to the woodlands tends to be overestimated, especially in small mining districts. For example, many residents of White Pine County have the impression that the woodlands around the Ward charcoal ovens were "clear-cut" for 20–30 miles. This may be attributed to estimations at larger mining districts, like Eureka (see Lanner 1981).

Below, the amount of ore processed or sold at Ward during the time of the Martin White Company is used to estimate how many acres of woodland were "harvested." Table 1 uses the estimations of ore processed, the amount of charcoal bushels needed to reduce a ton of silver ore, the amount of bushels in a cord of wood, the number of cords in each acre of woodland, and the acres of woodland harvested to process the ore. This process is outlined in the Table 1 and described in the following paragraphs.

Smith's total of 15,459 tons of ore is used in Table 1, instead of the more cautious total of 13,347 tons reported by Couch and Carpenter. This larger total was used as a cushion to not underestimate the ore production and woodland resource depletion at Ward. Normally, to reduce one ton of ore it would take at least fifteen to twenty bushels of charcoal (Bailey 2002:59). Given that the ore at the time of the Martin White Company contained more slag and less silver, a higher and more sustained temperature was needed. No less than 20 bushels of charcoal would be needed to reduce a ton of ore (William Wilson, personal communication 2004).

Lanner (1981:125) states that a normal amount of pinyon in historic times was ten cords per acre, and a cord made about 30 bushels of charcoal. Harry Rhea, a Natural Resource Specialist at the

***Table 1.*** *Calculating the acres of woodland needed to process 15,459 tons of silver ore, along with calculations of woodlands with 14 or 8 cords per acre.*

| Variables | Amounts | Calculations | Results |
|---|---|---|---|
| The total ore processed at the district (Smith 1976:Table 24) | 15,459 | | 15,459 tons |
| The number of charcoal bushels to reduce a ton of silver ore | 20 | 20 x 15,459 | 309,108 charcoal bushels needed. |
| One cord of wood will make 30 bushels of charcoal | 30 | 309,108 ÷ 30 | 10,306 cords needed |
| Cords of wood in each acre of woodland | 10 | 10 ÷ 10,306 | 1,031 acres (1.61 sq miles) of woodland depleted for processing 15,459 tons of ore |
| Cords of wood in each acre of woodland | 14 | 14 ÷ 10,306 | 736 acres (1.15 sq miles) depleted |
| Cords of wood in each acre of woodland | 8 | 10 ÷ 10,306 | 1288 acres (1.92 sq miles) depleted |

Ely BLM Field Office, says that some of the areas around Ward would have had 300-year-old stands of pinyon and juniper that would have yielded 14 cords per acre (personal communication 2004). Robin Tausch, a well-known United States Forest Service Researcher, states that woodcutting for charcoal was selective, meaning the larger trees that were more cost effective to cut down were "high graded" (personal communication 2004). Sparse woodland areas containing less than eight cords per acre were rarely exploited for charcoal (Earl 1969:52).

Using Lanner's 10-cord-per-acre woodland, a minimum of 10,306 cords, or 1,031 acres of woodland, was cut down to process the ore at Ward. Table 1 also shows the results for a sparse eight cord per acre woodland and a maximum 14 cord per acre woodland. By changing the density of the woodlands, only modest gains or losses are seen in woodland depletion. Ten thousand, three hundred, and six cords is a small amount of woodland depletion. It is far less than the suspected radius of 32 to 48 km (20 to 30 miles) surrounding Ward. Table 1 does not factor in the possibility that some ore could have been produced and not reported to the State of Nevada; however, given that the district was plagued with complex ore, a drop in the price of silver, and failures at ore production, this is unlikely to have a substantial effect on the results.

## POPULATION DRIVEN RESOURCE DEPLETION

Except for the 1880 U.S. census data, the population numbers in Figure 6 are estimated on historic accounts and estimations of the rise and fall of the district (Lincoln 1923:256; Miller 1924:346–349; Paher 1970:259–260); Smith 1976:80; Walker and Seaton 1883:Table XXIV). This chart illustrates the population numbers beginning with the early years, the rise and fall of 1876–1878, and the slow 10-year demise of the population.

The amount of firewood/fuelwood needed each year for any population can be extremely variable. Included in this variable are: the size of homes/habitation type, insulation in the walls of the home, type of wood burned, moisture in the wood, how it was burned, what food was cooked, climate, how cooking was done, and the comfort level desired by the residents (Charles Adkins, Neal Hitch, Ron May, and Michael Pfeiffer, personal communication 2004). Also included would be heating for commercial buildings such as markets and specialty shops such as tailors and shoemakers. Given that most archaeological studies for domestic fuel consumption seem to be scarce, modern cases from the United States Forest Service Experiment Stations, personal communication with current residents of White Pine County, and a slight dose of

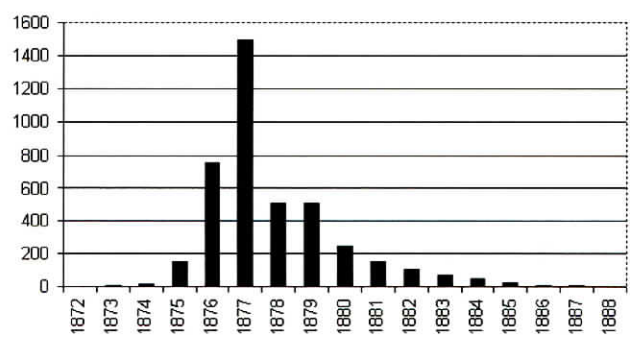


***Figure 6.*** *Population at Ward, showing the decline after 1877.*

***Table 2.*** *Average annual temperature in Wisconsin, South Dakota, and Ely, Nevada, along with cords of fuelwood needed for a primary source of heat.*

| State | Average Annual Temperature (Fahrenheit) | Cords of Fuelwood needed |
|---|---|---|
| Wisconsin | 43.2 | 5.24 |
| South Dakota | 46.1 | 3.31 |
| Ely, Nevada | 45.0 | 4* |

*Estimated annual domestic fuelwood consumption at the Ward Historic Mining District.

archaeological inference was used to determine the consumption amounts.

The Forest Service conducted a study in the midwestern states of Wisconsin and South Dakota. In Wisconsin, 5.24 cords are burned in a home that is solely dependent on a fireplace or iron stove for heat (Table 2) (May and Mace 1996). In South Dakota, that same category showed 3.31 cords used (Table 2) (May 1996). Similar studies for the state of Nevada were not found; however, the average annual temperatures in South Dakota, Wisconsin, and nearby Ely, Nevada are compared in Table 2. Not surprisingly, the colder annual average temperature of 43.2 degrees in Wisconsin promoted more fuelwood consumption over the warmer (but not tropic) South Dakota. The average annual temperature in Ely is also a cool 45 degrees (NOAA 2004 and Weatherbase 2004).

The studies in Wisconsin and South Dakota do not indicate the size of homes that were heated or the amount of insulation. It is highly probable that these modern homes would have been larger than the small cabins at Ward, thus they would require more cords to heat. In contrast, these modern homes probably do not use fuel wood for cooking, whereas the residents of Ward would be cooking and heating water year round.

By comparing the annual average temperatures and cords of fuelwood needed in South Dakota and Wisconsin to the temperature in Ely, I propose that the residents of Ward would have needed at least four cords of wood each year per family. The residents I spoke to in Ely use two and a half to four cords a year for their primary source of heat in their modern size homes (Mark Henderson, Teresa Hutchinson, and Bruce Pay, personal communication 2004). These homes are larger, but the occupants are not using fuelwood for cooking. Therefore, four cords per year seemed to be a reasonable amount.

To make sense of it all, Table 3 was created. It summarizes the population over time and divides that to persons to a family from the 1870 and 1880 Census (Walker and Seaton 1883:Table XXIV). Then it takes the cords per family estimate and multiplies it by the total amount of families, which gives the amount of total cords used. This number

***Table 3.*** *Domestic fuelwood consumption at Ward, based on a ten cord per acre woodland.*

| Year | Population | Persons to a Family | Families | Cords per Family/ per Year | Total Cords Used | Acres Depleted |
|---|---|---|---|---|---|---|
| 1872 | 2 | 2.0 | 1.00 | 4 | 4.00 | 0.40 |
| 1873 | 11 | 4.3 | 2.56 | 4 | 10.23 | 1.02 |
| 1874 | 15 | 4.3 | 3.49 | 4 | 13.95 | 1.40 |
| 1875 | 150 | 4.3 | 34.88 | 4 | 139.53 | 13.95 |
| 1876 | 750 | 4.3 | 174.42 | 4 | 697.67 | 69.77 |
| 1877 | 1500 | 4.3 | 348.84 | 4 | 1395.35 | 139.53 |
| 1878 | 500 | 4.3 | 116.28 | 4 | 465.12 | 46.51 |
| 1879 | 500 | 4.3 | 116.28 | 4 | 465.12 | 46.51 |
| 1880 | 250 | 4.11 | 60.83 | 4 | 243.31 | 24.33 |
| 1881 | 150 | 4.11 | 36.50 | 4 | 145.99 | 14.60 |
| 1882 | 100 | 4.11 | 24.33 | 4 | 97.32 | 9.73 |
| 1883 | 75 | 4.11 | 18.25 | 4 | 72.99 | 7.30 |
| 1884 | 50 | 4.11 | 12.17 | 4 | 48.66 | 4.87 |
| 1885 | 25 | 4.11 | 6.08 | 4 | 24.33 | 2.43 |
| 1886 | 10 | 4.11 | 2.43 | 4 | 9.73 | 0.97 |
| 1887 | 5 | 4.11 | 1.22 | 4 | 4.87 | 0.49 |
| 1888 | 0 | 4.11 | 0.00 | 4 | 0.00 | 0.00 |
| Total | ° | ° | ° | ° | 3838.18 | 383.82 (.59 square miles) |

*Figure 7. Historic saw-cut stump next to a young pinyon pine in the pinyon-juniper woodland.*

*Figure 8. Axe-cut Utah juniper in the pinyon-juniper woodland.*

*Figure 9. Axe-cut mountain mahogany near the Paymaster Mine.*

then is divided from a ten cord per acre woodland, showing a total of 3,838 cords of fuelwood needed and 383 acres of woodland needed for domestic needs.

## FIELD WORK SUMMARY

A series of linear transects, vehicle reconnaissance, and pedestrian reconnaissance was conducted in the summer of 2004 to explore and discover the remains of woodland depletion at Ward. What was found was very interesting and is summarized below:

- Tremendous amounts of historic tree stumps still remain. Stumps are pinyon, juniper, and mountain mahogany. Most of the stumps were located in clusters.
- The stumps that were located were very large, many larger than the modern trees. The average diameter for a single-leaf pinyon (*Pinus monophylla*) stump was 89 cm (35 inches) and 85 cm (33.4 inches) for a Utah juniper (*Juniperus osteosperma*). Based on these measurements, many of these trees cut down would have dwarfed the trees of today (Figure 7).
- The size and arrangement of stumps gave the appearance of a woodland where the trees were larger with more space between them. This would coincide with the pinyon-juniper expansion as a result of wildland fire suppression and cattle grazing.
- More juniper stumps were located, despite the sources that state pinyon and mountain mahogany were the prime fuels; however, this may be attributed to the preservation quality of juniper over pinyon.
- I was surprised to find charcoal pits and a charcoal sled close to the charcoal ovens. Future research may provide clues to when and how these were used at Ward.
- Similar to modern woodcutting today, some of the historic woodcutting locations paralleled the historic roads.
- More saw-cut pinyon stumps (as opposed to axe-cut juniper stumps) were found around the charcoal ovens than the town site, suggesting specialized or tradesmen cutters focusing on pinyon.
- More axe-cut juniper stumps were seen near the town site (Figure 8).
- Axe-cut curlleaf mountain mahogany (*Cercocarpus ledifolius*) stumps were found near the mines (Figure 9).
- Most importantly, Tausch's theory of "high grading" was proven. A perfect circle of woodland depletion was not seen. The woodcutting area seemed to be amorphous and vast with some epicenters around the charcoal ovens and town site.

## CONCLUSION

In writing this paper I have noticed that there are numerous variables that could affect the amount of woodland resource depletion. Many of these variables are unknown, such as the size of each home at Ward and exactly how much charcoal


***Figure 10.*** *The only known photograph of Ward, showing the buildings, homes, and vegetation. Juniper, pinyon, or mountain mahogany are located around the buildings. Dark streaks of pinyon-juniper woodlands appear on the Schell Creek Mountain Range in the background. A stand of juniper appears near the valley floor. An axe-cut mountain mahogany appears in the foreground and is marked with an arrow (University of Nevada Reno, Special Collections).*

was made at the district. For example, the Martin White Company also stored wood and charcoal for future use, thus expanding the woodland depletion. However, I feel that this paper has provided a basic starting point to understand the extent of the depletion.

From my calculations, a total of 382 acres of woodland were harvested for domestic use and 1,031 acres were harvested for industrial use, making a total of 1,413 acres (14,144 cords), or 2.2 square miles (5.7 square km), of clear cutting. One could argue that 2.2 square miles of woodland or 14,144 cords is far below what was used. However, even if the amount of cords per family and charcoal for the industry were doubled or tripled, it would still only be a minimal amount of depletion. The fact is that the charcoal ovens were not used to the extent previously thought and the boom period at Ward was quick and only topped out at 1,500 residents.

As Tausch has suggested, I also propose that selective cutting took place at Ward. This selective cutting would have "stretched" the depletion over much of Ward Mountain and into other areas of the Egan and Schell Creek Ranges. An exact radius would not have occurred; more likely it would have been a patchwork of cutting around the town site, mine area, wood ranches, and charcoal ovens. Therefore, the 2.2 mile radius is not a good indicator of what was cut down. Instead, at least 14,144 cords of wood were cut to fuel Ward. This is supported by the only known picture of Ward that shows trees inside and around the town (Figure 10) and some beginning fieldwork (summarized below). In conclusion, the extent of woodland depletion at Ward was not the 20 to 30 mile clear-cut area as thought of by local residents, but a patchwork of 14,144 cords.

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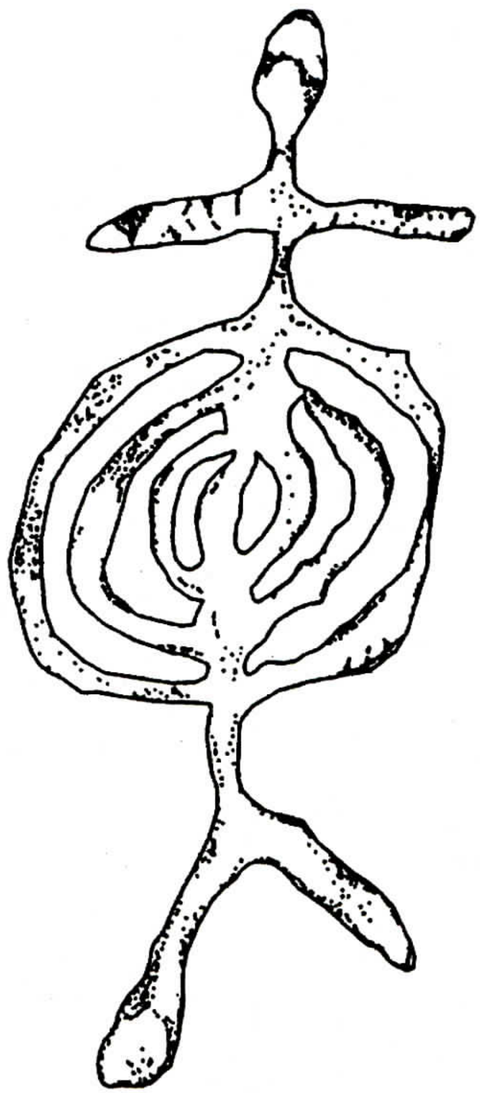

# *A Pebble Mound /Railroad Ballast Harvesting Site Near Hazen, Churchill County, Nevada*

*Steven Stearns and Alvin R. McLane*

*A pebble mound site (26CH2335) recorded in March 2005, northeast of Hazen, Nevada has shed some light on the function of one of these enigmatic sites. The spacing of the rock rows of cobbles, raked pebble piles (some of which have been wholly or partially removed), and an approximately 100-year-old shovel blade found associated with one of the pebble mounds make a case for ballast harvesting during the 1901–1903 construction of the Hazen branch of the Southern Pacific Railroad (Myrick 1962). This is not a new proposal of their function but provides further credence to earlier proposals for the function of pebble mounds in this area.*

Pebble mounds which include boulder/cobble cairns features along old beach terraces have been recorded in the vicinity of Hazen, Nevada. The Peg Wheat and Sadmat sites (26CH190 and 26CH163, respectively) are two better-known sites containing these mound features, but others have also been identified in Nevada and in the southern California desert such as in Silver Lake and Death Valley (Taylor et al. 1985; Wlodarski and McIntyre 1979). Typically, these "pebble mound complexes" can be described as a series of patterned low-lying semi-circular mounds. "Pebbles" comprise rounded to sub angular gravel averaging 2 to 7 cm in size. Sometimes, small rock cairns (comprising large cobbles and small boulders) as well as linear cobble rows or alignments are also found on these sites. Site size ranges from under an acre to near 100 acres with hundreds of pebble mounds present. Generally, these pebble mound/cobble cairn sites have the following characteristics:

- Associated with Pluvial lake terraces/beach features with some dissected by an erosional drainage feature—elevations in the Lahontan Basin are ca. 4,000 ft above sea level.
- Abundant gravel, cobbles, and boulders are associated with these terraces.
- Pebble mounds are circular to oval piles of well-sorted gravel ranging in diameter from ca. 1 to 1.5 m and generally they are less than 30 cm high.
- Cobble piles ("cairns") and linear, circular, and curvilinear cobble patterns found on these sites are similar to some geoglyphs. On many sites pebble mound spacing is symmetrical.
- Patinated artifacts and projectile points assigned to the Western Pluvial Lakes Tradition (12,000 to 8,000 years B.P.) are sometimes associated with these features (most pebble mounds features, however, are absent of prehistoric artifacts).
- Few historic items are found on these sites.
- An historic railroad is usually found within a few miles or less in these areas.

Estimated age of the pebble mounds by archaeologists vary from historic times to over 8,000+ years. The historic date has been speculated by their presence near railroads or historic trails but there have been relatively few historic artifacts associated with these sites (see below). Prehistoric dating has been suggested by stemmed points and similar rock features found on Western Pluvial Lake Tradition and Archaic period sites (Irwin-Williams et al. 1986).

## PEBBLE MOUND FUNCTION

Initially, pebble mound/cairns were first noted during studies in the desert areas of California and were later found in Nevada (Touhy 1981). In California, rock mounds or cairns are associated with shallow burials, food caches, mining, erosional features, and trial-side shrines (Laylander 1996; Taylor et al. 1985:2–4). One of the earliest accounts of these features was by Rogers (1939) during his early man (San Dieguito) studies (similar rock piles were later found in southern Nevada at Tule Springs [Susia 1964]). In northern Nevada pebble mounds were first recorded along the ancient Lake Lahontan shoreline that also contained artifacts associated with Western Pluvial Lakes Tradition. As a result they, too, were thought to be prehistoric.

Studies by the Desert Research Institute (DRI) by Irwin-Williams et al. (1986) focused on techniques of gathering rainwater runoff using constructed pebble mounds near the Hazen area (their mock site is in the vicinity of 26CH163 and 26CH190). In their view, the raked pebble mounds enhanced water runoff that in turn could be collected or diverted to important subsistence plant species. They also draw from the analogous pebble mound features found in the Israeli Negev desert where they are used to successfully water a variety of crops. The Negev area also receives rainfall amounts similar to northern Nevada. DRI's experimental use of pebble mounds as water harvesting devices proved successful—pebble mounds significantly increased water runoff. However, the possible advantage of constructing pebble mounds on either the Sadmat or Peg Wheat sites for water gathering is questionable due to the accessibility of perennial water from the nearby Truckee or Carson rivers.

An historic link between the pebble mounds and the railroad was proposed by Touhy (1981) and Dansie (1981). Touhy (1981:8) in his reference to the Sadmat site states:

> "...I should like to make it clear that not only are pebble mounds present there, but many of them appear to be mere remnants of mounds, the pebbles having been scooped up by unknown parties for unknown uses."

He (Touhy 1981:8) also inserts his take on the function of the pebble mounds at the Sadmat site.

> "...I am of the opinion that some of the pebble mounds eventually will be shown to be of historic age, and related to the gathering of gravel for use in railroad grade or highway construction or repair work."

Dansie (1981:21) also saw a possibility for an historic connection:

> "most of these sites are located from one to three miles from the railroad. ...what look like typical mound complexes from the air, but which on the ground show that mounds seem to have been removed.... Some of these are located near railroad grades."

She also suggests the possibility of pebble mounds having been used for the nearby emigrant wagon road improvements. However, she discounts their use for this purpose because of the intensive labor required to rake the rock piles and construct or improve this trail because of the overall physical condition of the emigrants at this point of their journey (having just crossed the exhausting Forty Mile Desert).

A railroad pebble mound connection has been in existence for a few decades, but convincing archaeological evidence for railroad construction or maintenance activities have not been presented. Recently, an intensive examination of site 26CH2335 has furthered evidence for ballast harvesting in connection to the nearby Hazen line. The site and description of its features and historical connection follows.

### Site 26CH2335

Site 26CH2335 was first identified on private land in conjunction with the development of a Nevada Department of Transportation (NDOT) material pit. Upon its discovery it was initially labeled as a geoglyph. This was based on multiple circular rock patterns 3 to 5 m in diameter and linear alignments of several meters (Figures 1, 2 and 3). At first, remnant pebble piles were difficult to see on this site. This was in part due to juxtaposition of

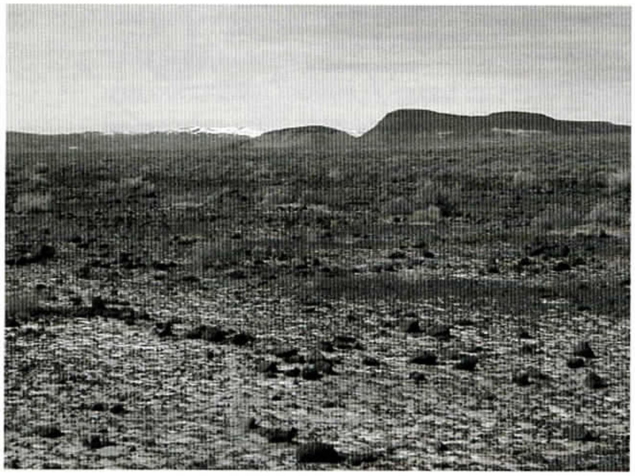

***Figure 1.*** *Pattern cobbles and boulders associated with remnant pebble mounds.*

***Figure 2.*** *Remnant pebble mound with juxtaposed linear cobble feature.*

***Figure 3.*** *Cairns/cobble piles on the perimeter of remnant pebble mounds.*

the cobble patterns (Figure 2) that dominated the landscape. In fact, these pebble piles were revealed only after a second visit to the site. Because it was first identified as a geoglyph, Alvin McLane, a Nevada rock art and geoglyph specialist, was asked to visit the site and provide his assessment of this feature. At this time, he also concurred with its identification as a geoglyph; however, he was puzzled by its complexity and size (it measured ca. 300 m X 100 m along a Lahontan beach terrace). This led him to return a few days later and, with the aid of Steve Glotfelty, they intensively studied these geometric features and expanded the survey area following this terrace to the northeast and southwest[1]. As a result, the site's boundaries enlarged as they located a total of seven areas containing rock alignments. The expansion of this site, over two miles to the southwest of the NDOT project, incorporates the Sadmat Site[2]. They found linear, raked rows of harvested pebbles several hundred feet long (Figure 4) and many remnant pebble mounds located adjacent to them. Also, at one of these remnant mounds is a ca. 100-year-old

***Figure 4.*** *Raked gravel "windrows."*

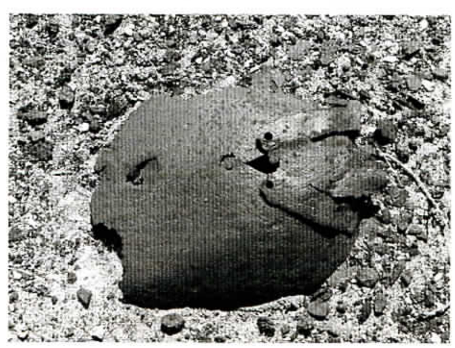

***Figure 5.*** *Shovel blade in remnant pebble mound in the vicinity of the Sadmat site.*

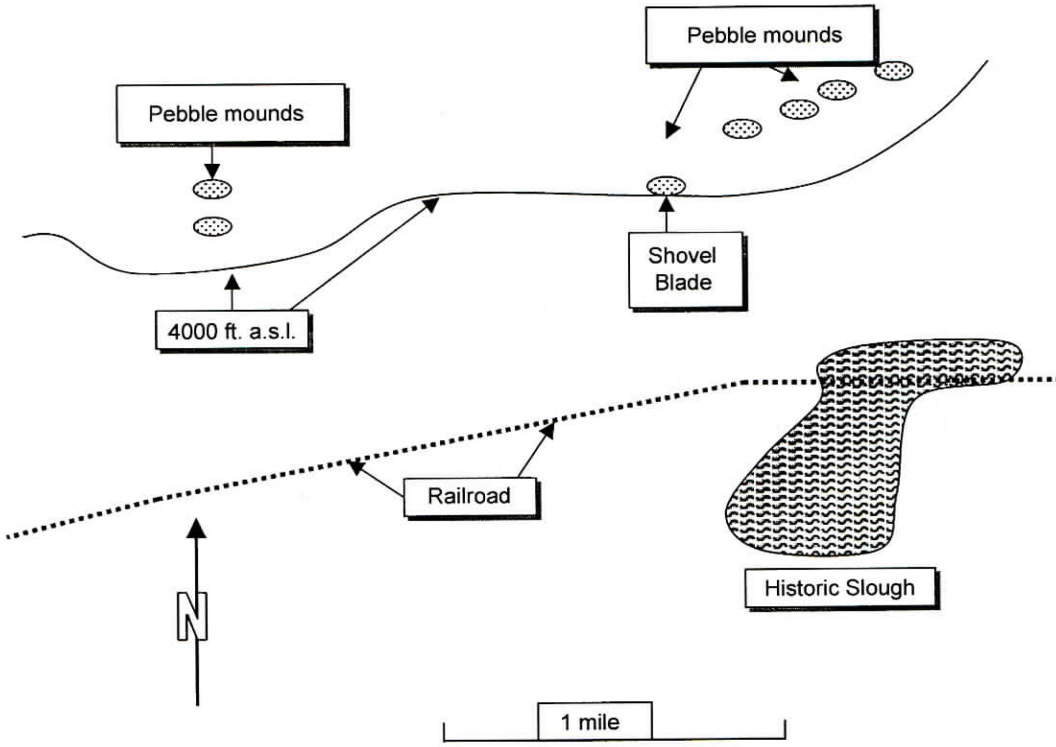


***Figure 6.*** *Some pebble mound locations near Hazen*

shovel blade (Figure 5). It was evident that the classification of this site as a geoglyph was wrong. Instead site function focused on the historical harvesting of pebbles for ballast during the construction of the Southern Pacific/Hazen line railroad (Myrick 1962) located less than one-half mile away.

The argument for the function of 26CH2335 as a ballast-harvesting site is compelling based on the surface features recorded during this survey. Site features described by McLane include:

- Seven harvesting areas located—some several hundred feet long along an approximate 2.50-mile linear area (Figure 6).
- A number of the rocks had the patina side down with the lighter, unpatinated surface facing up.
- In the center of cleared areas (showing the under silt/hard pan), with the rocks moved to the side (sometimes in circular patterns, linear arrangements, and rock mounds), were small pebble clusters[3] (see Figures 1–3).
- Circular cleared patterns were observed which were just wide enough to conveniently rake the pebbles into piles and spaced in a linear pattern wide enough to drive a wagon through. Then

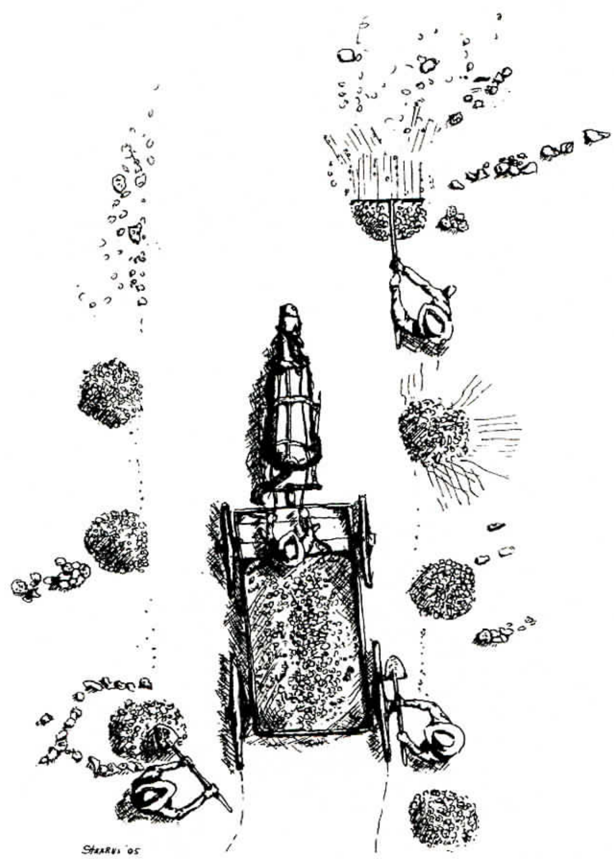

***Figure 7.*** *Proposed ballast collection method.*

the pebbles could be loaded in from both sides (Figure 7).

- An occasional mound of raked up rocks located somewhat off to the side of the linear pattern were not removed and one can see the circular raked pattern with the cobbles squarely in the middle.
- In one of the harvested areas, rocks have been raked into rows (Figure 4).
- The western locality showed a number of rock piles that were not removed, but there are also some piles that were harvested.

By itself, the geometric patterning, especially the long very regularly spaced parallel narrow rows, are indicative of an historical origin. The methods of raking these "windrows" of pebbles and cobbles indicate an expedient method for gathering ballast material. The following steps might explain the progression of ballast harvesting:

- Small railroad construction crews with hand tools including rakes, pitchforks and shovels were sent out along a beach terrace containing suitable rock material. This could be done by only a handful of people.
- Crews worked quickly raking pebbles into piles and removing cobbles and small boulders probably in just one or two passes thereby clearing a pathway for a wagon.
- Material could be shoveled into a wagon from both sides (Figure 7) and transported to a staging area or directly to the railroad bed. A shovel blade left adjacent to a pebble mound provides evidence of this (Figure 5).

## CONCLUSION

The amount of material (cubic yards) yielded from these pebble mounds is unknown. However, the proposed process is simple enough and because this site can be developed expeditiously with only a handful of workers and a few wagons, this method could deliver part of the ballast needs in the construction of the Hazen line. These ballast-harvesting sites may have only been occupied for only a few hours or perhaps only a day. Because of the simplistic technology proposed here, and the few people participating in these activities, one would not expect a great deal of archaeological evidence left behind. The site formation process accounts for the linear symmetry of the mound spacing that is quite evident from aerial views of many pebble mound sites. As a result of the field studies at 26CH2335 it seems in order that other pebble mound sites should be reexamined for similar evidence for railroad ballast harvesting.

**Acknowledgments.** James Bunch and Patricia DeBunch assisted in the original NDOT survey as well as the 26CH2335 site recording and Steve Glotfelty assisted in the second phase of its recording. Also, we would like to thank Jim Bunch (NDOT), Barbara Stearns (NDOT), Jeff Wedding (Harry Reid Center for Environmental Studies, Las Vegas) and Alanah Woody (Nevada Rock art Foundation) for their editorial comments and information. Photos are by Patricia DeBunch and Alvin McLane.

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## NOTES

[1] McLane suggests that these piles were left when the larger rocks in the mound were removed, probably by pitchforks, with the smaller rocks falling through the tangs.

[2] Studies of all of the known gravel mound complexes in northern Nevada may continue by Maggie Brown, archivist at the Nevada State Museum, and avocational archaeologist Oyvind Frock.

[3] According to the Sadmat site form, this site is plotted near the expanded boundaries of 26CH2335 (in the southwest part of this site) but Sadmat does not correspond to all of the GPS locations given by McLane and Glotfelty.

# *Desert Dwellings: The Historic Domestic Architecture of Rural Nevada*

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*Because of its extreme aridity, sparse vegetation, and deflationary soils, northern Nevada's portion of the Great Basin contains thousands of well-preserved and highly visible surface sites of historic domestic activity. Sizable trash dumps containing a wide array of domestic refuse, however, are usually not in association with nearby standing architecture. Many of these sites are attributable to the ephemeral nature of historic land uses such as mining, railroad construction, and animal husbandry. In addition, the popularity of impermanent architectural forms and a propensity to salvage valuable building materials contributed to the scarcity of readily identifiable domestic structures. This paper describes the variety of domestic forms used historically in rural northern Nevada and proposes some archaeological correlates that relate extant material remains to probable domestic architecture. It concludes with the suggestion that the modest and sometimes enigmatic domestic architectural sites in northern Nevada can and should contribute to wider theoretical concerns of historical archaeologists.*

Much of the historic domestic architecture of rural northern Nevada was well suited to its highly mobile and opportunistic population. If one theme dominates the history of Nevada (and the present-day state, for that matter), it is mobility for the sake of economic opportunity. Unlike other states or regions of the country, Nevada lacked any appreciable land uses such as crop cultivation, fishing, or manufacturing that normally bind people to a place. Until well into the twentieth century, the livelihood of a significant number of Nevadans has depended on land uses *that move* (Figure 1). Mining, railroad construction, and animal husbandry, historically important activities, are, by definition, finite with respect to any particular place; rich ore bodies were worked and exhausted, railroads were completed, and cattle and sheep constantly required new grazing lands.

***Figure 1.*** *"Moving House, East Rochester 1912" (courtesy Nevada Historical Society, Reno).*

This paper considers the archaeological manifestations of these more-or-less mobile occupations. Specifically, we are interested in a wide range of domestic architecture, and remnants thereof, that were implanted upon the cultural landscape. To be sure, population centers such as Virginia City, Reno, and Elko, which owe their early existence to silver and gold, the transcontinental railroad, and cattle, remain viable places to live and work in spite of the greatly diminished role of those economic pursuits that spawned them. There are, however, thousands of ghost towns, abandoned camps, and remnant architectural forms throughout rural northern Nevada that await systematic study. It should be noted that this paper deliberately focuses on less permanent forms rather than Nevada's well-documented rural and urban architecture (see Nicoletta 2000). It is akin to a recent publication by the Nevada Humanities Committee (Davis 2003), except we place greater emphasis on archaeological concerns; most of the forms discussed below are unoccupied or are entirely within the realm of archaeology.

As Hardesty (1991:29) has observed, "The conduct of historical archaeology in the region ...continues to be site-specific and serendipitous without the benefit of regional research strategies." This would certainly characterize the way historic domestic architecture has been studied to date. We believe that classification is a prerequisite to research design, and this paper is an initial attempt to examine systematically the architectural and archaeological manifestations of rural domestic sites found in northern Nevada. The methods used are adopted from cultural geographers and folklorists and their work on folk housing and other elements of the cultural landscape. Scholars in this field, particularly Francaviglia (1991), Glassie (1975), Jordan (1978), and Kniffen (1936, 1965, 1974), provide guidance and inspiration for those of us trying to order and understand the seemingly chaotic assemblage of desert dwellings.

Archaeologists and geographers have a long tradition of collaboration with one another over issues pertaining to material culture, particularly problems of taxonomy and classification. It is no coincidence that the archaeologist James Ford drew the pen-and-ink illustrations for the geographer Fred Kniffen's (1936) seminal article on Louisiana house types. Also, Kniffen's influence on Ford is apparent in Ford's (1954) use of house types to illustrate his influential *American Anthropologist* article entitled "The Type Concept Revisited." Perhaps beginning this tradition of collaboration was the close professional and clearly symbiotic relationship between two University of California professors—Alfred Kroeber and Carl Sauer—both now considered patriarchs in their respective fields. Contributing to the bond between these sister disciplines is a shared interest in the concept of culture.

## PHYSICAL CHARACTERISTICS OF THE GREAT BASIN

For those unfamiliar with the Great Basin, it is, as the name suggests, a topographic basin, or area of internal drainage between the Rocky Mountains and the Sierra Nevada range. It is part of the Basin and Range Physiographic Province of North America that is characterized by hundreds of north-south trending mountain ranges separated by intervening valleys. Aside from its unique and vivid topography, the physical attribute of aridity is everywhere present. The high wall of the Sierra Nevada range creates a rainshadow effect that results in an average annual precipitation of less than 10 inches per year. This paucity of rainfall has obvious implications for soil formation and vegetation; soils are not well developed and vegetation at lower elevations is limited to desert shrub species.

Aridity had a profound influence on the types of domestic architectural forms built in Nevada. Without falling prey to environmental determinism, it is worthwhile to consider some correlations between folk architecture and the environment. The wooded East had its lumber and log construction. The Prairie and Plains offered up its sod for house construction. And, in the arid Southwest, adobe (mud brick) was the building material of choice. Nevada, then as now, had few trees capable of producing significant amounts of lumber as measured in board feet (with the exception of the Sierra Nevada) and not much sod (although sod construction does exist in Paradise Valley). Therefore, we should expect to find architectural forms more in keeping with environmental conditions just described.

## TYPES OF DESERT DWELLINGS

Those of us who have spent time investigating historic domestic structures both in the field and the archive recognize that there are some common, and some not-so-common, structural forms that were part of the historic architectural repertoire in northern Nevada. This initial working typology is presented in what we perceive to be a rough order

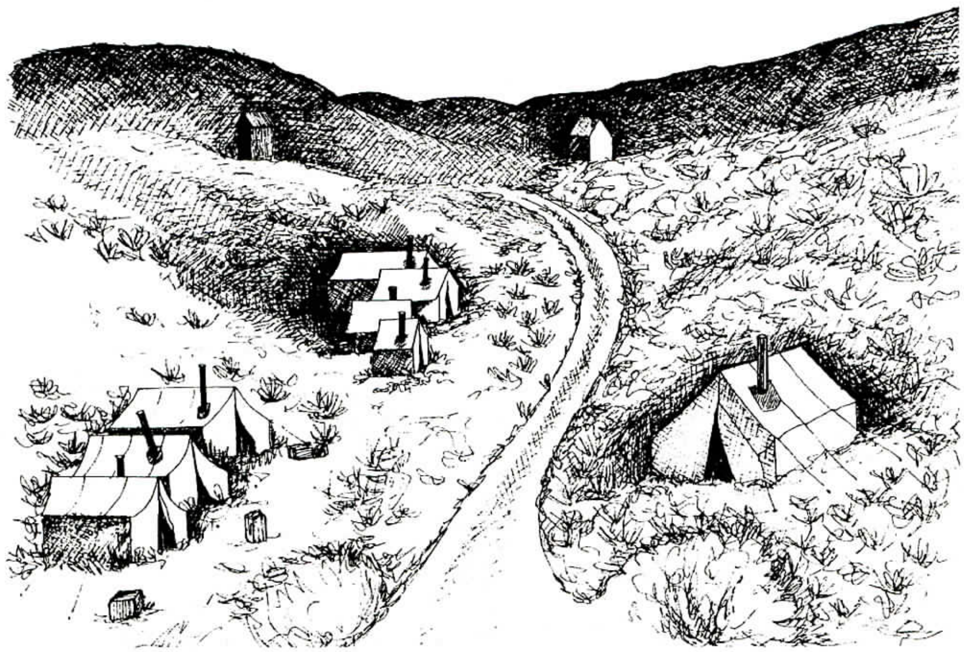

*Figure 2. Canvas Tents in the Sagebrush (drawn by Sandra Hedicke Clark and based on a photograph of a 1930s Pershing County, Nevada mining camp shown in Paher 1970:122).*

of popularity—from tents to bottle houses. Our intention is to focus on some of the adaptive qualities and archaeological implications of these structural forms.

**Tents.** Tents were probably the most common form of domestic architecture on the mining frontier (Figure 2); their main virtues being their portability, ease of construction, and relative durability. Hundreds of contemporary lithographs and photographs of mining camps, not only in northern Nevada but all over the West, show that many of the domiciles, and quite a few commercial establishments, were mostly canvas (James 1998:31; Paher 1970:126, 207).

The basic white canvas wall tent could be embellished architecturally by the addition of a wooden platform for a floor, log or lumber walls, and even a cheap sheet metal stove. This sort of impermanent camp architecture was, as Nelson (1987) has observed, quite popular during the Civil War, especially during prolonged winter encampments. This seems to have been the simplest and most expedient desert dwelling of choice from the early 1860s up to the 1930s. In fact, Marshall (1995:48) points out that cattle ranches in Paradise Valley have retained the use of the canvas tent as temporary or seasonal shelter.

The archaeological imprint of this form of domestic architecture is the sometimes subtle, yet usually identifiable, tent flat. The hallmark characteristics of historic tent flats include: 1) a visibly cleared rectangle of ground that is relatively artifact-free (in fact, they sometimes appear as geometric voids in a surface sheet midden); 2) often having vegetation and rock inclusions that are more sparse than the immediate surroundings (revegetation is slow in the desert, and rocks once removed tend to stay removed); 3) showing signs of terracing if the flat is situated on anything but level ground (often having rock retaining walls above and below the flat itself).

**Stone Houses.** Another architectural form not uncommon to the historic northern Nevada mining frontier is the stone structure (Hardesty 1988:84–86). Since most historic mining sites were situated in or near the rock outcrops of mountain ranges rather than the alluvium-filled valleys, and that large quantities of waste rock is the obvious by-product of hard rock mining, the use of this material for domiciles and other structures seems quite adaptive. Stone houses usually consisted of substantial stone walls with the roof finished with log, lumber, or canvas.

Former cities of stone still exist in the mountains in many places in northern Nevada. Humboldt City, for example, was the site of frenzied mining activity roughly contemporaneous with the early Comstock Lode. In 1860, this canyon opening up

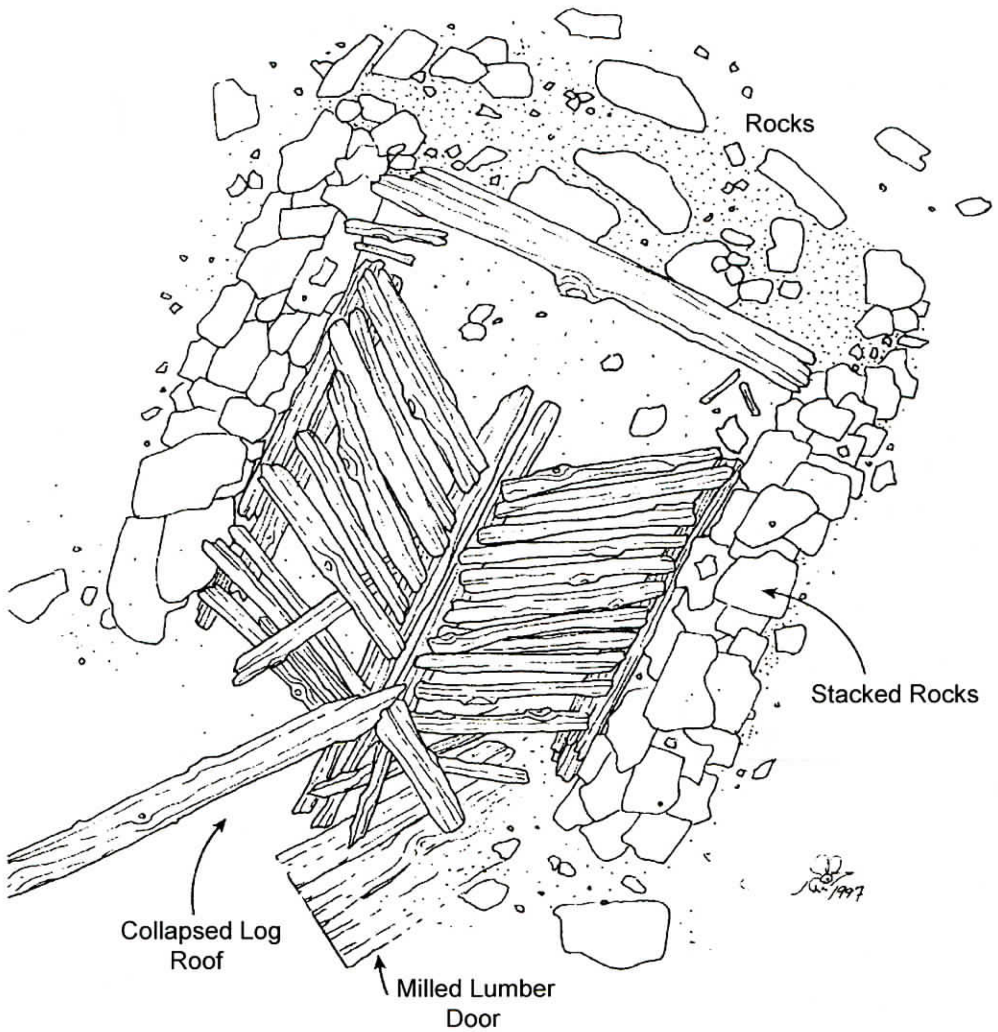


***Figure 3.*** *Archaeological Remains of a Dugout in Northern Nye County (drawn by Jerry W. Oothoudt and based on field sketches and photographs in Mires 1997).*

to the Humboldt River Valley was home only to local Paiute Indians, but by 1863 after the discovery of silver the place boasted a Euroamerican population of around 500. Among its 200 structures, most built of stone without benefit of mortar, were two hotels, two saloons, a post office, a blacksmith shop, and numerous homes (Paher 1970:130). By 1869, the rich ore bodies were exhausted and the town abandoned. The stone walls of Humboldt City, however, remain remarkably intact to this day. Further, Kautz (personal communication 2005) suggests that there may have been skilled Chinese stone masons at work in mining towns such as Candelaria in Mineral County.

Perhaps the best documentation for stone construction in northern Nevada is Marshall's (1995) study of Italian stonemasons of Paradise Valley, which is part of his larger monograph. In addition to photographs, drawings, and floor plans of stone houses and other structures, this fascinating chapter describes the architectural legacy of several stonemasons, as well as details some of their family connections both in northern Nevada and northern Italy. It also relates some of the challenges and advantages of working with the locally available granite and sandstone.

**Dugouts.** Northern Nevada's cultural landscape also contains the so-called "dugout" (Figure 3). As the name suggests, this was simply an excavation into a convenient hillside forming the floor and three walls. All that was generally required was to enclose the front and add a roof. One variant of the dugout, observed by Hardesty (1988:86), consists of an excavation into level ground forming what prehistorians call a semi-subterranean house pit. In certain respects, the dugout and the hillside tent flat are related forms, differing only in architectural superstructure but sharing a method of landscape modification.

In 1996, the authors had the opportunity to investigate an ethnic Chinese encampment in Hogpen Canyon outside of Eureka (Mires 1999a; Mires et al. 1997). It contained seven well-defined dugouts, a few of them showing evidence of rock retaining walls and earthen berms. The dugouts were roughly rectangular in shape with the long axis perpendicular to the hill slope out of which they were excavated. Archaeological data recovery of these features yielded a variety of domestic artifacts, many with clear ethnic Chinese association, and included an abundance of architecture-related items such as cut nails and flattened tin cans, presumably recycled as siding/roofing material. These flattened cans, consisting of both cylindrical food cans and rectangular kerosene cans, were modified by cutting out the ends, splitting the cans along their seams, and flattening them. Nail perforations along the flattened can margins is testimony to their adaptive reuse, an observation made at numerous Chinese sites in the Intermountain West.

**Board and Batten Houses.** A more permanent architectural form common to prosperous mining and railroad towns was the simple board and batten house. Access to milled lumber via the railroad is obviously the critical factor. In fact, as McAlester and McAlester (1984:89) point out, the nationwide expansion of railroads in the latter half of the nineteenth century dramatically transformed the domestic architectural landscape of much of the country because in every little town along the railroad could be found the omnipresent lumberyard.

Board and batten, as a simple form of siding consisting of long vertical boards with the battens covering the spaces where the boards meet (Phillips 1989:153), was extremely popular as a method of construction. In any town in northern Nevada once served by the railroad, these functional domestic structures can be found. Marshall (1995:34), for example, illustrates a circa 1920 board and batten bunkhouse from Paradise Valley that was shipped to the Smithsonian Institution in 1980 for its "Buckaroos in Paradise" exhibit. It is a simple floor plan consisting of a single pen measuring ten by twelve feet.

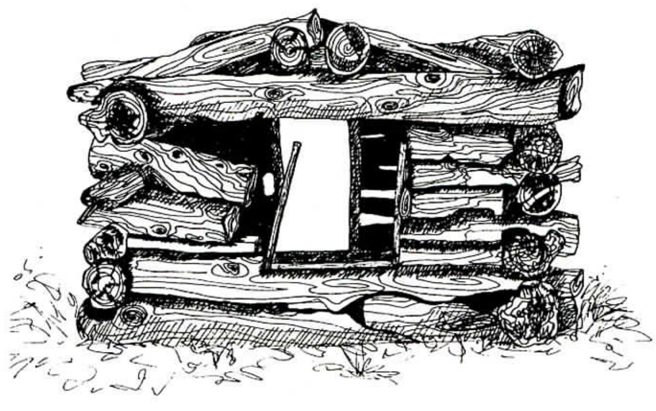

***Figure 4.*** *Log Structure in White Pine County (drawn by Sandra Hedicke Clark and based on photographs in Simons et al. 2005).*

**Log Houses.** A folk housing type not so common to northern Nevada (as might be expected) is the log house. Actually, most of Nevada's mountain ranges are forested at the higher elevations with various combinations of aspen, piñon, and juniper (among other species), and settlements with ready access to standing timber usually included some log construction. Even in these environments, however, the far greater investment in labor required to build a free-standing log structure often favored tents and dugouts. Nevertheless, domestic structures built either partially or entirely of vertical or horizontal logs are part of the architectural and archaeological record of northern Nevada (Figure 4). There are even examples of hybrid structures, such as a Eureka County log and railroad-tie root cellar (Davis 2003:177).

The short-lived Pony Express (1860–1861) utilized log construction for some of its stations in northern Nevada. Two log Pony Express stations survive and retain architectural integrity: Friday's Station in Stateline and the Ruby Valley station, relocated to the grounds of the Northeastern Nevada Museum in Elko. The former was constructed by means of horizontal logs, saddle-notched corners, and a gable roof (Nicoletta 2000:62–63), whereas the latter utilized vertical log construction topped by a shed roof (Nicoletta 2000:1957–1958).

Interestingly, the first Euroamerican structure in Nevada was a log house built in 1851 along the California emigrant trail adjacent to the formidable

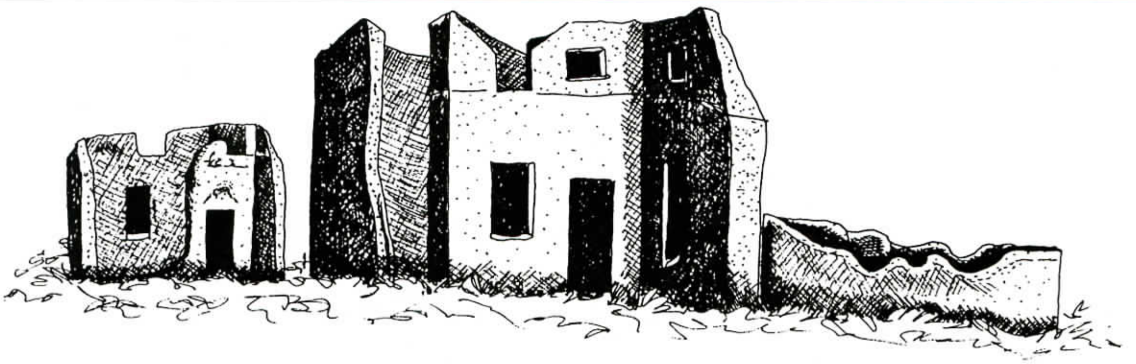

***Figure 5.*** *Adobe Buildings of Fort Churchill (drawn by Sandra Hedicke Clark and based on a photograph by Darlene Julian).*

eastern escarpment of the Sierra Nevada range. The small settlement that grew up here, known first as Mormon Station and later Genoa, served as an important trading post for California-bound fortune seekers (Laxalt 1977). Unfortunately, the original structure was destroyed by fire in 1910, and the replica one-story log cabin—the centerpiece of Mormon Station State Park—was constructed in 1947 (Nicoletta 2000:114).

**Adobe Houses.** Adobe, or sun-dried mud brick, was used as a construction material on occasion in northern Nevada. Certainly, adobe structures are not nearly as common here as in Mexico and the American Southwest, but there are some impressive examples of adobe architecture in northern Nevada. Fort Churchill, built in 1860 to protect emigrants and settlers against real or imagined Indian attack, was essentially a collection of adobe structures (Figure 5). This place is now maintained by Nevada State Parks, and some adobe walls have managed to survive more than a century of exposure to the elements—some have not. Hardesty's (1988:86) investigation of the historic mining site of Shoshone Wells in Lander County includes the identification of five adobe buildings dating to the 1860s and the observation that "numerous" adobe brick yards were in operation within the mining district. Marshall's (1995) study of Paradise Valley revealed that adobe construction, locally referred to as "dobie," was fairly common, and that an adobe "factory" was built along Cottonwood Creek. He states that, "Adobe was used in all kinds of structures, from smokehouses, to cellars, to dwellings. They included a wagon-making shop, bunkhouses, a blacksmith shop, a saloon, a hotel, a butcher shop, the Army buildings at the short-lived Camp Winfield Scott in the upper end of the valley...and the 1893 Odd Fellows Hall" (Marshall 1995:28).

Although the geographical and temporal parameters have yet to be established, it seems reasonable to assume that one environmental constraint that may affect the spatial distribution of this quintessential desert building block is a good source of water for mud. And, Hardesty (1988:86) suggests that adobe as a building material may prove to be a good mid-nineteenth century time marker on the Nevada mining frontier. Marshall (1995:28–30) states, "The peak period for adobe construction in Paradise Valley came in the early decades of settlement, from the 1860s to about 1900, though some smaller adobe outbuildings may have built as late as 1910."

**Railroad-Tie Houses.** A somewhat unusual architectural form in northern Nevada is the railroad-tie house. Although no systematic study of these structures has been conducted, their distribution, not surprisingly, seems to coincide with historic railroad corridors. However, Marshall's (1995) comprehensive study of the buildings of Paradise Valley includes several examples of the type. He explains that people could buy surplus railroad ties in Winnemucca (an important entrepôt along the Central Pacific Railroad) for pennies, and their use as a domestic building material to some extent mimics horizontal log construction (Marshall 1995:22). Nicoletta (2000:159) confirms the popularity of this conveniently recycled building material, as illustrated by two railroad-tie sheds in Lamoille. She states that, "When the Central Pacific began repairing its tracks in the 1890s, thousands of ties became available for reuse in a variety of buildings, from sheds and garages to cabins" (Nicoletta 2000:159). For extant examples of barns and sheds constructed from railroad ties, the interested reader should refer to a recent collection of black and white photographs in a monograph entitled *Sagebrush Vernacular: Rural Architecture in Nevada* (Davis 2003).

**Bottle Houses.** A final type of desert dwelling that seems to have an almost idiosyncratic distribution is the bottle house. Clearly, a major component of this architectural type is the empty glass bottle. Given northern Nevada desert dwellers' prodigious consumption of bottled beverages, alcoholic and otherwise, huge quantities of glass bottles accumulated rather rapidly. Some innovative homebuilders obviously saw that these empties were good for something other than target practice.

Although located in southern Nevada, the so-called Bottle House in Rhyolite is considered "the finest remaining example of a bottle house in Nevada" (Nicoletta 2000:196). Incredibly, it incorporates an estimated 20,000 beer bottles into its L-shaped one-story plan (Paher 1970:314). To the north, the mining towns of Goldfield and Round Mountain also have extant examples of the type.

**Other Forms of Shelter.** Nineteenth century Nevadans in need of expedient shelter utilized a variety of other forms. The authors have documented numerous camps of itinerant charcoal-burners, or *carbonari*, in the vicinity of Eureka, and in some cases remains of their lean-tos still exist. These simple shelters were constructed from cut piñon and juniper branches, a by-product of their industry, and resemble a shed roof with the lower end either resting on the ground or on a low rock retaining wall. Jackson (2000:117) cites that miners in the vicinity of Treasure Hill, in eastern Nevada's White Pine Mining District, would "put up shanties of cedar and mud and roofed with cedar boughs and earth." James (1998) notes that Nevada's mining mecca—the Comstock Lode—in its early years was a hodgepodge of housing amid the diggings. It should come as no surprise, in fact, that many of the expedient and impermanent architectural forms used in Nevada proved their worth during the California Gold Rush (Brands 2002; Holliday 1981).

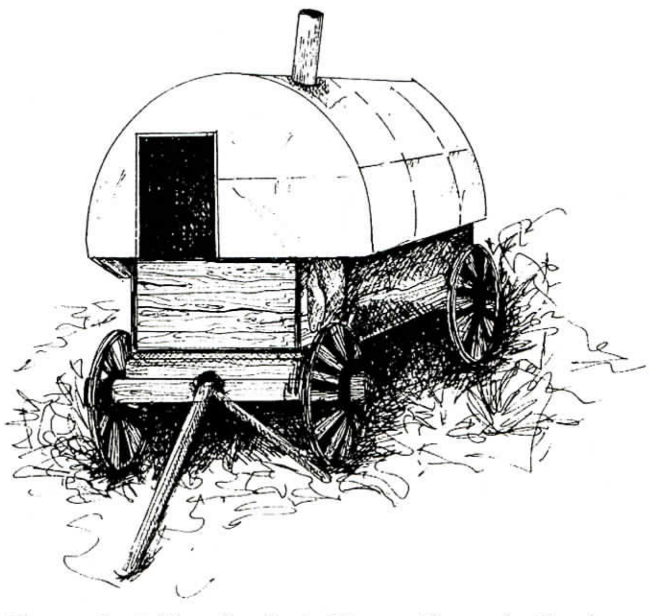

*Figure 6. A Sheepherder's Wagon (drawn by Sandra Hedicke Clark and based on a photograph in Sawyer 1971:166).*

One final form of desert dwelling deserving of mention is the sheepherder's wagon (Figure 6). In northern Nevada these are often associated with ethnic Basque people. Obviously, this home on wheels—truly the precursor of the modern camper-trailer and recreational vehicle—is in a class by itself when one considers domestic architecture. Nevertheless, these wagons were used as shelter in a single location for up to 10 days; long enough to generate an associated sheet midden of domestic refuse sufficient to warrant documentation by some cultural resource management survey that happens upon it. These horse-drawn wagons containing all the amenities such as a spacious bunk, kitchen cupboard, sheet metal stove, and shelves for personal belongings, first appeared in the 1880s and 1890s (Georgetta 1972; Sawyer 1971). In keeping with the theme of our research, the sheepherder's wagon epitomizes historic domestic architecture adapted to land uses that move.

## ARCHAEOLOGICAL CORRELATES AND THEORY

One archaeological correlate that this discussion of desert dwellings suggests deals with the position of these sites within the framework of a capitalist society. Leone and Potter (1988, 1994) have suggested that capitalism should be the central focus for historical archaeologists. They specify two ideological themes—impoverishment and resistance—and state that "capitalism is an economic system that requires the impoverishment of some who participate in it...[and that] impoverishment and resistance are constants, to be sought out and found wherever capitalism flourished" (Leone and Potter 1994:15). Among the points that they argue is that the so-called "thinness" of archaeological deposits of many historic sites in the West is "more important ideologically than descriptively" (Leone and Potter 1994:14). They imply that these materially modest sites represent capitalism's exploitation of a working class.

The "thinness" of the archaeological record of a multitude of domestic sites in rural northern Nevada, however, can better be attributed to an overwhelming *willingness* to participate in capitalism, not resistance. Less was more on the northern Nevada frontier, where mobility, unencumbered by things, was a valued adaptation. Admittedly, there were capital-labor disputes after an initial period of entrepreneurial enterprise, but it was not uncommon for individuals to live an extremely Spartan lifestyle while amassing personal fortunes. The historical record is replete with examples of people who periodically sent money home, or came here, made money, and retreated to a "more civilized" place with trees and water in which to enjoy the fruits of their labor.

Further, the archaeological record of northern Nevada, from the perspective of capitalism, goes well beyond the borders of the "Silver State" and its landscape of ghost towns (Francaviglia 1991; Paher 1970). The opulence of San Francisco, and, some may argue, even the preservation of the Union, are directly linked to the enormous mineral wealth that Nevada produced in the latter half of the nineteenth century. To be sure, much of this wealth fell into the hands of a select few who controlled the means of production. But, a sufficient number of individuals succeeded in amassing a modicum of wealth, the archaeological correlates of which may, or then again, may not be measured by material culture. This underscores some serious flaws in the application of an overarching theoretical stance that equates the archaeological record with ideas of impoverishment and resistance. It suggests, to us at least, that Leone and Potter could greatly benefit from a field season in northern Nevada!

## CONCLUSION

Inspired by the classification of folk housing by cultural geographers, various forms of domestic architecture common to rural northern Nevada are presented in this brief paper. Most of these are unoccupied and are more accurately described as archaeological features rather than standing architectural forms. There are literally thousands of tent flats and dugouts—the archaeological footprints of human habitation—that dot the cultural landscape, and hundreds of archaeological survey reports on file with the Nevada State Historic Preservation Office attest to their ubiquity and morphological variability. Other forms such as stone, log, and adobe houses often lack a roof and consist primarily of walls in varying states of decay and disintegration.

Another concept shared by archaeologists and cultural geographers is the palimpsest dimension of human habitation. The nineteenth century discoverer of the ancient city of Troy, Heinrich Schliemann, was surprised that the city made famous by Homer was stratified to such an extent, and archaeological deposition and stratigraphy have been part of our professional vocabulary ever since. Geographers have developed the same notion, albeit with little emphasis on below ground cultural detritus, and employ a modified form of sequent occupance (Broek 1965:29; Whittlesey 1929) to describe change over time within a single place. Apropos to this study is James's (1998) discussion of the evolution of the built environment of Virginia City. He notes that prior to the construction of more permanent architecture, early Comstock miners and other opportunists lived in canvas tents, shanties of various description, and even in mining excavations themselves (James 1998:12). As Virginia City established itself as an urban place, these haphazard domiciles were abandoned in favor of homes, hotels, and boarding houses.

The emphasis on northern Nevada's rural, as opposed to urban, landscape in this paper is clearly a consequence of preservation. The various domestic architectural forms described here are those that correspond to the first phase of settlement in many a Nevada town or city. Subsequent urban development has either relegated their remains to the lowest level of the palimpsest, Nevada's version of the "hills of Hissarlik," or obliterated them entirely.

In rural northern Nevada, even initial settlers determined to establish a degree of agricultural permanence usually began their occupance of the land by constructing quick and easy shelters. Marshall (1995:21) explains that in Paradise Valley "the first settlement phase saw builders, of whatever ethnic group, use the materials close at hand that were convenient and inexpensive if not free for the taking." As this excellent Library of Congress-sponsored study documents, the residents of Paradise Valley later constructed sturdy, and even architecturally elegant, buildings out of wood, brick, and stone.

This paper serves as an initial attempt to classify some of the simpler forms of domestic architecture primarily associated with the early years of Nevada's history. These forms are often of greater interest to the archaeologist than to the architectural historian because so often they lack architectural integrity or represent little more than expedient shelter. This is certainly true of the tent flat, where once stood canvas and frame and all that remains is a rectangular outline. There are excellent sources in print on Nevada's folk, vernacular, and high-style architecture, some of which are cited here, but with few exceptions (e.g., Marshall 1995) their focus is on occupied standing structures in urban context. This dichotomy between the domestic constructions that interest the archaeologist and those that attract the attention of the architectural historian or student of vernacular architecture is difficult to define. We suggest that it is a false dichotomy insofar as some archaeologists take considerable interest in buildings, and some architectural historians have used archaeological methods in their research (see Mires 1999b).

Archaeologists working in northern Nevada have the rare opportunity to study a cultural landscape rich with evidence of past human activities. The arid environment coupled with an historically sparse and mobile population has resulted in the unparalleled preservation of cultural resources. Among these are domestic structures doubtless familiar to most Nevada archaeologists. We hope that this study provides some organizational perspective and promotes a greater appreciation of "desert dwellings."

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# *A Summary of Climate Change in the Great Basin: With Emphasis on the Bonneville Basin (28 ka–Present)*

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The Great Basin is the arid-to-semiarid section of the intermountain region of the western United States, including most of Nevada and western Utah, and fringing into Oregon, Idaho, and California (Minckley et al. 2004; Morrison 1991). The Sierra Nevada and Cascade Range form the boundary of the Great Basin on the west, the Rocky Mountains on the east, and the Columbia and Colorado River drainages mark the north and south extent respectively (Minckley et al. 2004; Morrison 1991). In the late Pleistocene about 120 pluvial lakes existed in the Great Basin, only about 10 percent of these are perennial and of substantial size today (Morrison 1991; Smith and Street-Perrot 1983). The stratigraphic records of these pluvial lakes are extremely useful in documenting Quaternary climate changes (Currey 1990; Morrison 1991). These fluctuations in lake levels were driven by changes in climate (e.g., precipitation, temperature, evaporation, etc.), and the study of these pluvial lakes is therefore valuable as an indicator of past climatic conditions (Smith and Street-Perrot 1983).

This paper attempts to summarize the paleoclimatic data from the Great Basin (concentrating on the Bonneville basin), with the aim to facilitate a synthesis of past climatic conditions in this area, thus allowing for the identification of large-scale patterns in the Great Basin in the past (Thompson et al. 1993). Lake Bonneville has one of the best-known Pleistocene lake chronologies worldwide (Rhode and Madsen 1995), but the climate control on these fluctuations is far from resolute (Madsen et al. 2001). Pluvial lakes in the Great Basin may respond to future global change and understanding how climate has affected lake levels, vegetation, and other factors in the past has substantial environmental significance for the future.

## MODERN VEGETATION AND CLIMATE

Vegetation in the Great Basin is distributed according to elevation (Minckley et al. 2004). Basin floors (1200–2500 m) are dominated by sagebrush (*Artemisia* spp.), shadscale (*Atriplex* spp.), and minor evergreen shrubs. The low diversity is a result of low effective moisture and winter dominated precipitation patterns (Minckley et al. 2004). Between 1500–2300 m elevation conifer woodlands exist, including juniper (western juniper, *Juniperus occidentalis*; Utah juniper, *J. osteosperma*; Rocky Mountain juniper, *J. scopulorum*) and pinyon pine (*Pinus edulis*), with sagebrush as a common understory component (Minckley et al. 2004). Sagebrush and rabbitbrush (*Chrysothamnus* spp.) dominate the zone between

2300–2750 m, with other common tree taxa being aspen (*Populus tremuloides*), mountain mahogany (*Cercocarpus* spp.), ponderosa pine (*Pinus ponderosa*), pinyon pine, and fir (*Abies* spp.) (Minckley et al. 2004). Higher elevation woodland zones (>2700 m) are composed of whitebark pine (*Pinus albicaulis*, >3000 m), limber pine (*P. flexilis*), and bristlecone pine (*P. aristata*, >3250 m) (Minckley et al. 2004).

The basin floors of the Bonneville basin are occupied by greasewood (*Sarcobatus vermiculatus*) steppe, with pines, and sagebrush (Davis 1998). Above the basin floors sagebrush dominates and pines are also common (Davis 1998). Between 1850–2280 m elevation the pygmy woodlands are comprised mainly of pines and junipers (Davis 1998). On the mountain slopes (2280–3050 m) forests of spruce and fir are the principal taxa (Davis 1998). Within the northern Bonneville basin the valley bottoms are cool and dry, experiencing limited precipitation, and the mountains are cold and wet with high amounts of precipitation (Madsen 2000).

Most of the precipitable moisture in the Great Basin is delivered by the westerly winds from the Pacific Ocean, as explained in more detail by Minckley et al. (2004). The western mountain ranges in the Great Basin form a barrier to effective moisture moving inland as a strong rain shadow is produced, especially by the Sierra Nevada mountain range (Minckley et al. 2004; Morrison 1991). Another important source of precipitation during the winter months is southerly airflow from the Gulf of Mexico; most of the precipitation this brings falls in the mountains, leaving the lower elevations dry (Minckley et al. 2004; Morrison 1991).

## LAKE BONNEVILLE CHRONOLOGY

Lake Bonneville, the predecessor of the Great Salt Lake, was the ice age lake that filled the Bonneville Basin. This lake was more than 300 m higher in elevation than the Great Salt Lake is today, and covered an area of approximately 50,000 km$^2$ at its highstand between ~ 18–14 ka (all ages in radiocarbon years before present) (Hart et al. 2004; Oviatt 1997). The water levels have undergone many large-scale fluctuations especially between the time period of 28–10 ka (Oviatt 1997).

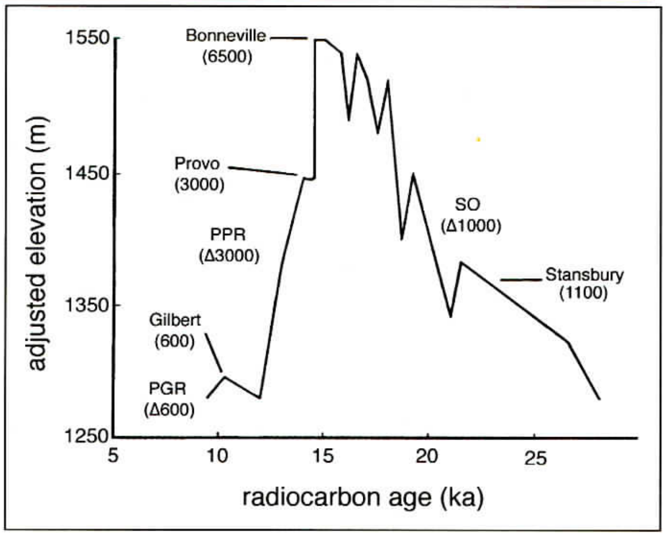


***Figure 1.*** *Chronology of Lake Bonneville, modified from Oviatt, 1997. Age is in radiocarbon years B.P.; elevations are adjusted for the effects of isostatic rebound. The Stansbury, Bonneville, Provo, and Gilbert shorelines are indicated. PGR = post-Gilbert regression, PPR = post-Provo regression, and SO = Stansbury oscillation. Numbers in parentheses represent water-volume totals at major shorelines, or water-volume fluxes at lake-level fluctuations (km$^3$).*

### Late Wisconsin (28–14 ka)

Lake Bonneville began to rise about 30 ka from levels close to that of the Holocene Great Salt Lake (Oviatt et al. 1992). The Stansbury shoreline (Figure 1) was deposited during the Stansbury oscillation which occurred between 22–20 ka, at which time the lake levels of Lake Bonneville oscillated at least once, possibly several times (Oviatt et al. 1992).

After the Stansbury oscillation, Lake Bonneville underwent a rapid transgression between 20 ka and 18 ka, although lake-levels fluctuated up and down several times (Oviatt 1997). The average rate of transgression decreased after 18 ka, and Lake Bonneville reached its highstand 15 ka, forming the Bonneville shoreline (Figure 1) (Oviatt 1997). Shortly after this highstand, at 14.5 ka, the alluvial fan threshold near Zenda, Idaho, failed and lake levels dropped by approximately 100 m (Oviatt et al. 1992). The Bonneville Flood, produced by a more significant spillway failure later, was rapid and the Provo shoreline was formed 14.3 ka as the lake continued to overflow at Red Rock Pass (Oviatt et al. 1992).

### Terminal Wisconsin (14–11 ka)

Overflow at Red Rock Pass ceased about 14 ka, and the basin became hydrologically closed again, with rapid lake regression (Oviatt et al. 1992). As a result, Tule Valley and Sevier basin were separated from the Great Salt Lake basin, and the latter dropped to very low lake levels. Between 13 and 12 ka is regarded as the end of the Bonneville lake cycle, and the beginning of the Great Salt Lake, as the lake reached a minimum elevation and subsequent fluctuations were much lower in magnitude (Currey 1990; Oviatt et al. 1992). The Gilbert shoreline was formed between 10.9 and 10.3 ka when the Great Salt Lake transgressed once more (Figure 1). This was the lake's last highstand, as the Great Salt Lake has never fluctuated to these levels again (Oviatt et al. 1992).

### Holocene (10 ka–present)

The Great Salt Lake fluctuated at levels lower than the Gilbert shoreline after approximately 10 ka (Oviatt et al. 1992). It appears that the Great Salt Lake dropped abruptly after 10 ka from the Gilbert shoreline (Currey 1990), and after 7 ka the Great Salt Lake may have dried almost completely, rebounding around 5.9 ka. The lake expanded and appeared to freshen ~3–2 ka when the Great Salt Lake Desert was flooded as far west as the Utah/ Nevada border (Currey 1990).

## CLIMATE CHANGE IN THE BONNEVILLE BASIN AND SURROUNDING AREAS

### Late Wisconsin (28–14 ka)

The Bonneville Basin experienced on average cold and moist conditions during the Late Wisconsin glacial period between 28–14 ka, which corresponds to marine oxygen isotope stage 2 (MIS 2) and the period of highest Lake Bonneville levels (Madsen 2000). The full glacial (28–14 ka) vegetation regime was characterized by cold-adapted sagebrush steppe with scattered stands of Engelmann spruce (*Picea engelmanni*) and limber pine (*Pinus flexilis*) in the northern Bonneville basin, suggesting that conditions were very cold and quite dry (Madsen 2000; Madsen et al. 2001). In the southern basin, however, a more diversified woodland-steppe existed, dominated by western Bristlecone pine (*Pinus longaeva*), at 2012 m elevation, which suggests a cold, but moister climate than its northern counterpart (Madsen et al. 2001). The latitudinal vegetation gradient may be a result of a southward shift of the jet stream during the Last Glacial Maximum (LGM) (Madsen et al. 2001). Assembling data from other studies using plant macrofossils from fossil packrat middens (*Neotoma* sp.), pollen records, and faunal assemblages from stratified cave deposits, Madsen et al. (2001) reconstructed climate change during the Late Wisconsin in more detail. In the northern Bonneville basin, limber pine decreased while Engelmann spruce increased in abundance, and upper montane meadow shrubs appear in the record (Madsen 2000; Madsen et al. 2001). The latter two plant types are characteristic of increasingly moist and cool conditions, which came into effect ~22 ka, whereas limber pine prefers cold and very dry climates (Madsen 2000; Madsen et al. 2001). After the LGM, around 17 ka, packrat midden data suggest that vegetation became alpine to subalpine in character, dominated by sagebrush with some grass and cinquefoil, and sparse limber pine. Pollen and midden evidence show that after 17 ka spruce increased slightly again, as well as montane mesophilic shrubs, while limber pine disappeared, indicating a moister and somewhat warmer climate than during the LGM (Madsen 2000; Madsen et al. 2001).

Smith and Street-Perrott (1983) discuss the pluvial lakes of the western United States through a compilation of past studies that used various geomorphic and stratigraphic methods to determine changes in lake levels. Between 25–10 ka more than one hundred closed basins in the western United States contained lakes, only about 10 percent of these are perennial and of substantial size today (Smith and Street-Perrott 1983). During the period 24 ka to 14 ka B.P. most of the lakes in the western U.S. studied by Smith and Street-Perrott (1983) were at high lake levels. Glaciers on the western edge of the Great Basin were near their Late Wisconsin maxima at the LGM, while in contrast the major pluvial lakes in this region (including Lake Bonneville, Lahontan, and Russell) were filling but remained well below their

Late Wisconsin maxima (Thompson et al. 1993) and the last stand of these pluvial lakes was not synchronous with the LGM, but occurred about 4 ka later, ~14.5 ka (Morrison 1991). At this time there was an almost simultaneous drop in Great Basin lakes from their former highstands (Benson et al. 1990). Minckley et al. (2004) attribute the filling of these pluvial basins and the expansion of the woodlands in the Great Basin earlier during the LGM to greater-than-present effective moisture. Greater effective moisture is either an increase in precipitation and/or a decrease in temperature, as cooler conditions decrease evaporation. In this case the higher effective moisture was likely due to the positioning of the polar jet over the Great Basin (Minckley et al. 2004).

### Terminal Wisconsin (14–11 ka)

Pollen, midden and faunal evidence suggests that average temperatures increased following the LGM, but summer temperatures remained quite cool from 14–10.9 ka as can be seen from the reduced, but substantial sized glaciers remaining at this time, as well as the expansion of limber pine (Madsen et al. 2001; Rhode and Madsen 1995). Vegetation from 14–11 ka in the foothills on the western margin of Lake Bonneville appears to have been composed primarily of montane shrubs, similar to that found in subalpine settings in the Great Basin today (Rhode and Madsen 1995). The lower elevations of the eastern margin of the lake were dominated by conifers such as white fir (*Abies concolor*) and Engelmann spruce (Madsen et al. 2001). While lake levels began to drop drastically between 14–12 ka (Oviatt 1997), the lake was still able to support Lake Bonneville fish adapted to cold temperatures, suggesting that the lake was sufficiently cold and fresh (Madsen et al. 2001). Limber pine was common in middens between 12.9–11.5 ka, demonstrating a drying trend while temperatures remained cool (Madsen et al. 2001). The presence of fecal pellets of pika, a lagomorph that inhabits sub-alpine and alpine environments, adds credibility to the suggestion that temperatures remained cold (Madsen et al. 2001). Approximately 11.3–11.2 ka, fish species that exist in cold, oligotrophic, deep-water lake environments today began to die off in Lake Bonneville (Madsen 2000). It was around this time that desert scrub vegetation dominated by sagebrush (*Artemisia* sp.) and shadscale (*Atriplex confertifolia*) began to replace the limber pine and common juniper (*Juniperus communis*) woodlands, suggesting that the regression of the Great Salt Lake was due to warmer and/or drier conditions than previously existed (Madsen et al. 2001; Rhode and Madsen 1995). The Bonneville basin therefore appears to have become warmer and/or drier than the previous glacial climate, although summer temperatures remained cool, and effective moisture decreased.

In the Great Basin, alpine glaciers retreated from their maxima before 13 ka, which is coincident with a drop in lake levels in this region (Thompson et al. 1993). Deglaciation of the middle and upper sections of Little Cottonwood Canyon (LCC) took place between 13–8 ka. Pollen evidence suggests that growing season temperatures were cooler than the Holocene average and precipitation was slightly lower than the average Holocene precipitation (Madsen and Currey 1979). There was less effective moisture than during the LGM throughout western North America after about 13.4 ka due to the northwards retreat of the jet stream (Minckley et al. 2004), and temperatures were cool (Thompson et al. 1993). In addition, as seasonality increased, cool winter temperatures could have decreased the effective moisture even further by decreasing the moisture holding capacity of the air, despite a relatively high storm frequency (Minckley et al. 2004). In contrast, southern portions and the northern edge of the Bonneville basin show evidence of greater moisture, as do the southern deserts in the west (Thompson et al. 1993). The southern increase in moisture could be interpreted as intensified monsoonal activity (Oviatt 1988), although Thompson et al. (1993) declare the situation complicated. Smith and Street-Perrott (1983) characterize between 14–10 ka as a period of rapid, large-amplitude fluctuations, and it is not obvious whether these changes were synchronous across the western U.S. Raw data from western U.S. lakes show spatial variability in lake behavior (Smith and Street-Perrott 1983), and the pollen record shows additional conflicting evidence (Thompson et al. 1993). The Great Basin remained cool between 14–11 ka and effective moisture decreased, although different areas show opposite climatic changes leaving the situation not fully resolved or understood.

### Early-mid Holocene (11–5 ka)

Madsen et al. (2001) suggest that the return of the Great Salt Lake to a relatively high level, forming the Gilbert shoreline between 11 ka and 10 ka, coincides with the Younger Dryas (YD). The Younger Dryas was an abrupt reversal from near-interglacial climatic conditions to conditions close to that of the LGM approximately 13 ka, and then back to interglacial conditions after the YD at about 11.7 ka (Ruddiman 2001). Cooler conditions increase the effective moisture, as there is less evaporation when temperatures are lower. The Great Salt Lake did not appear to experience and abruptly rise over the YD period, but the lake level rose slowly over the initial part of the 1300-year YD period (Madsen et al. 2001; Oviatt et al. 2005). The connections between the global-scale YD climate change and the regional climate patterns in the Bonneville basin are not well constrained (Oviatt et al. 2005). Between ~ 11.2–10.4 ka, the Great Salt Lake was deep enough and cold enough to support a recolonization by much of the Lake Bonneville fish, although species adapted to warmer and more saline conditions were relatively more successful (Madsen et al. 2001). The relative role of temperature and salinity on the fish population during the YD is, however, uncertain because many species are intolerant of both of these factors (Madsen et al. 2001). Benson et al. (1990) also observe minor lake level increases in surrounding lakes that occur between 11.5 and 10 ka (i.e., Lake Lahontan, Lake Searles and Lake Russell). The Ruby Marshes to the west of the Great Salt Lake and a high-elevation lake to the east on the Wasatch Plateau also show evidence of refilling at the time of the YD (Madsen 2000; Madsen et al. 2001; Thompson 1992).

The palaeovegetation record for the Bonneville basin is quite sparse for the early Holocene, but what little data there are indicate a reduction in pine woodlands and an increase in sagebrush-grass and shadscale associations shortly before 11 ka (Madsen et al. 2001). Unfortunately there is not high-enough resolution to determine the nature of vegetation changes that took place during the YD, but the small mammal record from Homestead Cave (situated on the western margin of the Great Salt Lake) indicates that the Bonneville basin was cool and moist, with relatively cool summers and an equable climate (Madsen et al. 2001). The northern and southern Bonneville basins show discrepancies again; Rocky Mountain juniper (*Juniperus scopulorum*) was common, and limber pine and common juniper had almost disappeared in the southern Bonneville basin (Madsen et al. 2001). In the northern Bonneville basin, bristlecone pine remained dominant until shortly after 10 ka, and Utah juniper (*J. osteosperma*) and douglas fir (*Pseudotsuga menziesii*) appeared by the end of the YD (Madsen et al. 2001). The rich small-mammal record found in Homestead Cave shows that the environment was an open, cold, desert steppe with sagebrush communities dominating the lower slopes and extending down into the valley around 11 ka (Madsen et al. 2001).

Around ~10.2 ka, the replacement of sagebrush by shadscale suggests a shift to relatively dry conditions (Madsen et al. 2001). This dry interval appeared to last only about 400 years, before becoming cooler (by about 3°C) and moister around 9.8 ka. Another shift to warmer and drier conditions occurred a relatively short time later at about 8.0 ka and lasted approximately 2 ka, supported by evidence of an increase in coniferous forests in Little Cottonwood Canyon (Madsen and Currey 1979; Madsen et al. 2001). A decline in faunal and floral diversity at 8 ka as recorded in Homestead Cave supports this hypothesis, as well as the fact that the Little Cottonwood Canyon was fully deglaciated by 7.0 ka (Madsen et al. 2001). From about 9 ka, the Great Salt Lake reaches its historical level at 1280 m (paleo-surface index, $y_{LPM}$, scaled to last pluvial maximum = 1.00) and fluctuates around this level to present day (Don Currey, personal communication 2004). Between 6 and 5 ka there was a slight decrease in temperature, but conditions remained warmer than the average Holocence conditions, as well as wetter (shown by the replacement of limber pine by spruce) (Madsen and Currey 1979).

Between 10 and 5 ka, the western United States appeared to have experienced a widespread drought, which culminated 6–5 ka, when all lakes were at their lowest levels (Smith and Street-Perrott, 1983). The summer insolation maximum occurred around 10 ka, resulting in a 10 percent decrease in winter insolation, and a similar increase in summer insolation values compared to the LGM (Minckley et al. 2004). This increase in summer insolation likely created warmer conditions in the Great Basin and increased evapotranspiration, thus decreasing the amount of effective moisture (Minckley et al. 2004). The disappearance of most of the glaciers in and around the Great Basin by this stage, the upslope shift of upper treelines, the migration of species to higher elevations, and the culmination of present-day, desert-like conditions by the Middle Holocene, supports the suggested increase in summer insolation (Minckley et al. 2004). There were, however, different responses between the northern and southern Great Basin, the former being drier than present, while the latter experienced greater-than-present effective moisture due to the strong onshore summer flow from the North pacific, demonstrating the onset of the North American monsoon (Minckley et al. 2004; Thompson et al. 1993).

### Late Holocene (5 ka–present)

Approximately 4.4 ka there was a gradual return to cooler temperatures, as well as an increase in effective moisture (Madsen et al. 2001). Conifer and sagebrush pollen increase, while shadscale and other xeric desert scrub vegetation decrease (Madsen et al. 2001). Homestead Cave contains evidence of the reappearance of waterfowl (primarily shallow-water species) and small mammals that inhabit sagebrush-grass communities (Madsen et al. 2001). Around 3 ka a major cooling event occurred, which is evident in all the biotic records as well as shoreline and core records from the Great Salt Lake (Madsen et al. 2001). Pollen records indicate an increase in effective moisture, and midden records show that Utah juniper grew at elevations at least 50-100m lower than it does today (Madsen et al. 2001). These biotic changes were accompanied by an increase in elevation of the Great Salt Lake between 3 and 2 ka to the highest Holocene stage after the Gilbert expansion (Currey 1990; Madsen et al. 2001). From approximately 2.4 ka midden data show essentially modern vegetation patterns, implying that climate at this stage was modern in character (Madsen et al. 2001).

Effective moisture in the western U.S. increased to present-day levels around 5 ka allowing some lakes to undergo periods of significant re-expansion, especially those on the western margins of the Great Basin and in California (Minckley et al. 2004; Smith and Street-Perrott 1983). The southern Great Basin was slower to respond to these increases in effective moisture, reacting about 2.5 ka later than in the northern Great Basin (Minckley et al. 2004). Minckley et al. (2004) propose that present-day climatic conditions in the Great Basin formed after 5 ka, demonstrating decreased summer and increased winter insolation. Sagebrush became the dominant taxon on the basin floors of the Great Basin, replacing shadscale communities, and present-day woodland associations formed as the upper treelines moved downslope (Minckley et al. 2004).

## SUMMARY

### Late Wisconsin (28–14 ka)

Lake Bonneville underwent a rising trend throughout the Late Wisconsin, although several oscillations did take place (Oviatt et al. 1992). Most of the pluvial lakes in the Great Basin were at high levels during this time (Smith and Street-Perrott 1983). The overwhelming evidence for the Great Basin, including the Bonneville basin, is that the environment was colder and moister than at present. However, there is indication that the northern Bonneville basin was very cold and quite dry, while the southern basin experienced a cold and moist climate (Madsen et al. 2001). This greater-than-present effective moisture was likely a result of the southerly displacement of the polar jet over the Great Basin, as well as, a stronger-than-present Aleutian Low, and a weaker-than-present eastern Pacific Subtropical High (Madsen et al. 2001; Minckley et al. 2004).

### Terminal Wisconsin (14–11 ka)

The Terminal Wisconsin was a period of rapid regression for Lake Bonneville, barring a brief transgression of the Great Salt Lake to form the

Gilbert shoreline (Oviatt et al. 1992). Conditions were warmer and/or drier in the Bonneville Basin over this time period following the LGM, but summer temperatures remained cool (Madsen et al. 2001; Rhode and Madsen 1995). In the Great Basin, lake levels dropped (Thompson et al. 1993) and there was a decrease in effective moisture throughout western North America as the jet stream retreated northwards (Minckley et al. 2004).

### Early Holocene (11–5 ka)

Madsen et al. (2001) suggest that the formation of the Gilbert shoreline (12–9 ka) coincides with the cold Younger Dryas, and other Great Basin lakes also show a minor increase over this time period (Benson et al. 1990). The increase in summer insolation at 10 ka, during the insolation maximum, created warmer conditions and increased evapotranspiration in the Great Basin (Minckley et al. 2004). Between 10 and 5 ka, there appeared to have been a widespread drought, which culminated 6–5 ka, when all lakes were near their lowest levels, and effective moisture appeared to have reached a minimum since the late-glacial (Smith and Street-Perrott 1983). The northern Great Basin was drier than present, while the southern regions experienced greater-than-present effective moisture due to the strong onshore summer flow from the North pacific, demonstrating the onset of the North American monsoon (Minckley et al. 2004; Thompson et al. 1993).

### Late Holocene (5 ka-present)

Effective moisture increased at 5 ka to present-day levels allowing some lakes to undergo periods of significant re-expansion, in addition there was a gradual return to cooler temperatures (Madsen et al. 2001; Minckley et al. 2004; Smith and Street-Perrott 1983). The Great Salt Lake expanded and appeared to freshen ~3–2 ka (Currey 1990). Present-day climatic conditions formed during the Late Holocene, as summer insolation decreased and winter insolation increased (Minckley et al. 2004).

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