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The Relevance of Old Dirt and Old Water to Location, Preservation, and Visibility of Prehistoric Archaeological Sites in the Great Basin

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Abstract

Great Basin archaeology is a story of the relationship between people and water. The earliest known sites are along edges of ancient pluvial lakes, but as Pleistocene lakes dried, people moved to locations where fresh water was available at springs. The nature and quantity of water resources on the landscape at any particular time is critical for archaeological research in a number of ways: it is a necessity for people and the plants and animals on which they subsist, it attracts and holds sediments that preserve the sites, and it provides the archaeologists of today a clue to where they should look to find evidence of the past. But, the interplay between preservation of sediments of the right age to preserve traces of past human populations and the places on the landscape that attracted past human populations in their quests to obtain the necessities of life in arid environments may leave an archaeological record that must be carefully interpreted in terms of both taphonomy and human behavior. The role of springs in determining post-pluvial lake site locations is evident in a brief review of selected sites along the western Great Basin and Mojave Desert, including the critical record from Ash Meadows.

Introduction

Most of the earliest known archaeological sites in the Great Basin, which date to the terminal Pleistocene (15,000 to 10,000 yr B.P. (years before present), have been found along the edges of pluvial lakes. Holocene-age sites (the last 10,000 years) tend to be associated with marshes, rivers, and springs or in caves and rockshelters, many of which are near marshes, rivers or springs. In many parts of the Great Basin, there are hiatuses in local archaeological sequences that correlate with extended dry climatic events during which the huge Pleistocene pluvial lakes and extensive Holocene wetlands dried up. But the meaning of the hiatuses is unclear. Not only did water influence where people lived because it is a necessity for people and the plants and animals on which they subsist, but water also attracts and holds sediments that preserve archaeological sites, and water provides the archaeologists of today a clue to where they should look to find evidence of the past. Distinguishing between whether the distribution and age of known archaeological sites represent prehistoric behavioral patterns, biases introduced by climatic and geological processes, or biases introduced by ease of finding and recognizing sites of particular ages is a problem that continues to defy archaeologists intent on understanding prehistoric adaptations to arid environments. In the eastern and northern Great Basin, people appear to have congregated around springs as the Pleistocene lakes dried, but the role of springs in determining post-pluvial lake site locations in the western Great Basin and Mojave Desert is less well known, and the fate of people who lived in villages near late Holocene marshes also remains unclear. Review of selected sites from areas of the Great Basin where depopulation has been inferred reveals that dunes associated with springs may provide evidence for population movement rather than depopulation in these areas.

Because water is a critical resource for all forms of life in arid environments, recognition of where and when abundant and predictable water has occurred in the past has structured much of what we know about Great Basin prehistory. The distribution of available water, particularly as it occurred in lakes and rivers, has influenced where archaeologists have looked for sites and how the distribution of sites in relation to water sources has been interpreted. Wet and dry climatic cycles provided the chronological structure of Great Basin prehistory before radiocarbon dating became widely available, in terms of both correlating environmental sequences and in terms of interpreting what gaps in sequences meant. Archaeologists in the middle decades of the 20th century routinely attributed hiatuses in artifact sequences to extreme conditions of the middle Holocene Altithermal proposed by Antevs (1948) [endnote 1]. Such inferences are now tempered with a greater understanding of the variability and timing of climate changes during the middle Holocene (see Grayson 1993 for a more detailed discussion), but as more archaeological and paleoenvironmental evidence become available and are compiled into regional sequences, it has become clear that at least some hiatuses in the archaeological sequences for some areas do correlate with periods of climatically decreased moisture, particularly climatic events that occurred as pluvial lakes dried around 7,000 yr B.P. and during drought conditions at approximately 700 yr B.P. Prior to both of these periods, there appears to have been relatively large human populations living near low elevation lakes and wetlands. Most of the early Holocene artifacts assigned to the Paleoindian and Early Archaic Periods (prior to 11,000 until about 7,000 yr B.P.) have been found in areas that would have been wetlands adjacent to the receding pluvial lakes. Likewise, prior to about 700 yr B.P., people were living in substantial village sites near wetlands on all sides of the Great Basin (Aikens and Witherspoon 1986). It is unclear, however, what happened to the Paleoindians after the pluvial lakes dried up. Likewise, the archaeological records for people of the late Holocene villages ends abruptly at times that correlate with periods of drought.

Development of the archaeological sequences in the Great Basin in which these hiatuses are found began with compiling stratigraphically ordered assemblages of artifacts from caves and rockshelters that could provide estimates of relative age of different kinds of artifacts and events in the past. Determination of the age of sites outside the caves and rockshelters was largely a matter of comparison of artifacts from the open sites with those from the caves, or correlation with climatic events. The synthetic chronology for people in the Great Basin that resulted, however, had a large gap that included most of the middle Holocene. Because dry periods are known due to their impact on plants and animals (e.g., Thompson 1990), it is logical to assume that hiatuses in archaeological records that correlate with drought conditions caused stress on human populations. But it is now becoming increasingly clear that simple abandonment of any particular area as a result of stresses induced by drought is probably an overly simplistic interpretation.

The readiness with which depopulation as a result of drought has been accepted as the cause of hiatuses in the archaeological record of the Great Basin is undoubtedly due to accounts of early explorers, who thought the Native Americans were living a rather marginal existence, and the ephemeral nature of archaeological sites and artifact assemblages compared to the elaborate ceramic assemblages and condominium-style houses found in the Southwest. Consequently, the conclusion that during periods of drought the people in the Great Basin wetlands had to choose between starvation or leaving made sense. Such interpretations of the plight of the Native Americans of the Great Basin failed to take into account the impact Euroamerican presence had on their ability to move to other areas and resources [endnote 2]. Studies of modern foraging people are documenting the manner in which many foraging peoples shift their focus among various resources in their diets as particular plants or animals become more or less abundant. As their focus shifts from one resource to another, the locus of a group's activities may change depending on where the resources of interest are found. Similar shifts in resource use in the past would result in distinct changes in where archaeological evidence of their presence (artifacts, food remains, hearth and floor structures, etc.) was deposited. Change in residential patterns (e.g., Fagan 1974; Sampson 1985; O'Connell 1975; Kelly 1990, 2001; Thomas 1985) and even conflict among competing groups (e.g., Sutton 1986; Novak and

Kollmann 2000) are now recognized as alternatives to starvation and abandonment as alternative human responses to periods of drought, particularly the late Holocene drought.

Alternatively, or in combination with a shift in which resources attracted people at particular times, climate changes can also affect rate and location of sediment deposition resulting in a bias in where evidence is preserved. Before the pluvial lakes dried and when extensive wetlands were present during the late Holocene abundant water in many valleys allowed people to congregate in relatively large concentrations or return to the area on a regular basis. Archaeological sites were created around those water sources and buried in sediments deposited as a result of processes characteristic of the water sources: fluvial transport, flooding, wave action, etc. Once the water sources that fed the pluvial lakes and late Holocene wetlands ceased to be active enough to maintain wetlands, the most active agent of sediment movement in many Great Basin valleys was wind. In many cases wind exposed, rather than buried, the wetland sites.

During the late Holocene, between about 3,000 and 700 yr B.P., when wetlands were again extensive around the edges of the Great Basin, people created large year-round villages of houses built over pits that leave substantial traces, some of which consist of hundreds of artifacts scattered over miles of desert (e.g., the Humboldt Lakebed Site, Loud and Harrington 1929; Stillwater Marshes, Raven and Elston 1988, Kelly 2001). Like pluvial lakeshore sites, late Holocene wetland sites were preserved in sediments deposited by processes associated with the water sources. People living in the villages also used nearby caves to store resources that permitted them to stay in the villages year-round (e.g., Lovelock Cave, Loud and Harrington 1929; Hidden Cave, Thomas 1985). The same dry conditions that enticed people to use caves for caches and burials preserved their contents for millennia. Thus, some sites created during wet periods are well preserved and relatively easy to find. After approximately 7,000 years ago and 700 years ago, wetlands were greatly reduced or eliminated and the known archaeological sites are much smaller, more dispersed, and above the valley floors where sediments are more likely to erode than to accumulate. Consequently, sites created after the wetlands were gone are harder to find. And it is harder to determine their age, the cultural affiliations of the people who made them, and the kinds of activities they represent.

Evidence for what happened to the Paleoindian people at the onset of middle Holocene conditions is even less clear than it is for the late Holocene people. Occupation of the early Holocene wetlands appears to have ended between 7,000 and 6,000 years ago and they were not reoccupied until after 5,000 yr B.P. [endnote 3]. It has been argued that if people continued to live in the Great Basin during the middle Holocene, their populations were sparse and dispersed (c.f., Aikens and Jenkins 1994; Elston 1982). A significant exception is the eastern Great Basin where sites around the edges of Pleistocene Lake Bonneville provide a record of continuous human occupation of the region from at least 10,000 yr B.P. until the contact period (e.g., Danger Cave, Jennings 1957; Hogup Cave, Aikens 1970). Warren and Ranere (1968) and Madsen (1982, 1997) explained the continuity in the archaeological record of the Bonneville Basin in terms of the continuing occurrence of lakeside wetlands even as the levels of Lake Bonneville lowered. When the pluvial lake filled the basin to its highest extent, the lake edges approached relatively steep mountainsides and alluvial fans, which reduced lake-edge environment to a narrow band. That narrow band would have supported the most productive wetlands and is where most Paleoindian artifacts have been found. As the lake receded, wide lake-edge environments were created in the relatively flat valley bottom, fed by springs whose productivity was maintained by the water from the extensive montane systems that border the lake basin. Madsen has argued that similar springs likely existed elsewhere as well. Yet similar evidence of continuous human occupation in other parts of the Great Basin near springs adjacent to the beds of pluvial lakes has not been found (Beck 1995).

One possible explanation is that the northwestern Great Basin was drier than the Bonneville Basin during the middle Holocene (Kelly 1997). But it remains to be demonstrated that there were substantially drier climatic conditions during the middle Holocene in the northwestern, central, and southern Great Basin than those of the eastern Great Basin. Another possible explanation is that the geological structure of the regions is different, resulting in different hydrology under similar climatic conditions. In the Bonneville Basin, which has a large, open, relatively uniform lake basin, springs remained along the lake margin even as the shallow end of the lake dried into the Bonneville Salt Flats. Those springs provided permanent water sources near many of the areas where archaeological sites are found (Warren and Ranere 1968; Madsen 1982). Unlike the Bonneville Basin, the Lahontan Basin was comprised of seven major sub-basins bounded and separated by numerous mountain ranges. In the northern and southern Great Basin there were a number of pluvial lakes, but none approached the magnitude of either Bonneville or Lahontan. The smaller pluvial lakes were widely separated and did not coalesce, even at pluvial maximum, as did the lakes that made up Lake Lahontan (Smith and Street-Perrott 1983). When these smaller pluvial lakes receded they may not have created the extensive lake-edge environments like those that appear to have thrived adjacent to Lake Lahontan and Lake Bonneville, but they clearly did provide productive wetlands, especially in the areas of low-elevation springs that were the source of ponds and lakes in the southern deserts (e.g., Haynes 1967). After the pluvial lakes and their associated marshes were gone, the permanent water sources appear to have been springs at higher elevations or valley bottom springs fed by extensive subterranean hydrological systems as occur in Ash Meadows. Evidence is now becoming more abundant that, while populations may have declined as climatic conditions became drier due to climate changes, changes in site preservation and visibility may also contribute to the hiatuses in the archaeological sequences for many areas. The problem then becomes, if people were present in the Great Basin during the periods for which there are hiatuses in the archaeological sequences, how and where can the sites be found. One suggestion that has been made is to look for sediment deposits of the appropriate age ("old dirt," J.O. Davis, Geoarchaeologist, Research Professor (deceased), Desert Research Institute, pers. comm.). A correlate of that suggestion is to look for "old water." That is, if evidence of Paleoindians is found along pluvial lakeshores and evidence of late Holocene villages is found in wetlands because people were living where reliable and abundant water provided the richest resources, then as the pluvial lakes and late Holocene wetlands desiccated, the people most likely moved to areas where more reliable water sources could be found. To find evidence of where they went, it is necessary to find where the reliable water sources were.

Old Dirt and Old Water

It is noteworthy that many sites associated with water sources that persisted through the middle Holocene, particularly springs, occur on, in, or under dunes. It has been noted that dunes are found downwind of virtually every pluvial lake and river channel in the Great Basin (Mehringer and Warren 1976). The location of dunes downwind of pluvial bodies of water is a phenomenon that clearly reflects the importance of playas and river channels in accumulated beach and bar deposits that provided sediment sources for dune formation. But the formation of such dunes also reflects a significant change in sediment distribution. As the pluvial lakes desiccated, there were no more waves to form beaches and bars. Then, the sands and silts dried and became available for aeolian transport. For dunes to form, however, there needs to be some topographic irregularity or obstruction that decreases wind velocity and allows transported sediments to accumulate (Waters 1992). In the case of many Great Basin dunes in which archaeological sites are found, the obstruction around which dunes began to accumulate was most likely shrubs and other vegetation growing around perennial springs. As the dunes continued to grow the proximity of the springs provided water that allowed continued vegetation growth that stabilized dunes, preserving archaeological materials deposited in them as people turned to springs for reliable water sources. But some of the dunes in the western Great Basin are formed of clay and loam, as well as sand, through processes that occur under environmental conditions in which highly saline surface crusts form due to a near-surface water table. The water aggregates the fine sediments into pellets and then effloresces making the sediments available for eolian transport (Elston *et al*. 1988; Bowler 1973). Once they begin to form, dunes have also been known to block runoff from springs, thus creating wetlands such as those in the Ash Meadows area (Mehringer and Warren 1976). They act as sponges that rapidly absorb rain and release it slowly (Sharp 1966; Mehringer and Warren 1976).

There are a number of reasons dunes have not been as well investigated as caves in the search for a complete sequence of Great Basin prehistory. Although a number of studies are now in progress, it has been noted that the geomorphological literature describing dunes in North America is sparse and focused primarily on active dunes, particularly large active dunes and/or those that occur in large fields (Smith 1982). Smaller, stable dunes are more likely to contain or overlie archaeological deposits. But even the smaller stable dunes vary greatly in shape and composition. Quartz sand probably is the most common dune sediment, but volcaniclastics are a significant component of dunes in the northern Great Basin, and pelletized clay comprises much of the matrix of dunes associated with pluvial lakebeds in the western Great Basin. Wind direction, sediment type, and source affect the location and shape of the resultant dune: sheets, lunettes, barchans, etc. (c.f. Bowler 1973). Further, the propensity for dunes to grow and move has not only allowed some to override drainages from springs damming the runoff into wetlands that support important biotic resources such as marsh plants and waterfowl, but that same movement can make their archaeological contents extremely difficult to interpret and they are notoriously difficult to excavate. However, once dunes become stabilized by the cementation of fine sediments or the establishment of vegetation, they may contain detailed, if subtle, sequences of distinct and datable archaeological components and fine-grained environmental information (Carter *et al*. 2003; Davis 1980; Davis and Elston 1972; Mehringer and Warren 1976; Mehringer and Cannon 1994). But, rather than focusing on the importance of water in creation and stabilization of dunes and, consequently, preservation of archaeological sites, reasons given for finding archaeological sites in and under dunes include the ability of dunes to support stands of vegetation important to native peoples of the Great Basin (e.g., rice grass and mesquite) or that they provided dry islands in wet environments. In fact, the reasons sites that fill the hiatuses in Great Basin archaeological sequences occur in dunes may be a complex mix of prehistoric location of abundant plant and animal resources, deposition of sediments that preserve sites, and visibility to modern researchers. As the locations and processes of dune formation, deflation, and stabilization become better known as they relate to archaeological site preservation and visibility, it becomes more apparent that failure to distinguish between human behavioral responses to environmental changes and changes in sediment deposition and erosion may introduce significant bias in interpretation of middle and late Holocene archaeological sequences.

Some Important Archaeological Sites Associated with Dunes and Springs

Dunes stable enough to preserve evidence of middle Holocene environments and human activities have been recognized in the eastern Great Basin, and there is good reason to believe that a number of the archaeological sites found elsewhere in the Great Basin on the surface or on erosional discontinuities beneath dune deposits may represent middle Holocene and late Holocene occupations. A brief summary of a few selected archaeological investigations (Figure 1) reveals the potential for finding the elusive evidence of human activities in the Great Basin by developing an understanding of where both permanent water and aeolian sediments occur in the appropriate relationships to have provided amenable living conditions in the past and amenable conditions for preservation of archaeological evidence.

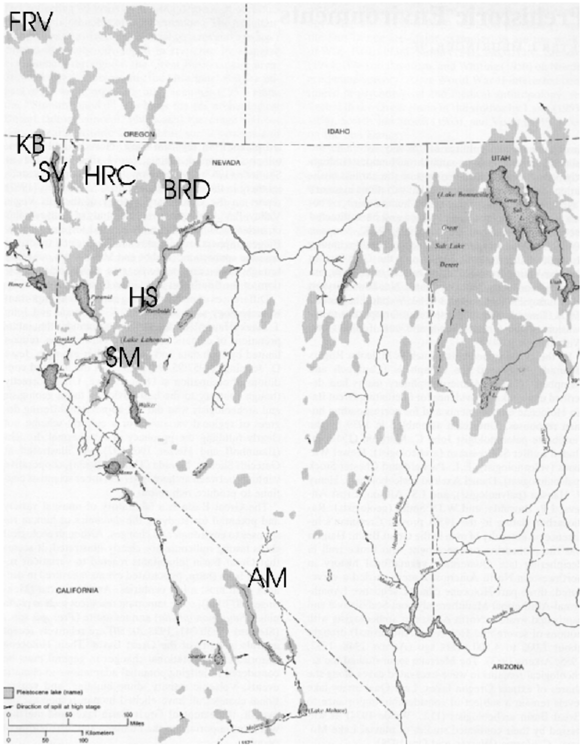

Figure 1. Selected archaeological localities discussed in the text: AM – Ash Meadows, BRD – Black Rock Desert, FRV – Fort Rock Valley, HRC – High Rock Country, HS – Humboldt Sink, KB – Klamath Basin, SM – Stillwater Marsh, SV – Surprise Valley.

Fort Rock Valley: The Fort Rock Valley of southern Oregon is one of the first places in the Great Basin from which Paleoindian sites were reported. Archaeological materials from these sites were instrumental in establishing that people have been in the arid west for at least 10,000 years. Investigations in the Fort Rock Valley also have been cited as evidence for middle Holocene abandonment, or at least a major population decline, in the northern Great Basin (Cressman 1942, 1951, 1977; Bedwell 1973). Springs were named as the most likely source of water that could support human populations during the period of aridity that followed the early Holocene, but it was also noted that

> "...probably only the strongest springs, scattered along the great scarp faces in the region, continued to flow. During these stringent times, when the region became a parched and almost barren land of little game and little vegetation, populations gradually declined until only a few scattered groups remained, their lives tied closely to the infrequent springs" (Bedwell 1973).

Recent investigations have revealed that middle Holocene sites *are* preserved in dunes in the Fort Rock Valley. The Fort Rock Valley dunes are comprised of a variety of materials that reflect the time and environmental conditions under which they were formed. The dune deposits overlie Pliocene/Pleistocene (approximately 1.6 million years ago) diatomite and volcaniclastic sediments or late Quaternary lake clays and silts. The earliest sediment accumulations are generally sand-sized particles from unspecified sources. The earliest known archaeological deposit in the dunes is a fire hearth dated to 9,500 yr B.P. Mazama tephra, dated to 6,850 yr B.P., contributed much of the middle Holocene-aged dune sediments. The upper levels of the dunes are silt-sized particles, most likely reworked tephra. There is a period of dune erosion, stability, and weathering between 5,000 and 6,000 yr B.P., and redeposition of Mazama pumice to the edges of very small lakes. Other, less well-developed, episodes of erosion, stability and weathering, and soil formation were noted, but their ages and significance remain uncertain (Mehringer and Cannon 1994).

While the results of investigating the archaeological evidence preserved in the dunes of Fort Rock Valley support traditional inferences that the most intense use of the region post-dates 5,000 yr B.P., fish and waterfowl remains dated to 6,650 yr B.P. indicate there was no long, uninterrupted middle Holocene drought in this area (Mehringer and Cannon 1994). The fish and waterfowl fauna from the middle Holocene dune deposits in the Fort Rock Valley document the ephemeral, but persistent, nature of spring-fed wetlands, even when conditions are thought to have been at their most arid, and the persistence of human reliance on those resources when they were available.

Black Rock Desert: The Black Rock Desert is another area from which numerous Paleoindian artifacts have been recovered. The artifacts are mostly from the surface along the eastern edge of the playa where extensive wetlands would have thrived during the early Holocene (Clewlow 1968). The occupational sequence for this area, as elsewhere in the Great Basin, is poorly known because most artifacts were found on the surface and cannot be dated, but it now appears that the Black Rock Desert wetlands desiccated at approximately the same time as those of the Fort Rock Valley and evidence of subsequent human populations likewise is less abundant. Middle Holocene style artifacts do occur in the vicinity, but it is unknown if these artifacts represent continuous use by greatly reduced numbers of individuals, sporadic use by larger groups, or abandonment and later reoccupation as inferred for nearby areas.

A number of large springs mark the location of the Black Rock Fault that runs along the west side of the Black Rock Range. Trego Hot Spring is on the southern end of the fault, at the southern edge of the Black Rock playa. Much of the Trego Hot Spring archaeological site is under a large dune formed downwind of Black Rock Desert in the wetland created by the runoff from Trego Hot Spring. The oldest artifacts, estimated to date to 6,000 yr B.P. based on style of projectile points, lie as a lag on an unconformity that represents the early Holocene, sandwiched between eroded silty clay deposited by Lake Lahontan and overlying aeolian deposits. Davis (1980) suggested that the source of the aeolian sediments was probably pluvial beach sand deposited along the margin of the Black Rock Desert playa by wave action of Lake Lahontan during intervals when the Black Rock Desert held at least a shallow lake. Once the lake was gone, the dry beach sands were redeposited downwind into dunes along the east and south margins of the playa. Then, the water table dropped enough to allow deflation of finer sediments from further out on the playa. The fine sediments were washed into the dunes by infrequent but intense rains that stabilized the dunes and now provide stratigraphic evidence of changes in environmental conditions. The earliest radiocarbon dates for the site are younger than 4,000 yr B.P., but these dates are from materials preserved *in* the dune deposits. The lag artifacts underlying the dune appear to be older, representing use of the site prior to reworking of the aeolian sediments (Davis 1980). As in the Fort Rock Basin, the oldest artifacts from the Trego Hot Spring site appear to represent a middle Holocene occupation associated with a large spring, in dune sediments derived from lacustrine sediments.

Other, earlier dune sites may have occurred around the margins of the Black Rock Desert playa in the marshes while the wetland was still present. Clewlow (1968) suggested that artifacts found on the surface of the playa were left by people using marsh resources. Roney (1979), however, observed that no plant, animal, or mineral resources occur on the playa to attract people to many of the desolate reaches where concentrations of artifacts have been found. He suggested that the playa sites are most likely lag from deflated dunes, noting that some areas where artifact concentrations have been found would have been inundated if the playa floor were wet enough for marshlands to develop. On the other hand, at least some of the playa sites lie in areas that may have been productive dune habitats before deflation eroded the dunes. He supported that conclusion by arguing the artifacts most likely were not deposited by alluvial processes because they are not size sorted and do not exhibit wear patterns that would be expected had they been subjected to alluvial movement. If people were living in dune sites along the shorelines of the receding pluvial lakes, then moving to the newly forming dunes around springs as the lakes dried would not represent a radical change in subsistence practices or choice of landscape features for site locations. The significant change was in the location and nature of the water source from pluvial lake to large spring.

The Barrel Springs site on a spur of the Kamma Range on the southern edge of the Black Rock Desert provides another hint that people were present and making use of spring sites adjacent to other important resources, in this case, a rhyolite outcrop, during the middle Holocene. Although the most abundant evidence at this small quarry site has been assigned to the period from about 3,000 to 1,300 yr B.P., a small archaeological component was found in a deeper stratum at the site, indicating the presence of people well before the radiocarbon dated assemblages (Cowan 1972). Small springs now occur in many of the mountain ranges that flank the Black Rock Desert. And there are undoubtedly many more like Barrel Springs that are now recognizable as springs due to calcium carbonate deposits but they are now inactive and consequently are not found on topographic maps or marked on the landscape by green vegetation. Although unimpressive archaeological sites when viewed in isolation, these spring sites hold great potential for understanding prehistoric adaptations to the Great Basin deserts as the pluvial lakes dried, and through subsequent climatic cycles of increasing aridity, followed by rejuvenation of wetlands and springs.

High Rock Country: The High Rock Country is a dissected volcanic tableland at about 1,835 m elevation in northwestern corner of Nevada, 600 m or more above the playas created by Lake Lahontan. Water in the High Rock Country is primarily from seasonal creeks and streams, and numerous permanent springs that are fed by snowmelt from the nearby peaks that reach heights of over 2,750 m. The earliest archaeological evidence found in the High Rock Country represents the time interval from 8,000 yr B.P. to 7,000 yr B.P. (Layton 1970). During this interval people appear to have been expanding their resource base from a focus on wetland resources around the pluvial lakes to use of a wider range of animals, particularly the artiodactyls. There is no securely dated evidence for the period from 7,000 to 6,000 yr B.P. in the High Rock area, which Layton suggested may indicate abandonment of the region during the most arid interval of the middle Holocene. The Silent Snake Spring site is located near several small permanent springs at the mouth of a canyon about 675 m below Division Peak from which fresh water drains year-round. Layton estimated that the site was occupied from approximately 6,000 yr B.P. to 3,500 yr B.P., based on artifact styles and a single radiocarbon date of 5,300 yr B.P. The artifact assemblage included numerous seed grinding implements, projectile points, and artiodactyl bones, indicators of the importance of both seeds and hunting in the diet. The preponderance of mountain sheep in the fauna from this site contrasts starkly with the paucity of artiodactyls in low-elevation wetland sites, but is a predictable resource to have been used in the High Rock environment. A number of sites in caves and rockshelters provide evidence that has been interpreted as indicating that the most intense occupation of the High Rock Country was during the following interval, from approximately 3,500 to 1,500 yr B.P. (Layton 1970).

Humboldt Sink: The Humboldt Sink is now the frequently dry terminus of the Humboldt River. It may contain a large lake with significant wetlands along the margins during wet periods, but during periods of drought it becomes a dry playa reflecting its role as one of the major subbasins of Lake Lahontan. A number of archaeological sites have been recorded around the edges of Humboldt Lake, but deflation has left most of these sites as little more than surface lag (Loud and Harrington 1929). Excavation of pit features in areas that had not eroded to the level of the underlying pluvial lake deposits revealed that the area had supported substantial villages. Radiocarbon dates indicate the villages were occupied by 2,600 yr B.P. (Livingston 1986), but there is no record that they were occupied at the time the first Euroamericans arrived. It has been suggested that earlier occupation of the wetlands may have occurred but, along with deflation, selective removal of the exposed larger, earlier artifacts by collectors has biased the record (Heizer and Clewlow 1968).

Humboldt Lake has most likely always been brackish, but there was some evidence that fresher water would have been available in a main channel of the Humboldt River, which flowed near the largest of the archaeological sites on the lakebed. Deflation, and lack of detailed stratigraphic study during excavation, precluded secure identification of the landforms on which the site was constructed, but it is thought that the village was situated on a low dune or a small delta formed by the Humboldt River as it reached the lake, allowing easy access to fresh water (Livingston 1986). It has also been suggested that some of the abundant pit features may actually have been wells, rather than storage or burial pits (O'Connell, Professor, Department of Anthropology, University of Utah, pers. comm.). There are not enough data from the excavations to reveal whether or not occupation was sporadic or continuous, or how changes in lake levels affected people who created the sites. Water appears to have been present, though variable in quantity, in the Humboldt Sink throughout the Holocene and wetlands were used on a regular basis though there is still some question regarding whether or not people of the same cultural tradition are represented throughout the sequence. In fact, there are indications that there may have been competition between prehistoric peoples for the resources of this perennial wet area prior to the arrival of Euroamericans.

Stillwater: The Stillwater Marshes are extensive wetlands in the Carson Desert fed by the Carson River, supplemented with input from the Walker River during some periods. Investigations at archaeological sites in the Stillwater Marshes provide better evidence of the nature of prehistoric occupation of low-elevation wetland environments in the western Great Basin, especially in terms of the landscape features on which prehistoric villages were built. The houses in the Stillwater Marsh were constructed on dunes that were dry islands in the marsh (Elston *et al*. 1988), similar to the manner hypothesized by Roney (1979) for activity areas represented by early Holocene playa sites in the Black Rock Desert. The Stillwater dunes are generally lunette in shape and comprised of pelletized clay. Study of landforms and sediments in the Stillwater Marshes revealed no occurrences of Mazama ash, or other datable deposits from the early to middle Holocene. Along with the occurrence of dune deposits lying directly on lake clays, these data support Morrison's (1964) suggestion that there was a period of massive erosion during the middle Holocene, between 6,900 yr B.P. and 4,250 yr B.P.

Radiocarbon dates and artifacts from Hidden Cave indicate people were visiting the cave from prior to 5,300 yr B.P. until about 800 yr B.P., with the greatest evidence of their presence dated to the period from about 3,200 to 5,000 yr B.P., a time that overlaps the period of deflation in the Stillwater Marshes. The nature of the archaeological assemblages and the living space inside the cave suggest that the primary use of the cave was not residential, it most likely served as a storage space for equipment and resources, and was also used for burial and occasional, short-term refuge (Thomas 1985). These interpretations of the Hidden Cave site, and the numerous other sites in the area indicate that people were undoubtedly present, if not abundant and thriving, in the Carson Desert during the middle Holocene.

Surprise Valley: Surprise Valley is a long, narrow valley that contained pluvial Lake Surprise on the westernmost edge of the Great Basin. The valley is now three ephemeral playa lakes fed by runoff from the surrounding mountains and springs. Occupation of Surprise Valley apparently began approximately 6,500 yr B.P., with the appearance of sizable village sites situated on stabilized dunes, scarps, or alluvial fans near marshes and permanent streams or springs in the valley bottoms. These sites are dated to the period between 6,500 and 4,500 yr B.P., the time when populations appear to have declined or disappeared from the shores of pluvial Lake Lahontan to the east. The size and structure of the lodges during this period have led to the inference that they housed communal groups. After 4,500 yr B.P., there is a change in house structures to smaller brush wickiups, which has been interpreted as indicative of reduction in the size of the stable residential group as a result of reduction in local resource availability (O'Connell 1975).

Klamath Basin: The Klamath Basin is a large stream-fed wetland consisting of several lakes and associated marshes, just northwest of the hydrologic boundary of the Great Basin. The Nightfire Island archaeological site, located on what was an island in Lower Klamath Lake prior to Euroamerican development, was first occupied about 7,000 yr B.P. and continued to be used, with short hiatuses, until shortly before contact. As with the Surprise Valley sites, occupation of the Klamath Basin appears to have begun as the shorelines of the large pluvial lakes of the Great Basin receded. During its heyday, the Nightfire Island site was a substantial village, maintained through episodes of lake level changes by building platforms to raise the structures above the water level. The longest period of abandonment was between 3,200 and 2,700 yr B.P., a time thought to have been cool and dry, and during which Lower Klamath Lake may have only been a few shallow ponds (Sampson 1985). It may be significant that occupation of the Stillwater Marshes and the Humboldt Lakebed sites appear to have begun during the time Nightfire Island was abandoned.

Ash Meadows: Ash Meadows is in the lowlands at the southern end of the Amargosa Desert. The area currently is an oasis of more than 30 active seeps and springs in what is otherwise one of the most arid regions of the Great Basin. These springs, some of which may have been active since the Pliocene, are fed by both local precipitation and ground water that originates in the Spring Mountains (Loeltz 1960; Thomas 1964).

Early Holocene sites in the southern deserts have been documented for a number of areas around Ash Meadows (e.g., Davis and Shutler 1969), most of which are exposed on the surface and consequently undatable, as elsewhere in the Great Basin. But shallow deposits in four sites in the central Mojave Desert have provided radiocarbon dates and faunal remains that reflect a sequence reminiscent of the record from the High Rock Country: as the early Holocene waned there was a shift from artiodactyl use to smaller taxa, except in the Mojave, the small taxa were rabbits and tortoise rather than rabbits and rodents (Douglas *et al*. 1988). Most of the archaeological sites in Ash Meadows occur on, in, or under dunes, particularly large dune fields with dense mesquite stands. The earliest evidence of human use of Ash Meadows are large points thought to represent the interval between 7,000 and 4,000 yr B.P. Unfortunately, while these intriguing artifacts represent the period when much of the Great Basin has been argued to have been abandoned, as elsewhere, none of the Ash Meadows artifacts have been found in datable contexts or with faunal or floral remains from which inferences about human activities can be drawn. Artifacts assignable to all subsequent time intervals have been found in the area, with the most abundant artifacts representing the period from 700 yr B.P. to the present (Livingston and Nials 1990).

The Ash Meadows archaeological sequence is one of the most telling of all dune and spring environments for supporting the argument that aeolian movement of sediments and subsequent deposition influenced by spring activity has a distinct bias on our understanding of prehistoric human behavior. Mehringer and Warren’s (1976) study of the relationship between the peat and dune deposits in Ash Meadows to determine the history of spring-fed wetlands in the arid southern deserts provided a geomorphic sequence that reflects the deposition and stabilization of aeolian sediments and the potential archaeological visibility of archaeological sites contained in them. They interpreted profiles of backhoe trenches as a sequence of dune formation and peat deposition that occurred over the last 5,300 years. The deepest datable deposit they could document was a peat layer that formed between 5,300 and 4,500 yr B.P. That peat overlies an older dune sand in the deepest profile, and apparently older peat and dune deposits occur in the area but they are below the water table and could not be exposed for study. Mehringer and Warren interpreted the observable sequence of deposits as indicating that peat deposition and dune migration occurred simultaneously, with dune movement continuing and overriding the peat deposits at least three times. The periods of dune movement were interspersed with periods of stabilization, erosion and weathering. Similar studies at Corn Creek Dunes, Las Vagas Valley (Williams and Orlins 1963), Death Valley (Hunt 1960, Hunt and Mabey 1966), and Saratoga Springs (Smith 1982) reveal a similar relationship between dune deposition and movement and wetland deposits, reflecting the agency of dune activity in damming spring-fed drainages creating extensive marshes.

Discussion and Conclusions

The gaps in archaeological sequences once interpreted as abandonment may, instead, reflect a change in where people lived and foraged within the region. Or the gaps may simply reflect changes in sediment deposition resulting in changes in the manner archaeological sites are buried and preserved. Aeolian landforms, especially those associated with spring-fed wetlands, hold important clues for finding and interpreting evidence of the presence of people in areas of the Great Basin once thought to have been abandoned during times of drought. But it is an unfortunate fact that many of the springs that were active during the most arid intervals of the Holocene are probably the same springs that have been most prolific throughout the Holocene. That means they have been frequented and modified by people throughout the last 10,000 to 12,000 years. Probably the most destructive reuse of large springs, especially those in the southern Great Basin, was development for agricultural and recreational use during the 19th and 20th century before the archaeological importance of these areas was recognized and before there were laws requiring cultural resources inventories prior to development. When springs are developed for agricultural use the associated dunes are generally leveled and plowed for cultivation, which has increased the detrimental effects of spring development by orders of magnitude. Frequent reuse and the ongoing geological processes associated with permanent water sources may have disturbed or destroyed much of the evidence of the people who used them during the early and middle Holocene, but recognition of those that remain may be aided by developing a better understanding of the relationships between climate, spring productivity, aeolian sedimentation, and human behavior. Thus, while surveying springs and associated dune fields may provide a means of finding archaeological sites to fill in the hiatuses in archaeological sequences, especially those hiatuses that correlate with periods of known drought during the middle and late Holocene, it is important to recognize that what is permanent water now has not necessarily always been permanent, or in the same place that it is found now. Studies such as those found in other papers in this volume can contribute greatly to understanding where water was found at different times in the past, its productivity, and its ability to hold sediments that would preserve artifacts and features deposited nearby.

In many of the preceding comments is the understanding that archaeologists generally find important archaeological sites by looking for particular kinds of landscape features: pluvial lakeshores, caves, rockshelters, and as advocated here, dunes associated with springs. An important caveat must be noted in using the practice of finding sites by looking for sediments of the appropriate age. Searching lakeshores for early sites and dune sites for filling hiatuses in the sequences, may be the most expedient means of finding a sample of artifacts of the age of interest. But there is no assurance that the sample of sites found is representative of how people dispersed themselves across the landscape. It is unlikely that people in the past chose places to live, or hunt, or collect plants, or conduct any other activities based on the potential of that place for sedimentation except as sedimentation correlates with the presence of water. Most of the people living in the Great Basin prior to the recognition of the dangers of toxic and nuclear waste probably were as unconcerned about whether or not evidence of their presence was preserved for the next 10,000 years as most of us are about yesterday's newspaper. Concern with how long living refuse is preserved only became an issue of general concern in the last few decades when it was realized that what one throws away can hurt existing and future generations. Given their refuse was nontoxic, the landscape variables of concern to prehistoric people appear to be more a matter of where they could obtain the necessities of life: water, food, and shelter rather than where they would dispose of refuse. Thus, the sample of sites found by looking for particular sediments most likely will be biased in representing only those activities conducted in particular environments, the environments in which deposition of sediments was rapid and where little or no subsequent erosion has occurred. Biases introduced by the manner in which archaeologists look for sites have long plagued interpretations of what people were doing at particular periods in the past [endnote 4].

Endnotes

1. Sequences of artifact assemblages obtained from stratified sites and artifact typologies were matched into the chronological structure of climatic events, particularly those described by Antevs (1948), with significant hiatuses in archaeological sequences correlated to the middle Holocene drought. Probably the most explicit expression of the assumption that the middle Holocene Altithermal drought was responsible for depopulation of the western Great Basin is Heizer's (1951) description of a burial found in Leonard Rockshelter, adjacent to the Humboldt Lakebed. The individual he described as a "...miserable newborn infant which was too weak to withstand the heat and rigors of the Altithermal..." (p. 92). It was found near burned basketry that yielded radiocarbon dates of 5,779 and 5,694 yr B.P., placing it clearly in the Altithermal, when the area was thought to have been abandoned. He concluded that the infant and the basketry provided

   > "...no real basis to suppose continuous occupation by that particular culture group for 1,500 years or more in a region which may have permitted, but could hardly have encouraged settlement. Possibly intermittent occupation by migrating groups on their way to greener pastures characterized this time period in the valley of the Humboldt" (p. 97).

   An example of similar interpretation of later hiatuses as depopulation events due to drought conditions is Wormington's (1955) dismal portrayal of the relationship between prehistoric people and the environments of the eastern Great Basin. She argued that the Great Basin is inhospitable; a place where the slightest change in climate could lead to drought and starvation. The alternative to starvation, Wormington suggested, was that droughts must have caused abandonment of the Great Basin on many occasions. She made these remarks specifically in reference to the late Holocene occupation of the eastern Great Basin by a cultural group known as the Fremont. In the 1950s, the Fremont were thought to have been farmers, whose populations immigrated into the eastern Great Basin from the Southwest during a period of climatic conditions amenable to dryland farming. Dryland farming is an enterprise particularly vulnerable to failure due to drought and it may well be that the late prehistoric people of eastern Great Basin who relied on farming did either leave or starve if they continued to rely on dryland farming in the eastern Great Basin during periods of drought. There are now numerous other interpretations of Fremont culture that have been proposed to explain the sudden disappearance of the relatively sedentary people of the eastern Great Basin (Madsen 1989).

2. The notion that the Great Basin was inhospitable and the indigenous people lived a marginal existence derived in no small measure from the condition in which the Great Basin Native Americans were first observed, which was the result of competition with Euroamericans. When the Native Americans of the Great Basin were first described, most were existing on very marginal resources. The first Euroamericans to spend any real time in the Great Basin were Hudson's Bay trappers, whose mission it was to decimate the furbearing animals of the region to discourage American encroachment into their prime trapping territories to the north. And the first

Euroamerican immigrants, people headed for the California goldfields and the farmlands of Oregon Territory, brought cattle, sheep, and horses that added stress to the forage and water sources that were already stressed by drought and overtrapping. Unlike the overtrapping, overgrazing was not intentional, nor was it directed at excluding others from using the resources. Those first Euroamericans came from areas such as the Northwest and the Midwest, where domestic animals had less of an impact on water and forage, and because they were only passing through they failed to recognize the impact their livestock had on the natural resources of the Great Basin desert. Thus, the first Native Americans to be observed by Euroamericans were living in an inhospitable environment; one created, at least in part, either deliberately or inadvertently, by Euroamericans (d'Azevedo 1986).

3. It has been suggested that when the pluvial lakes dried during the early Holocene wetlands were not entirely desiccated:

> "...even the largest Great Basin lakes may have dried up, [but] it is unlikely that major marsh systems were eliminated completely. For that to happen, major Basin rivers would have had to cease flowing into their terminal basins. However, they may have been reduced to the point where they could not support sedentary populations of any substantial size. Upland sites begin to appear in large numbers during this time, and the mobile strategy developed as the primary foraging approach used by most Great Basin hunter-gatherers during the middle Holocene" (Madsen 1997).

It is not difficult to dismiss this comment as overstated in view of the response of western Great Basin wetlands to droughts in recent decades. As dry periods reduced the flow of the Humboldt, Truckee, Carson, and Walker rivers to mere trickles during the 1980s and 1990s, the wetland areas of the Humboldt Sink and Stillwater Marshes desiccated to the point they not only would not support sedentary village life for people, but populations of fishes, migratory waterfowl, muskrats, and marsh plants were decimated, leaving dry stems and sun-bleached bones to attest to their prior abundances. The wetlands were not only reduced to the point where they could not support sedentary populations of people, but most of the resource species simply could not be found in these areas for a number of years. The wetlands have returned, under climatic conditions of greater precipitation and with careful management practices that ensure enough runoff is allowed to reach the terminal sinks. And as the water returns, so do many of the important resource species, particularly the migratory birds and fishes, and cosmopolitan wetland mammals such as muskrats. Yet, the point is well taken, that human response would have been the same under either scenario. Either substantial reduction or complete desiccation of major wetlands would have necessitated abandonment of sedentary villages that relied heavily on wetland resources. How far from their wetland homes people moved is another issue, that is, leaving the wetland villages could represent either a complete abandonment of the region or a change in the way people of the same cultural groups used the resources available in different areas within the region.

4. This suggestion is a lesson generalized from similar biases now recognized in interpreting Paleoindian archaeology. The Western Pluvial Lakes Tradition is an example of the kind of bias that can be introduced into the interpretation of site

distribution in the absence of a more comprehensive understanding of sedimentation and erosion processes as well as behavioral practices that determine what parts of the landscape are most commonly used. Because most of the early artifacts known by the 1960s and 1970s were found on or near pluvial lakebeds, it was assumed that the people who left the artifacts were adapted to wetlands adjacent to pluvial lakes (Bedwell 1973). In fact, it now appears those people were using a wide variety of environments (Grayson 1993). Most of the published late Pleistocene-early Holocene evidence for people in the Great Basin is from where the early artifacts were readily found by archaeologists due to geological processes. Not finding middle Holocene-age sites where they are easily observable likewise may be responsible for the inference of middle Holocene abandonment of much of the Great Basin.

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