What's In A Name? Some Southern Paiute Names for Mojave Desert Springs as Keys to Environmental Perception

Catherine S. Fowler
Department of Anthropology
University of Nevada, Reno
csfowler@unr.nevada.edu

Abstract

The Southern Paiute people lived in several areas of the Mojave and adjacent deserts where knowing the location and dependability of water resources was a key to survival. In order to hunt, gather food, and travel in this region, they worked out an elaborate set of names for water sources, most of which were springs, and set up a vast trail network between them. The translated names of springs often provide ecological clues as to what resources were present, but are also reflective of Southern Paiute environmental perceptions. Names make the desert a storied place, peopled with animals, plants and other beings that bring it life and give it meaning.

Introduction

The indigenous peoples of the world have long histories of residence in and adaptations to deserts, including the Great Basin and Mojave deserts of western North America. At the time of Spanish exploration in the 1770s, people whom we now call "Paiute," or more properly, Southern Paiute, were among several groups resident in these deserts (Heizer 1978; d'Azevedo 1986). Over hundreds of years, if not considerably longer, they had come to know these areas with a degree of intimacy required when a place is your primary source of subsistence and shelter. For them, knowing the locations and dependability of water sources was a key to survival. To hunt, gather food and travel in the region, they worked out an elaborate set of names for water sources, most of which were springs, and set up a vast trail network between and among them. Their translated names of springs as well as other geographic points often provide ecological clues as to what resources were present there in the past, as well as what Southern Paiute people found important to name--a guide to their environmental perception.

But springs meant more than survival to Southern Paiute people. Springs and other water sources were also highly symbolic, sacred places, part of a living landscape, a storied place, peopled with animals, plants and other beings that brought it life and gave it meaning. Stories and songs that often include the names of springs and other places celebrate great hunts and other events that turn a desert into much more than simple geographic space. They create a landscape and a homeland that once gave, and in many ways still gives, people a strong sense of being and belonging – a sense of place. For Indian people, landscapes and homelands are often more important than events and time.

The data and discussions that follow focus on Las Vegas - Pahrump Southern Paiute place names for springs and other water sources as well as some of their contextualization in cultural aspects such as song and story. The data are heavily dependent on the extensive field studies in the early 1930s of anthropologist Isabel T. Kelly, as well as on some subsequent work in the area since the 1970s.[1] The purpose is to provide a preliminary account of aspects of Southern Paiute views of water sources and more general landscape perceptions in the Mojave Desert, but also to illustrate some of the cultural values inherent in these resources.

Place Names as a Field of Study

Anthropologists, and particularly ethnographers, or those who focus on living peoples rather than on the archaeological past, have long noted the importance of place names, or toponymy, in providing for people a sense of geography (Boas 1934). But place naming is a complicated linguistic and cultural act that must be analyzed from several perspectives. For example, it is well known that the grammars of languages set at least some parameters for naming, and thus affect both the structure and meaning of the resulting names. Given that most (but by no means all) place names are nouns, how easily does the language in question form new nouns, either based on verbs, on other nouns (e.g., noun compounds), or in some cases, on whole phrases? If the names are not nouns, but are more verbal in character, how does this affect their use and the resulting dynamics of discussions of places? Native American languages can do some amazing things in creating new nouns and verbs, and these linguistic devices definitely shape the character and outcome of naming (Boas 1934).

In addition, to more fully comprehend the meaning and significance of place names, it is important to focus on their function within cultural contexts. In his recent book *Wisdom Sits in Places: Landscape and Language Among the Western Apache*, Keith Basso (1996) eloquently pictures what it is like to be part of an active place naming system through which people maintain a deep attachment to place as part of maintaining their sense of self. In four stunning essays, Basso explores a Western Apache sense of landscape and place from multiple perspectives: how places and place names evoke stories of long ago events that gifted narrators can elaborate from the thread provided by the name; how shared knowledge of outcomes and morals of the stories can be triggered by the mere mention of a place name, and thus carry lessons to modern Apache people that can and do change their lives; and how the landscape in general, places in particular, and a sense of place overall, define self and society for Western Apache people. Basso maintains throughout how we all, in many ways we do not fully comprehend, are grounded in places, take lessons from places, and in many senses culturally create places by being “place makers.”

Although the Southern Paiute place name system is no longer active in the same way as Basso describes, largely because of native language loss in the past 20 to 30 years,[2] is it possible by using linguistic and other tools to reconstruct aspects of their past landscape perceptions through the study of place names? Are there any systematic principles of perceptions of places recoverable from these data, and beyond, are there any stories and lessons hidden in the names that are significant and can be of use to Southern Paiute people today? I think that the answer is yes to all three questions, and that there is yet additional value in attempting such in helping us all better understand and appreciate the broader values that landscapes and their resources hold. In other words, it makes us more aware of the cultural significance of places so that we, too, can be better “place makers.”

The Place Name Data

Through the years, ethnographers and linguists working in the Great Basin cultural region have recorded place names from several of the region’s groups, including the Owens Valley and Northern Paiute peoples (Kelly 1932; Fowler 1992; Steward 1933); Western, Northern, and Wind River Shoshone groups (Miller 1972; Shimkin 1947; Steward 1938); and Southern Paiute (including Chemehuevi) and Ute peoples (Kelly 1964; Sapir 1930-31; Laird 1976; Goss 1972; Givon 1979).[3] However, most field workers have gathered these data as adjuncts to general ethnographic work, and thus, although the place names are occasionally numerous, they are rarely the focus of specific analysis. In 1932 and 1933, Isabel Kelly undertook a project that was specifically ethnogeographical, or an attempt to look at a total ethnic landscape, and that was among 15 remnant Southern Paiute groups of Utah, Nevada, Arizona, and California (Kelly 1932-33; Map 1). But, unfortunately, Kelly was unable to synthesize and publish her materials before her death in 1982, and thus the data, including some 1,500 place names, remain in her field notes. Kelly also did more general ethnographic work among all of these groups, and her materials on other topics are equally voluminous.

Map 1. Southern Paiute Territory (after Kelly 1934). The principal groups in the Mojave Desert are primarily the Las Vegas (western half of territory is Pahrump subgroup) and Chemehuevi.

During her roughly 15 months in the field, Kelly traveled the length and breadth of Southern Paiute traditional territory, collecting the ethnogeographic and other ethnographic materials. She also made several large maps, although she rarely indicates what base or reference maps she was using.[4] Her field notes include lists of place names with her map references, but, unfortunately, often without larger meaningful contexts into which to place them. It appears from her notes that she was using the extensive place name data to develop a feeling for subsistence and settlement patterns, as well as travel and trail networks, but she does not discuss this. Her procedures for gathering the data also are not stated, although it appears that she traveled to at least some of the areas she mapped with her consultants. She also seems to have shown consultants what maps she had, and they discussed places and place names using these. In a few cases, her consultants actually drew the maps and noted the places for her.

Although Kelly's ethnographic field work in much of the region was pioneering, there had been some earlier work on the Southern Paiute language and place names by the well-known linguist Edward Sapir in 1910 (Sapir 1930-31). After working with young Carlisle Indian School student Tony Tillohash from Kaibab, Arizona, Sapir took specific note of some of the linguistic aspects that seemed to be represented in the place names of Tony's language, including the level of specificity achieved through various noun formation processes. Sapir (Mandelbaum 1958) says the following:

> In the vocabulary of this tribe we find adequate provision made for many topographical features that would in some cases seem almost too precise to be of practical value. Some of the topographical terms of this language that have been collected are: divide, ledge, sand flat, semicircular valley, circular valley or hollow, spot on level ground in mountains surrounded by ridges, plain valley surrounded by mountains, plain, desert, knoll, plateau, canyon without water, canyon with water, wash or gutter, gulch, slope of mountain or canyon wall receiving sunlight, shaded slope of mountain or canyon wall, rolling country intersected by several small ridges, and many others.
>
> Each of these very specific features, is expressed in two to three syllables in the Southern Paiute language. Some, such as the equivalent of "desert," "mountain," "plateau," or "knoll"

> should not surprise us as English speakers, as they are also relatively short in English. But others, such as "shaded slope of canyon wall," "rolling country intersected by several small ridges," "spot of level ground surrounded by ridges," require an entire phrase in English. In the Southern Paiute language, one can focus in on these types of places and name them in a very short, convenient expression–and add an adjective or some other descriptor to make them even more meaningful.

All of this, Sapir (Mandelbaum 1958) remarked, reflects the interest of the people in specific environmental features–"accurate reference to topography being a necessary thing to dwellers in an inhospitable semi-arid region; so purely practical a need as definitely locating a spring might well require reference to several features of topographic detail". Sapir felt that the people must have spoken and thought of such things often to have them so well codified in their language.

From the some 230 of place names Kelly collected for the Las Vegas - Pahrump territory, it appears that people named or at least could recall[5] the names for the following kinds of places: springs (both hot and cold water); tanks, washes, streams, and rivers; camps where water was sufficient for planting; camps where one could not plant; mountain peaks, ranges, saddles, and margins; knolls, hills, and plateaus; islands and parts of islands; some valleys, especially if they have a characteristic cover or feature; trails and parts of trails; and various sacred sites. Of these, names for springs and other water sources and also mountains are most numerous. There are 92 names for springs; 70 for mountains or mountain-related features; and the remainder are other geographic points.

Quite a number of the place names Kelly collected for this region, including the spring names, have suggested etymologies or partial etymologies, no doubt obtained directly from her consultants. Names derive from various sources: animals, plants, human body parts, spirits, and descriptive features of various kinds. Rarely if ever are personal names used in spring or other place naming, although Kelly did obtain detailed information on the ownership of springs and the residence of specific individuals at various sites (Kelly 1932-33).

Kelly's translations of the spring names do not bear out quite the level of specificity in naming noted by Sapir, but many are only partial at this point, and additional analysis will doubtless yield at least some of Sapir's results. A sample of the English translations of spring names (built primarily on the stems -paa, 'water;' -paatsipitsi, 'water comes out;' or -paatsi, 'water-diminuative [or small]' is as follows:

> From animals or animal referents: "Dog Water Comes Out," "Coyote Water Comes Out," "Coyote Nose Water Comes Out," "Badger Water Comes Out," "Rabbit Trail Water Comes Out"
>
> From plants: "Purple Willow Small Water," "Chia Water," "Willow Standing In a Row Water Comes Out," "Has Willows Water," "Apocynum Small Water," "Mesquite Water," "Cactus Drinking Place," "Underbrush Water," "Has Indian Ricegrass Water," "Has Serviceberry Water," "Rabbitbrush Water," "Brushy Water," several different cane (Phragmites) waters (including "Dry Arrowcane Water"), "Cottonwoods Surround It Water Comes Out," "Watergrass Water," "Arrowweed (Pluchea) Water," "Cattail Water Comes Out," "Tule Water Comes Out," and three or four for plants that are not identified thus far

From birds: "Eagle's Water," an unidentified "Waterbird Water," "Quail Water"

Human referents: "Boy Water Comes Out," "Mountain Spirit Water," "Navel Water" (a tank), "Water Baby Cries Water," "Shit Water;" and for various

Geographic referents: "Green River Water" (in the Grand Canyon), "Whitewater," "Mountain Water," "White Mountain Base Water," "Sand Boils Water," "Dampness on Grass Water," "Crying Water," "Rocky Place Water," "Lava Water," "Dirt Water," "Special Rocks Water," "Playground Water," "End of the Wash Water," "Other Side Water," "Summit Water," "On the End of Lava Water," "Round Hole In the Ground Water," "Sandstone Water," "Red Ochre Water," "Running Down Water," "Water on Rocks Water," "Water Cave Water," "Damp Rocks Water," "Rotten Water," "Water Mouth," "Hard Place Water," "End of Cliff Water," "Dark Saddle Water," "Yellow Water," and "Dripping Water."

A sample of etymologies for other types of place names includes: "Red Sandstone on the End" (a mountain base), "Spotted Lizard's Back" (a rock formation), "Black Serrated" (a mountain crest), "Frost Sits on the Ground" (a mountain valley), "Doctor's House" (a cave), "Willows Standing in a Line" (a stream bank), "Gypsum Sitting" (a mountain), "Cottonwoods Surround It" (a camp area), etc. There are several more I am still puzzling over, and will need help from fluent speakers to better extract meanings.

Locating these springs and other features on modern maps is not an easy task. Several students and I have been poring over quad sheets, and also earlier maps, for the past three years trying to match general locations given by Kelly with known spring and other sites. The Las Vegas Valley is particularly problematic, given massive development.[6] We have had some success, but obviously we could spend much more time. Visiting these locations to check for the resources or conditions described in the names will be another task. And the Kelly data for Las Vegas-Pahrump area represent only about 15 percent of the Kelly place names for the whole of Southern Paiute country.

Trails, Songs, and Stories

But beyond identifications and etymological analysis, which give at least some minimal feel for landscape perceptions and a sense of place for the Las Vegas-Pahrump Southern Paiute people, there are other data in the Kelly notes that are also significant for more environmental understanding. For example, Kelly made some attempt to map trails between and among springs and other water sources and places. All of these sites were linked in a vast network of trails and paths, some more direct than others. Although it is clear that Kelly did not try to follow many (if any) of these out, she says in her correspondence that in many cases she could "see" just about where they would go (I.T. Kelly to A.L. Kroeber, 1953). Some undoubtedly followed animal trails, or at least may have started that way, but others were probably established by people and perhaps later used by both. It might be possible, with additional work, to calculate the distances between some of the water sources covered by these trails, and thus establish more about the travel habits of the people. Others have noted the significance of the vast trail network from the Colorado River to the California Coast, often marked and well used by the Mojave, Southern Paiute, and other tribes in their traverses of the Mojave Desert (Davis 1961).

Some additional data in Kelly's notes and elsewhere likewise suggest that the people had deeper symbolic views of their lands, and that springs and other places are tied to these as well. For example, there are data concerning hunting songs and ancient mythic journeys, some of which contain place names, including spring names. Carobeth Laird (1976), in her rich volume on the Chemehuevis (a Southern Paiute offshoot) based on George Laird's narratives, speaks of the importance to them of certain hereditary songs in chartering a man's (and occasionally a woman's) rights to hunt certain animals in certain territories. Although George Laird could recall only small snippets of such songs that he had heard as a boy, he was aware that they contained many references to specific places, and actually charted journeys (and short-cuts) to these places for those entitled to the songs. He recalled that there were at least a Deer Song, a Mountain Sheep Song, a Salt Song, Quail Song, and Day Owl Song. The idea for such songs as well as some of their content is something shared with the Mojave people, but it is also quite thoroughly fixed for the Chemehuevi and the Las Vegas - Pahrump Southern Paiute groups in the Mojave Desert.

Although equally fragmentary in 1933 when Kelly was in the field, she was able to record the following part of a Deer Song from a Las Vegas narrator:

> In the deer song, the deer travels around Charleston range looking for food.The snow is deep and it goes from place to place. It starts way up on top of Charleston Peak; then it comes through the snow, finally out of the snow and down the valley. Comes through tsoariuway (Joshua Tree Valley), between Charleston Range and Tule Springs. They sing all this in a song; name every place he stops, everything that he eats (Kelly 1933).

Kelly then gives two samples of parts of the song, both of which name three places that the deer stops, two of which are springs. One singer, who sings until midnight, takes the deer around Charleston Peak and down about half way to the valley. A second singer, who starts after midnight, covers all the places the deer stops when it comes down the rest of the way and emerges from the snow into the valley. Kelly reports that an abbreviated version of this song was sung for dances and funerals, but that hunters who owned it sang the full version upon request by other hunters who were about to go out for game and needed the power [and perhaps geographic lesson] of the song.

Kelly (1933) adds that the Vegas Mountain Sheep Song starts from Coachella Mountain near Los Angeles, travels to San Bernardino Mountain, then to two other mountains for which she gives Southern Paiute names and ends at Charleston Mountain. And she adds, "They arrive here in the early morning; are maybe 200 different verses all told; lasts all night, until sunrise." All of this indicates that the proper singing must have been an exceedingly rich and informative experience, both in terms of the places named and visited as well as the foods for the deer: a virtual environmental inventory.

Briefly, two other sacred song cycles not related to hunting but often part of funeral observances and other gatherings were also rich in place names and communicate a sense of cultural landscape. These are the Salt Song and the Talk Song, both of which Kelly sketched out with Las Vegas consultants. Kelly (1933) writes:

> [The Salt Song] concerned the travels of two sisters (YarHk, wild goose and Avinankawatsi, (a small unidentified water bird). Lived at the mountain called Agai, between Searchlight and Fort Mohave [Newberry Mountain]. They sang en route as traveling along, naming everything they saw–mountains, springs, everything. Traveled to Ft. Mohave on the other side of the river. Crossed to the other shore at Ft. Mohave and came up the river on the east side, at a place called Mowavit. Crossed the Colorado at the junction of the Virgin; went up to the salt cave there and named it;

> from there came to Charleston Peak, then to Ash Meadows; then to the salt lake below the town of Shoshone called panHgH; went to Blythe, crossing the river once more. Came up the east side, arriving just before daylight at Kwinava. Went into these mountains in the morning; there is a large cave there, two in fact. They entered one of the caves, thereupon the tale ends.

And, a small piece of the Talk Song (Kelly 1933):

> This comes from the ocean, this song. In the mornings the ocean is covered with mist or steam rising. In the beginning white birds, large ones called parosabH are in the fog. The man stands in his dream and watches the birds. They come out on dry ground, flapping their wings. As the birds fly out they name a mountain (Ikanavanti) in Cahuilla country. As they fly over the mountain, the longest feather swept the top of the mountain. As the bird passed over the mountain he said, 'I am passing through a land of jimson weed.' But this is not so; there was only one plant there. The bird passed over OsapimagantH, and right on the plain where there are no rocks he seesa pita, eagle feathers tied together to make warrior's headgear. He sees this and picks it up. The bird is traveling east. He flies over a wash west of Natapiagant; he looks at his shadow below and sees that the shadow of his wings just reaches from one end of the wash to the other...

Unfortunately, Kelly did not have a tape recorder (were only wire recorders in those days), and thus she was only able to transcribe fragments of this long tale and song. But what she did get goes on to take the bird many more places, ultimately ending in Hopi Country, naming all the while. This song is at least some indication of the wider traveling habits of the Las Vegas-Pahrump people, and their knowledge of the areas outside their immediate traditional territories – well to the Pacific Ocean, up and down the Colorado River, and into Hopi Country in what is now northeastern Arizona.

The Salt Song and the Talk Song are primarily funeral songs, sung in conjunction with the Mourning Ceremony (Laird 1976), and thus within the realm of the sacred. But sacred times were also times for practical learning, when people could visualize these places and the ways to get to them, and what one would see and hear along the way. In many ways, the songs "fixed" people, living and deceased, to the country and in the country through their recitation. They mapped trails both on the ground from spring to spring, as well as "as the bird flies" in grand arcs and circles.

Although in the last examples of song cycles, springs have not been given by name, it is quite clear from Kelly's fragmentary notes, as well as from her maps, that they are a definite part of the oration. Thus, springs, and water in general, take on symbolic as well as life sustaining functions. Water itself is a sacred substance to Southern Paiute people, and it must always be approached as a living thing, which means prayerfully. It has its own spirit, and there may also be other specific spirits that live in springs and other water sources that need to be carefully considered. Some of these can be harmful to humans, and thus they, and their water homes, need to be approached with great caution and respect. Springs are viewed as interconnected, with water in many ways being like the blood of the earth, flowing in veins under the ground and emerging to the surface only occasionally. The Doctors and other men of power could often travel on these underground trails. Water was their mechanism, and the interconnection of springs their pathways. Water spirits can do the same, although the Old People used to say that they, like people, had preferred homes – certain springs that they preferred and where they stayed. People knew where these were and always approached these very cautiously and with the utmost respect.

Springs not inhabited by specific spirits were often owned by known persons. Southern Paiute people are somewhat unique in the literature on Great Basin peoples, and on hunters and gatherers in general, in their claims to spring ownership. Again, it was Isabel Kelly, based on her work in the 1930s, who first spoke of spring ownership, this time in published accounts on the Kaibab Southern Paiute people (Kelly 1964). Heads of families (men or women) could and did own springs, and passed these springs on to their children or other relatives. Kelly's published reports, as well as her unpublished field notes, contain lists of spring owners, sometimes traced back two to three generations (this was sometimes difficult, given that there are strict rules governing the use of the name of the dead, and people do not like to mention by name those who have passed on). But suffice it to say that in all likelihood many, if not all of the principal water sources (springs and tanks), except those known to be controlled by specific spirits, were owned by real persons. And this pattern well predated the arrival of Europeans. In the Las Vegas Valley, some of the bigger springs were also gardening sites, with Southern Paiute people having planted corn, beans, squash, amaranth, sunflowers, and a few other plants there for some time before the arrival of Europeans.

Conclusion

Thus, to return to What's In a Name. Can we gain a deeper sense of Southern Paiute views of springs and broader perceptions of landscapes from data such as place names and songs and stories? I think that with additional work, including more time on the ground locating some of these places that we can. Locating them on modern maps, something that is underway, is a first step. A second is finding out if any remnants of the songs are preserved in living memory, as it obviously is the songs and related tales that are the richest sources for tying the place names to real activities and a fuller sense of geography. Perhaps these plus good etymologies will replace something of the soul of these materials, giving all of us, but particularly the grandchildren and great grandchildren of the original place-makers, an enhanced view of their country. A number of young Southern Paiute people today are trying very hard to develop their own sense of place, reclaim their history, and continue their journeys in place-making. Perhaps these data from the distant past will help in part to serve that purpose for them. And for all the rest of us who frequent these water sources and observe their life-giving qualities for the many plants and animals that live within them or from them, perhaps we too can gain a new respect from this small part of the human history of these places. Pausing to think of their names and their interconnections back through time gives them additional meaning in a contemporary world.

Notes

1. Robert Van Kemper, Southern Methodist University, has kindly granted me access to the Kelly archive over the years. The Wenner-Gren Foundation for Anthropological Research has provided research support for additional field studies and for graduate students to help with the mapping. Additional thanks are extended to Laurie Walsh and Barbra Erickson for their conscientious attention to mapping details.
2. Most Southern Paiute communities today are facing significant language loss, as English becomes not only their first language but their only language. Several communities have instituted language programs in an attempt to counteract this trend, and these efforts will likely continue.
3. Each of these three clusters of languages constitutes a sub-branch of the Numic

branch of the Uto-Aztecan language family. Other Uto-Aztecan languages are spoken in southern California, Arizona, and Mexico.

4. There were a few U.S. Geological Survey (USGS) quad sheets available for this region but not many. Kelly apparently used some automobile maps, and also for the Mojave area, the map accompanying USGS Water Supply Paper No. 224, titled "Better Known Springs and Wells in the Mohave and Adjacent Deserts of Southeastern California and Southwestern Nevada," dated 1908.

5. These data come primarily from three individuals, two of whom were able to provide extensive lists of names and general locations. Had there been more individuals available, undoubtedly the lists would have been even more extensive. Hunn (1994) has suggested that for hunter-gatherer groups, a number near 500 is perhaps the norm.

6. Dr. Elizabeth Warren, Goodsprings, NV, who has done considerable research on the early water history of the Las Vegas Valley, has aided my search for these springs immeasurably.

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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

Stephanie D. Livingston
Archaeological Consultant
sdlivingston@cs.com

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.

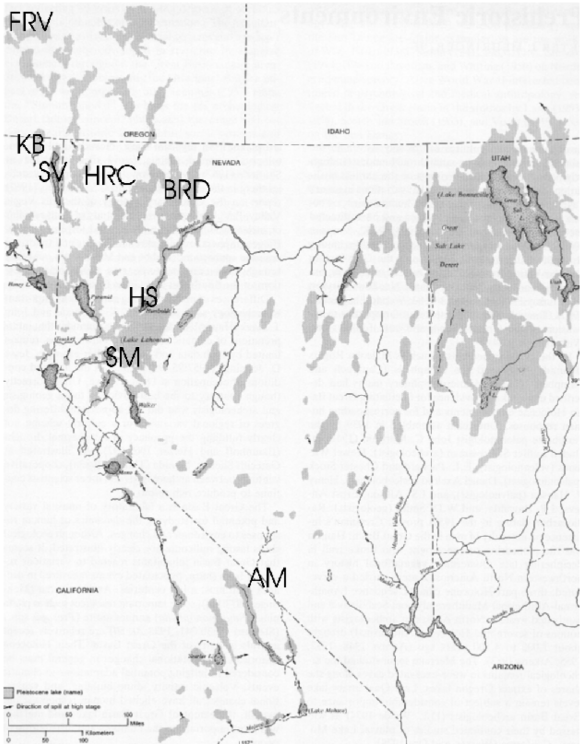

Figure 1. Selected archaeological localities discussed in the text: AM – Ash Meadows, BRD – Black Rock Desert, FRV – Fort Rock Valley, HRC – High Rock Country, HS – Humboldt Sink, KB – Klamath Basin, SM – Stillwater Marsh, SV – Surprise Valley.

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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9,500 Years of Burning Recorded in a High Desert Marsh

G. James West
University of California, Davis, Department of Anthropology, Davis, CA
and U.S. Bureau of Reclamation (retired), Sacramento, CA
gjwest@dcn.davis.ca.us

Kelly R. McGuire
Far Western Anthropological Research Group, Davis, CA
kelly@farwestern.com

Abstract

Natural and anthropogenic burning may be an important factor in desert marsh ecology. Ethnographic records indicate that Native Americans have burnt marsh vegetation to enhance subsistence and material resources. Here, the sediments, pollen, and age of marsh deposits located in Secret Valley, Lassen County, California are scrutinized for the temporal depth of such practices. A 1.8-meter-long core of peats, silts, and clays containing at least 22 burn layers provides a detailed environmental record. Radiocarbon age determinations and the presence of Mazama tephra indicate that the core covers a period of more than 9,500 calendar years. The pollen record demonstrates that marsh vegetation has been present throughout this time period. While the burn layers have destroyed portions of the pollen record, most burn layers are discrete and, as evident from the pollen, marsh vegetation, though not always with the same composition, rapidly re-established itself. Upland vegetation shows only minor change except for the historic period, which is marked by a decline in pine pollen and an increase in sagebrush pollen and dung fungal spores (*Sporormiella*). The dung fungal spores are associated with domestic animals introduced in the later half of the 19th century. Although it is impossible to absolutely attribute the marsh burning observed in the core to aboriginals, the frequency implies anthropogenic causes, short-term drought, or both. Recent archaeological excavations in Secret Valley reveal at least a 9,000-year history of human occupation, although intensive use of marsh resources is perhaps a more recent phenomenon, dating to the last 2,000 to 3,000 years.

Introduction

Marshes are few and far between in the desert west and as a result were important resource areas for prehistoric gatherers and hunters. Marsh vegetation provided both food and fiber; animals and insects that dwell in or visit marsh habitats provided much needed protein and other materials. Ethnograhically, it is well known that Native Americans of the desert west intensely utilized marsh resources and even may have managed or altered them to enhance the exploitation of these resources (Driver 1937; Fowler 1992). To examine this relationship the results of pollen and sediment analysis of a small marsh in Secret Valley, Lassen County, California, located on the western edge of the Great Basin northeast of Susanville, California (Figure 1) are presented.

Evidence of human occupation in Secret Valley spans the Holocene period (10,000 to 0 years B.P. [before present]). Chronological and assemblage data suggest a gradual increase in the intensity of prehistoric occupation beginning at 5,000 B.P., and the subsequent appearance of larger, more complex settlements by about 3,000 years ago. The latter date marks a period of cultural complexity evidenced by increased numbers of house structures, midden deposits, hearths, ovens, burials, and rich accumulations of artifacts and subsistence remains. Most of these village-like settlements are located proximal to Secret Creek and its associated bottom lands. Dietary remains recovered from these sites

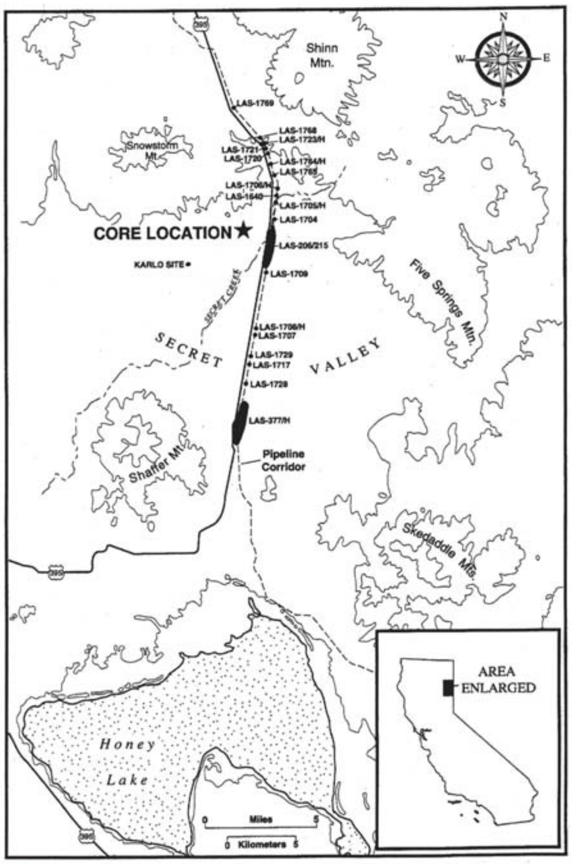

Figure 1. Secret Valley study area with core location. Archeological sites are noted along the Tuscarora pipeline corridor.

indicate a strong, long-term subsistence focus on marsh resources. This cultural pattern appears to have ended by 1,000 B.P.; house structures and well-developed midden deposits virtually disappear from the local archeological record. Sites post-dating this period are comprised of more ephemeral ground stone and rock concentrations and hearths accompanied by only limited debris scatters and/or midden pockets. These changes in settlement structure are thought, in part, to reflect shifts in land use associated with the late prehistoric arrival of Numic-speaking groups. Plant and animal remains recovered from these late-dating sites, however, still indicate use of local marsh resources (McGuire 1997).

Location and Description of Study Site

Three cores were recovered from a marsh located at the north end of Secret Valley about 1 km west of Highway 395 (40E34' 30", 120E15' 45"; 1,359 m [4,460 ft] elevation). The marsh is fed by springs coming out of the lower edge of Snowstorm Mountain. Water from the springs spreads out along flat ground forming a marsh before spilling into Secret Creek. Lava ridges, undulating volcanic plateaus, course lava flows, shallow alluvial-filled canyons, and pluvial lake beds make up the local landscape. The climate is Continental desert, characterized by cold, harsh winters and dry summers. Mean annual precipitation is between 15 and 25 cm and snow is not uncommon. Annual evaporation is more than 125 cm per year (Donley *et al.* 1979).

The marsh vegetation is characterized by typical aquatic-emergent plants: tules (*Scirpus* spp.), cattails (*Typha latifolia* L.), sedges (*Carex* spp.), rushes (*Juncus* sp.), grasses (primarily salt grass [*Distichlis spicata* Var. *Stricta* Torr.] and a large bunch grass [cf. dropseed *Sporobolus* sp.]), and an occasional yellow pond-lily (*Nuphar polysepalum* Engelm.). Surrounding vegetation is a sagebrush steppe (*Artemisia tridentata* Nutt., *A. arbuscula* Nutt.). In the more saline areas, greasewood (*Sarcobatus vermiculatus* [Hook.] Torr.) and saltbush (*Atriplex* spp., a Chenopodiaceae) shrubs are common. Rabbitbrush (*Chrysothamnus* sp.) and horsebrush (*Tetradymia spinosa* H. & A.) are seral dominants in disturbed areas. The introduced plants, star thistle (*Centaurea* sp.) and sheep sorrel (*Rumex acetosella* L.), were noted in the more disturbed areas. On the sandy soils Indian rice grass (*Oryzopis* sp.) was observed. A few junipers (*Juniperus occidentalis* Hook.) are scattered on the surrounding rocky hill slope, while pine (*Pinus* spp.) and fir (*Abies* spp.) are visible some 40 km to the west on the eastern edge of the Sierra Nevada.

The spring area and surrounding vegetation receive heavy grazing pressure (Figure 2). Cattle were present in and around the marsh when the cores were collected and they have enhanced the organic content of the marsh significantly.

Figure 2. View of Secret Valley Marsh looking southeastward.

Methods

Sampling of the marsh was done with a 2-inch (5.08-cm) diameter piston corer for the upper levels down to 125 cm. Below 125 cm, a 1-inch (2.54-cm) diameter, thin-walled Daknowsky-type sampler was used to penetrate the denser-harder sediments. The three cores recovered were designated: SV-1, SV-2, and SV-3. Core SV-3 was used for pollen analysis. Equal-sized samples of 2.5 cc were taken at stratigraphic and arbitrary intervals.

Standard palynological techniques were used to process the samples. Four tablets with exotic *Lycopodium* spores (Batch # 414831) were added to each sample to monitor processing and pollen concentration values (Stockmarr 1971). A Nikon Labophot microscope with phase contrast was used to scan and count the pollen grains. Pollen identifications are based on herbarium specimens obtained from the Jepson Herbarium, University of California, Berkeley and the Tucker Herbarium, University of California, Davis, as well as standard texts. In most instances pollen counts were made either to 200 grains (excluding Aquatic-Emergent types) or until 200 *Lycopodium* spores had been counted. The pollen diagram was drawn using TILIA (Grimm n.d.). Vials of the remaining processed samples are stored at the Department of Anthropology, University of California, Davis.

Studies were done of the magnetic properties of cores SV-1 and SV-2 by Ken Verosub, University of California, Davis. Continuous samples of sediment, from the top down to about 1.2 m were examined. The samples were measured at 1-cm intervals with an automated, high-resolution, long-core cryogenic magnetometer.

Pollen Data

Of the 53 samples processed, 39 contained pollen in sufficient abundance that statistically accurate counts could be made. The remaining 14 samples had no pollen present or less than 5 grains per slide. These samples came from burn layers described below. All samples contained microscopic-size charcoal. Forty-nine different pollen types were recognized: 12 arboreal forms, 26 nonarboreal, and 11 aquatic-emergent types (West 1997). Aquatic-emergent taxa dominated the counts and were excluded from the pollen sum for the determination of relative percentages. Identified grains from alien taxa included russian thistle (*Salsola*), *Centaurea, Rumex acetosella*, a single grain of *Eucalyptus* pollen. Relative values of the major pollen types are presented in Figure 3.

Other Palynomorphs

Davis (1987) has pointed out the significance of spores of dung fungus in historic and Pleistocene-age sediments in California. *Sporormiella* species are common on the dung of domestic herbivores such as cattle and horses and on the dung of deer and elk. Their presence in quantity can be equated with the historic period; by the 1880s, large numbers of domestic cattle and sheep were present in Lassen County and *Sporormiella* spores are the fossil evidence of this land-use change.

Sediments

The sedimentary record is complex, with numerous (ca. 22) burn layers represented by grayish-white ash interspersed between organic muds (Table 1). Reworking of some ash layers is evident while other layers suggest deposition in water. Under the microscope, the ash was characterized by finely divided opaque particles and small bits of charcoal; larger bits of charcoal also were encountered in several layers. More detailed descriptions of the sediments are provided in West (1997).

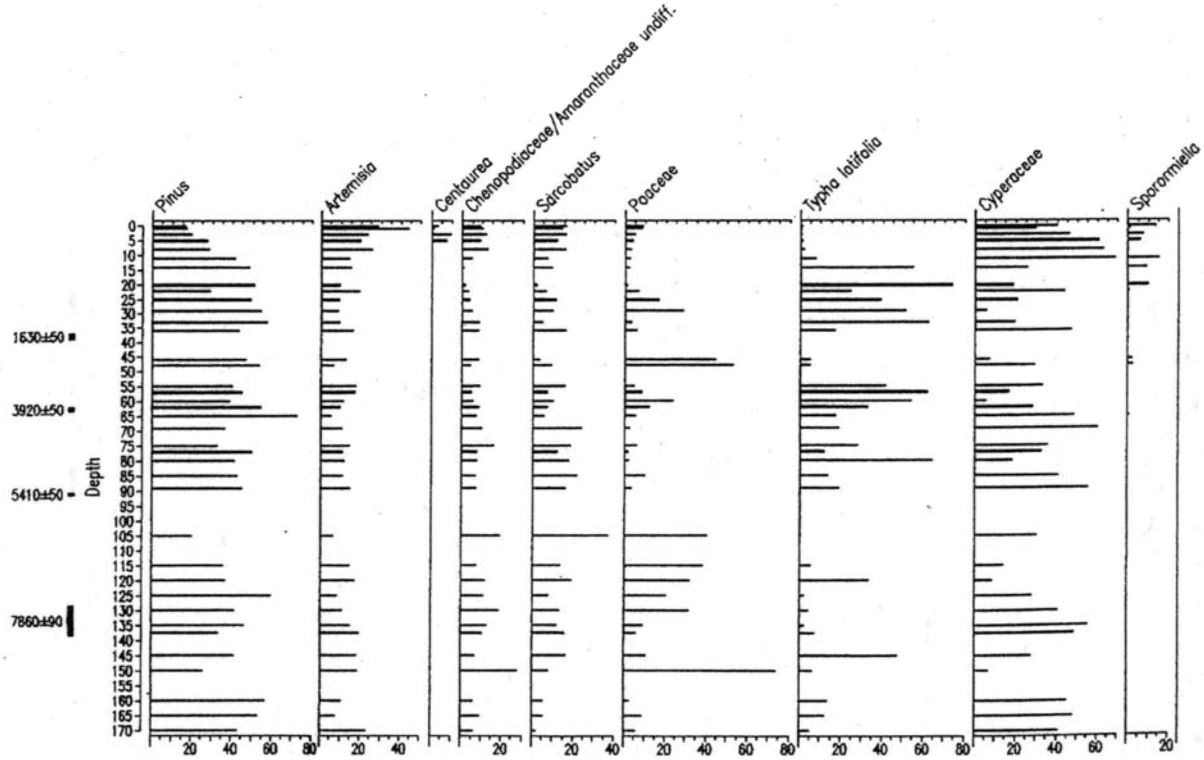

Figure 3. Relative values of major pollen types and *Sporormiella* spores. Aquatic-emergent taxa and Poaceae are excluded from the pollen sum for determining percentages. Depth is in centimeters.

Volcanic Ash (Tephra)

At least one tephra layer is present in the core at approximately 94 to 100 cm. Based on radiocarbon dates above and below the tephra layer, the ash is considered to be one of the Mazama tephras from Crater Lake, Oregon (age of the Mazama tephra is ca. 6,700 B.P.). Tephra exposed in the cut-bank of Secret Creek arroyo on the eastern margins of the marsh has been chemically identified as the Tsoyawata bed (Davis 1978) of the Mazama tephra (D. Craig Young, Geoarcheologist, Far Western Anthropological Research Group, Davis, CA, pers. comm.). The depositional context suggests that the tephra exposed in the core section is the same as the Tsoyawata bed identified in the cut-bank of Secret Creek arroyo. Other tephras may be present but were not distinct enough to be characterized.

Magnetic Properties (Cores SV-1 and SV-2)

Several magnetic parameters indicate higher concentrations of magnetite or maghemite in the upper 20 cm and lowest 20 cm of the composite section (K. Verosub, pers. comm.).

Chronologic Determinations

Four samples have returned radiocarbon age determinations (Table 2). The dates obtained from ash are composite for the sedimentary unit and do not provide the date of ignition.

Discussion

The data provide evidence for outlining the history of the marsh, and of the local and, possibly, regional vegetation. The radiocarbon determinations indicate that the sediments span most of the Holocene. Below about 20 cm, sedimentation rates are lineal and low, each 10 cm representing about 500 years. Projecting the smoothed rate to the base of the core gives an age of 9,500 to 10,000 years B.P.

Table 1. Core log of SV-3, Secret Valley, California.

Depth (cm)	Color	Description
Drive 1		
0 to 12	2.5Y4/2 *	Fibrous mud
12 to 16.5	2.5R3 *	Fibrous mud
16.5 to 19	2.5Y5/4 *	Burn layer ash (gray, dry)
19 to 26	2.5YR3*	Mud, organic
26 to 28.5	2.5Y4/2*	Burn layer ash (gray, dry)
28.5 to 31.5	2.5Y3/2*	Mud, organic
31.5 to 33	2.5Y4/2*	Burn layer ash (gray, dry)
33 to 39	2.5Y4/2*	Burn layer ash (^{14}C 37 to 39 cm ash, gray dry; 1,630 ± 50 B.P.)
Drive 2		
39 to 42.5	2.5Y4/4*	Burn layer ash (gray, dry)
42.5 to 49	2.5YR3*	Mud, organic
49 to 52	2.5Y3/2*	Silt/ash (gray, dry)
52 to 58	2.5YR3*	Mud, organic
58 to 59.5	2.5Y4/2*	Ash/silt (gray, dry)
59.5 to 60.5	2.5YR3*	Mud, organic
60.5 to 61.5	2.5Y4/2*	Burn layer ash, (gray, dry)
61.5 to 63.5	2.5YR3*	Mud, organic (^{14}C 62 to 63.5 cm, ash, gray, dry; 3,920 ±50 B.P.)
63.5 to 64	2.5Y3/2*	Mud, organic
64 to 72	2.5YR3*	Mud, organic (64 to 65 cm, ash, gray, dry)
72 to 72.5	2.5Y4/2*	Clay/ash (gray, dry)
72.5 to 73	2.5YR3*	Mud, organic
73 to 74	2.5Y4/2*	Clay/ash (gray, dry)
74 to 78	2.5YR3*	Mud, organic
Drive 3		
78 to 80	2.5YR3/2*	Ash (gray, dry)
80 to 91	2.5YR3*	Mud (fine laminations of ash); (ash, gray, dry 86 to 87 cm); (^{14}C 90.5 to 91.5 cm, ash, gray, dry; 5,410 ± 50 B.P.)
91 to 92	2.5Y4/2*	Ash (gray, dry)
92 to 94	2.5YR3/2*	Mud/ash/tephra (gray, dry)
94 to 97	2.5Y5/2*	Silty clay (Tephra, Mazama?)
97 to 100	2.5Y4/4*	Silt ash/tephra (Tephra, Mazama?)
100 to 109	2.5Y3/2*	Mud (ash 103 to 104 cm; 106 to 109 cm, gray, dry)
109 to 127	2.5YR3*	Mud (ash: 120 cm, gray, dry)
127 to 128	2.5YR4*	Silty clay (ash, gray, dry)
Drive 4		
128 to 147	2.5Y4/2*	Mud (ash 133 to 135 cm, dry) ^{14}C 128.5 to 138.5 cm, 7,860 ± 90 B.P.
147 to 153	2.5Y5/2*	Mud (ash/charcoal/mud ca. 149 to 150 cm, dry)
153 to 158	2.5Y3/2*	Mud (ash ca. 155 cm, dry)
Drive 5		
158 to 164	2.5Y3/2*	Mud
164 to 170	2.5Y4/2*	Clay

*moist

Table 2. Radiocarbon determinations from Core SV-3, Secret Valley, CA.

Depth (cm)	Material	^{14}C age B.P.	Calibrated age	Sample number
37 to 39	Ash	1,630 ∀ 50	A.D. 340 to 555	Beta 103232 (AMS)
62 to 63.5	Ash	3,920 ∀ 50	2,555 to 2,535 B.C. and 2,495 to 2,270 B.C.	Beta 103233 (AMS)
90.5 to 91.5	Ash	5,410 ∀ 50	4,350 to 4,140 B.C.	Beta 103234 (AMS)
128.5 to 138.5	Organic mud and ash	7,860 ∀ 90	7,015 to 6,460 B.C.	Beta 101270 (Standard, extended count)

Most striking is the presence of 22 ash layers (Figures 4 and 5). Similar ash layers have been observed by the senior author in cores from peat in the Sacramento-San Joaquin Delta (Delta). Peat fires in the Delta are reported in the historic record (Anonymous 1859; Sutter 1939) and continue to be a concern today (Cosby 1941; Weir 1950). Such fires have been described as being extremely difficult to extinguish once started since they often extend below the surface.

Figure 4. Photograph of Core 3 showing stratigraphy with ash layers.

Figure 5. Close-up of ash layers in Core 3, Drive 2.

It is well known that Native Americans burned vegetation, including marsh vegetation, for a number of reasons mainly related to subsistence practices (Burcham 1959; Wallace 1996). Edwin Beale (Bonsal 1912) noted that the Indians occupying the shores of Tulare Lake in the San Joaquin Valley frequently burned the tules to drive out game. There is evidence that the protein content of some wetland plant species increases following fire and herbivory is greater in burned marshes (Mallik and Wein 1986; Smith and Kadlec 1985). The intense prehistoric settlement around and utilization of the Secret Valley marsh resources imply that at least some of the burning observed in the sediments may be related to anthropogenic fires used to enhance the exploitation of marsh resources.

Burning episodes may have been a late fall or winter phenomena. In recent examples of marsh burning on the shores of Mono Lake, fires could only be maintained during the late fall and winter when the vegetation was dry (James Berry, State Park Ecologist, California Department of Parks and Recreation, Sacramento, CA, pers. comm.). The Mono marshes would not sustain fires during their growing season, a time they would be most susceptible to ignition from naturally caused upland fires. However, the effects of drought or seasonal climate shifts different than modern may alter this relationship.

In addition to the ash layers, charcoal is present in all the samples processed, suggesting the possibility of lower-intensity surface burns or upland fires. It cannot be readily determined if some of the charcoal is derived from fires beyond the marsh, but it would seem to be a reasonable assumption that at least some of the charcoal is from outside sources. Also, some of the ash layers may be representative of fires that started outside of the marsh. While relatively fire-resistant, pristine sagebrush/bunch grass communities were not fireproof (Young *et al*. 1977).

Young *et al*. (1977) concluded that burning of the sagebrush communities probably enhanced perennial grasses since burning made nutrients from the litter available for competing herbaceous vegetation. The defoliation of large expanses of sagebrush by the native moth, *Aroga websterii*, may have led to enhanced opportunities for fire since the accumulation of insect webs and dead leaves would have greatly increased the flammability of sagebrush communities (Young *et al*. 1977). Several abrupt, and apparently short-term, increases of grass pollen (Poaceae) associated with burn layers may be indicative of fires that included the sagebrush community.

The pollen record is discontinuous because of the burning, which destroyed the pollen grains. Nonetheless, with the exception of the burn layers, pollen is preserved throughout the section. While major changes in the pollen frequencies of prehistoric upland vegetation are not evident, changes in pollen frequency do occur and do provide important insights into the evolution of local and regional plant communities. After each burn, the pollen record indicates that marsh vegetation was quickly re-established, although the marsh plant communities changed as a result of such disturbances. The resolution varies, but in the early part of the record the marsh was dominated by Cyperaceae species, most likely tules. Cattails and members of the Apiaceae (carrot) family (cf. *Sium suave* Walt., water-parsnip) were present. This association was short lived and replaced by a community dominated by cattails and grasses. (However, not all the grass pollen grains were necessarily derived from species associated with the marsh.) Tules were present but much reduced in importance. Change occurred again: cattails declined in importance and grasses, tules, and members of the carrot family all increased. This community was similar to the earliest marsh but grass was a far more important component. Such dominance changes between grass, cattail, and tule occur throughout the record.

The inability to clarify which grass species are contributing to the pollen rain makes it difficult to determine whether the changes in grass pollen frequencies represent the marsh environment or more local upland vegetation change or both. If the higher grass pollen frequencies observed in pre-Mazama times are from upland species it implies that grasses, possibly perennial taxa, were more abundant. However, if the majority of grass pollen grains in pre-Mazama times are from species associated with the marsh, such as salt grass or arroweed (*Phragmites* sp.), it implies lower water levels and possibly drier conditions (grass pollen frequencies increase while those of emergent taxa decrease). Changes in the pollen frequencies of other pollen taxa, such as *Sarcobatus* and other chenopods, tend to support the latter interpretation.

There appears to be an inverse relationship between cattails, on one hand, and tules, greasewood and Chenopodiaceae/Amaranthaceae pollen values on the other. Tules and most other sedges have the ability to grow in fairly saline waters. Greasewood and many of the chenopods occupy alkali habitats. Cattails, except for those ecotypes growing along the California coastline, are relatively less salt tolerant than these other emergent/high groundwater taxa. While this inverse relationship may be due to seral competition between the taxa, the ultimate cause may be water quality (Stephenson *et al*. 1980). Water quality changes, in turn, may be related to spring flow as a result of climatic conditions or tectonic movement. Active faults are known for the region (Donley *et al*. 1979). While it is not possible with the data at hand to control for tectonic activity, no significant faulting was observed for the spring area. Subaerial tephra also may have influenced successional trajectories by altering soil and water chemistry, but measuring the impact of such change is problematic with the data at hand. The post-

Mazama sediments pollen spectra are different from the pre-Mazama, but it is uncertain if this change is the result of the ash fall, which affected climate and/or vegetation, or merely co-occurred at the same time as a climatic shift. Nonetheless, the increase in cattails appears to signal fresher water conditions and is likely the result of increased spring flow as the result of an increase in precipitation. If this relationship is correct, periods of more effective moisture occurred in the last 5,000 years, most markedly around 3,000 to 4,000 yrs B.P., and the last 1,500 years. The decline in cattails in historic times may be the result of selective grazing and associated water quality degradation and not due to changes in effective moisture. Prior to 5,000 years ago there may have been a couple of periods of increased moisture, but these were short-lived and the marsh was generally more alkaline, with lower water levels prior to 5,000 yr B.P. However, because of the gaps in the pollen record as the result of burning, the establishment of accurate time constraints for climatic interpretations is not possible.

For comparison, at nearby Eagle Lake, Davis and Pippin (1979) report markedly higher water levels from ca. 2,200 to 3,200 years ago, which falls within the period of more effective moisture observed for Diamond Pond, Oregon (ca. 2,000 to 3,800 years ago) (Mehringer 1986). Water level at Eagle Lake then receded after 2,000 years B.P., then rose again to between 1,095 ± 100 and 1,515 ± 100 years B.P. The lake then stayed at this elevation until historic water diversions to Honey Lake occurred. While precise chronologic comparisons with these and other northwestern Great Basin-Modoc Plateau paleoenvironmental localities are precluded, the trends appear somewhat consistent with one another.

The most significant change observed in the pollen values of upland taxa is the decrease in pine and increase in sagebrush in the most recent part of the record. This co-occurs with the presence and increase in dung fungal spores and the presence of pollen grains from alien taxa. These relative shifts may indicate an actual increase in sagebrush, as the result of selective grazing by domestic livestock, and a decrease in pine because of historic logging. The selective grazing explanation is consistent with the effects of the introduction of domestic livestock on succession in the sagebrush steppe described by Young *et al*. (1975, 1977).

The higher concentrations of magnetite or maghemite in the upper 20 cm coincide with the historic-age changes in the pollen spectra and may reflect increased erosion of magnetic grains due to changes in land use. The higher concentrations at the base of the composite section may simply be due to the decrease in magnetic detritus that accompanied the change from a late glacial to a Holocene climate (K. Verosub, pers. comm.).

The other change in pollen from upland taxa is an increase in TCT (Taxaceae, Cupressaceae, and Taxodium) (Adam 1967), undoubtedly derived from juniper in post-Mazama times, co-occurring with a slight increase in fir pollen. These changes may signal the shift to modern climatic conditions over the last 3,000 to 4,000 years. Similar fluctuations in juniper have been described by Mehringer and Wigand (1990) for the northwestern Great Basin and the Intermountain Northwest and the shift to modern climate that has been observed in the pollen record from Little Willow Lake, Lassen Volcanic National Park, and other localities in the Sierra Nevada (West 2004).

Conclusions

While the ascription of ignition is circumstantial, the data indicate:

1. A dynamic marsh, as represented by the pollen of aquatic-emergent plants, has been present at the core site for some 9,500 years. The stratigraphically consistent radiocarbon age determinations indicate that the marsh has been present continuously for this time period. During this same time frame, the surrounding vegetation has been a sagebrush community, with junipers becoming more prominent in post-Mazama times.
2. Marsh vegetation and organic sediments have been repeatedly burnt, forming distinct ash layers. After each fire the marsh vegetation quickly re-established itself but not always with the same species being dominant. These changes are undoubtedly

due to varying factors, but fire certainly played a role. There is a possibility that at least some of the fires extended beyond the marsh into the surrounding sagebrush community. The intense settlement and utilization of the marsh imply that some burn layers might be anthropogenic, but the effects of drought-induced natural fires cannot be excluded as a possible cause.

3. At least one volcanic tephra is present. The presence of Mazama ash recognized in the Secret Creek sediments and the time constraints provided by the radiocarbon age determinations suggest that the tephra at 94 to 100 cm is Mazama. The role of Mazama ash in altering the environment is unclear; however, pollen-frequency changes are associated with the ash layer.
4. The fluctuations in the dominance of various aquatic-emergent taxa suggest that changes in water quality have occurred and such changes may be related to variations in effective moisture. Keeping in mind the gaps in the pollen record, two periods within the last 5,000 years appear to have increased effective moisture: 3,000 to 4,000 years ago and the last 1,500 years. Prior to 5,000 years ago, there may have been two very short periods of higher effective moisture similar to those observed within the last 5,000 years.
5. The decline in pine pollen values and corresponding increase in sagebrush values occurring with increased dung fungal spores imply a historic age decline in upland pines and increase in sagebrush. The higher concentration of magnetite or maghemite may indicate increased erosion in the historic period. These changes may be related to logging and the introduction of domesticated livestock.

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