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

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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 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).

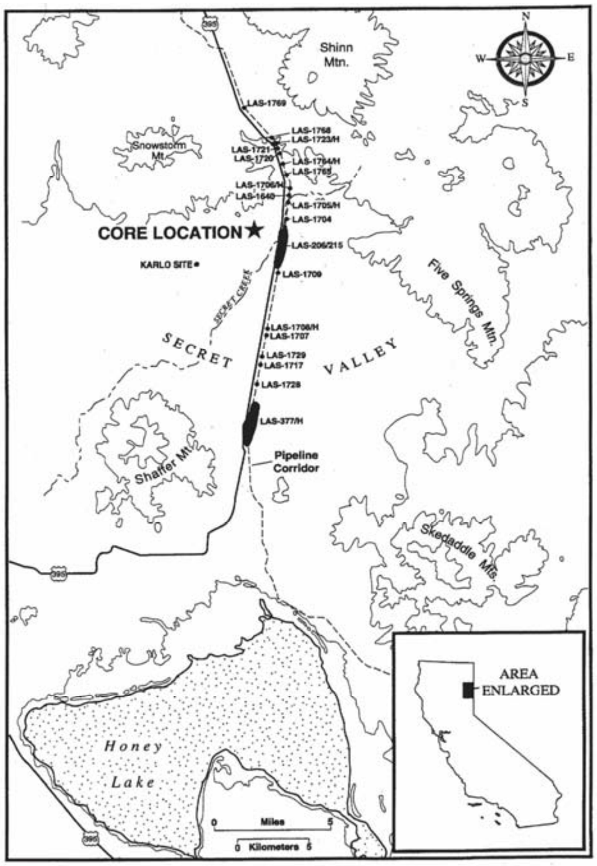

Figure 1. Secret Valley study area with core location. Archeological sites are noted along the Tuscarora pipeline corridor.

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 (40˚34' 30", 120˚15' 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).

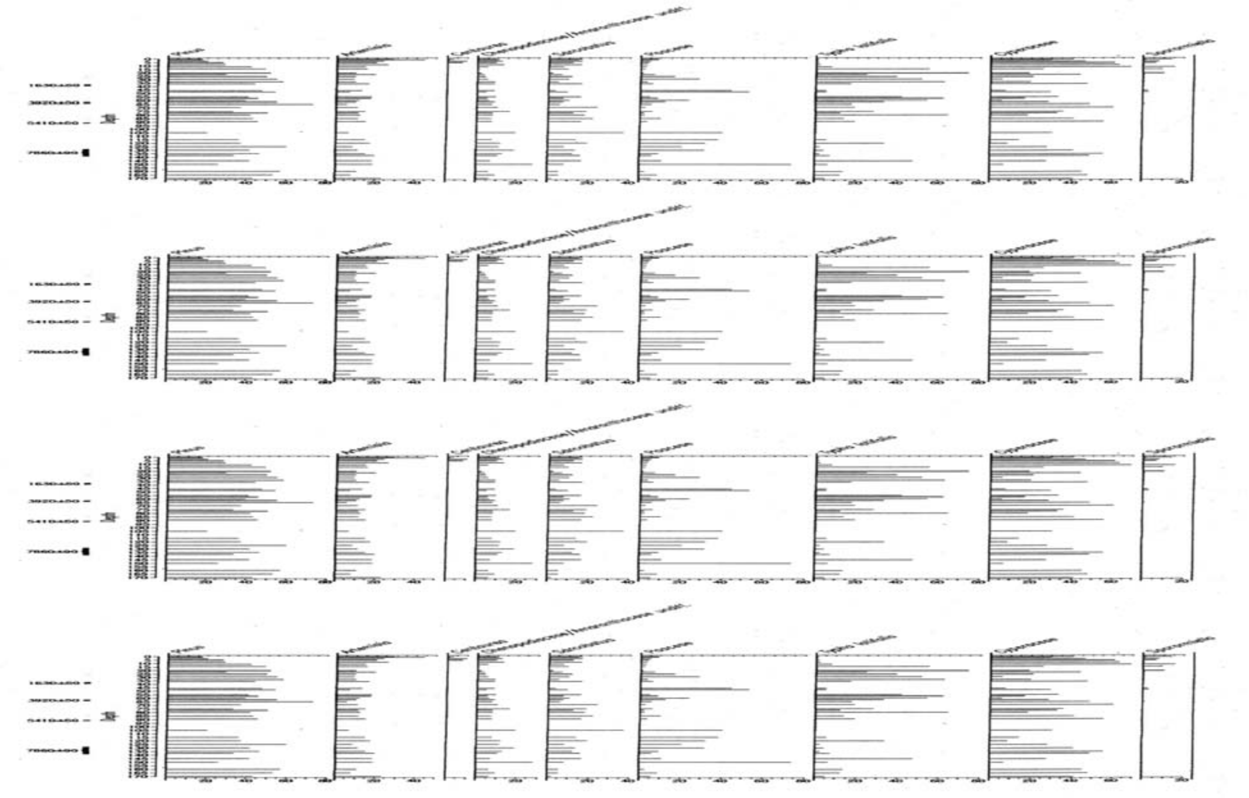

Figure 3. Relative values of major pollen types and *Sporormiella* spores. Aquatic-emergent taxa and Poaceae are excluded from the pollen sum for determining percentages. Depth is in centimeters.

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 cooccurred 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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