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DISTRIBUTION OF SITES AND RADIOCARBON DATES IN THE SIERRA NEVADA: IMPLICATIONS FOR PALEOECOLOGICAL PROSPECTING

R. SCOTT ANDERSON,[1,2] SUSAN J. SMITH[2] and PETER A. KOEHLER[3]

ABSTRACT. The number of paleoecological records for the Sierra Nevada of California has increased substantially since the compilation of Adam (1985). We examine here the geographical and temporal distribution of records within the range in order to identify areas for which "gaps" exist in our paleoecological knowledge. Seventy-two sites with paleoecological information are identified; these sites are dated with 234 radiocarbon dates. Sites occur primarily between *ca.* 36°N and 38°30′N latitudes, and from *ca.* 1000 m to over 3000 m elevation on both sides of the Sierran crest, although more sites have been analyzed on the west side of the crest than the east side. In general, packrat *(Neotoma)* midden series are located at the lowest elevations, meadow and marsh cores originate from mid-elevations, and lake sediments have been analyzed from the highest elevations. Significant gaps in our knowledge occur for much of the east side of the crest, for both sides of the range above modern treeline, and for time periods older than the latest Pleistocene.

INTRODUCTION

Analysis of pollen and plant macrofossils from sedimentary deposits has become an essential tool for the paleoecologist. Beginning in the mid-20th century, the number of sites from eastern North America increased rapidly and they presently number in the hundreds. A similar increase for western North America did not begin until after 1970 (Baker 1983; Barnosky, Anderson and Bartlein 1987), due, in part, to a perceived lack of suitable sites. An increase in the number of researchers examining sediments from high-elevation lakes and meadows, as well as the development of packrat *(Neotoma)* midden analysis from lower elevations (Betancourt, Van Devender and Martin 1990) has revolutionized our understanding of vegetation change within the more arid regions of western North America.

California is one region in western North America that witnessed little paleoecological research until recently. Adam (1985), which listed and annotated both published and unpublished studies for several regions of the state, was important in identifying "gaps" in our paleoecological knowledge, allowing investigators to provide research bridges between sites and to increase our understanding of paleoenvironments of the past. Here we concentrate on the Sierra Nevada range of California, summarizing and analyzing the recent explosion of information for that region. Our purpose is to identify the location and types of sites that have been most productive paleoecologically, as a logical step in paleoecological "prospecting", to identify possible locations for additional study.

DESCRIPTIVE BACKGROUND

The Sierra Nevada

The Sierra Nevada range, oriented with its major axis northwest to southeast, is located almost entirely within eastern California. The range extends almost 575 km from near Mt. Lassen in the north to Walker Pass in the south, with widths varying from *ca.* 100–125 km. The gentle slopes of 2–6% on the west side contrast with slopes of almost 26% on the east side near Owens Valley (Storer and Usinger 1963).

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[1] Center for Environmental Sciences and Education, Box 5694, Northern Arizona University, Flagstaff, Arizona 86011 USA
[2] Quaternary Studies Program, Bilby Research Center, Box 6013, Northern Arizona University, Flagstaff, Arizona 86011 USA
[3] Present Address: P.O. Box 861, Flagstaff, Arizona 86002 USA

The climate of the Sierra Nevada is Mediterranean, with hot, arid summers and cool, humid winters (Mitchell 1976; Major 1988). Topographic relief and range orientation affects the distribution of temperature and precipitation. Air masses moving from west to east lose moisture as they are forced over the high elevations of the range, causing large precipitation differences between the west and east sides. For a given elevation, precipitation averages nearly twice as much on the west side as on the east (Major 1988).

The Sierra Nevada is today a significant biogeographic boundary, separating the vegetation of the Great Basin from that of the more diverse cismontane Californian Province. Anderson (1990) summarizes the vegetation of the central Sierra Nevada. On the west side a blue oak (*Quercus douglassi*) and gray pine (*Pinus sabiniana*) woodland occurs above a grass-dominated prairie zone (to *ca.* 700–915 m elevation). The chaparral association, including buckbrush (*Ceanothus* spp.), manzanita (*Arctostaphylos* spp.), mountain mahogany (*Cercocarpus* spp.) and chamise (*Adenostema fasciculatum*), occurs between *ca.* 915 and 1225 m. The Sierra montane forest (*ca.* 1200–2200 m) is dominated by ponderosa pine (*Pinus ponderosa*), incense cedar (*Calocedrus decurrens*), black oak (*Q. kelloggii),* sugar pine (*P. lambertiana*), and white fir (*Abies concolor*). Common trees in the upper montane forest (to *ca.* 2200–2750 m) include lodgepole pine (*P. contorta* var. *murrayana*), red fir (*A. magnifica*), sugar pine, western white pine (*P. monticola*), and Sierra juniper (*Juniperus occidentalis* ssp. *australis*). The subalpine forest (to *ca.* 2570–3200 m) consists of lodgepole pine with mountain hemlock (*Tsuga mertensiana*), western white pine and whitebark pine (*P. albicaulis*), with Sierra juniper on exposed locations. On the east side of the crest, limber pine (*P. flexilis*) replaces whitebark pine. The alpine zone is dominated by herbs and subshrubs.

On the east side of the crest, below the subalpine and upper montane zones described above, a Jeffrey pine (*Pinus jeffreyi*) woodland is found, often grading at lower elevation into a western juniper (*Juniperus occidentalis* ssp. *occidentalis*) and pinyon pine (*P. monophylla*) assemblage with sagebrush (*Artemisia tridentata*). Shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and joint-fir (*Ephedra* spp.) are found in valley bottoms.

Compilation of the Database

The database for this study consists of a compilation of locations ("sites") where paleoecological significance could be demonstrated. A "site" was considered to have paleoecological significance if 1) chronological control was present, with a minimum of one ^{14}C date, and 2) some indication of sedimentological change (pollen or plant macrofossils, inorganic sediments) was apparent. Most sites include locations where comprehensive studies of pollen and/or plant macrofossil stratigraphies were conducted. Rarely, some sites include only dated stratigraphic profiles.

Sites (with the associated ^{14}C dates) used in this analysis were compiled from various sources. The published literature on Sierra Nevada paleoecology was perused, yielding data on individual ^{14}C dates. Only those records analyzed specifically for paleoecological information were included in this study; sites designated primarily as archaeological were excluded. Unpublished data were integrated from various sources. Much of the data from unpublished sites was readily available and was analyzed by one or more of the authors of this paper.

RESULTS AND DISCUSSION

Sites compiled for this study are located primarily within the central and southern portions of the Sierra Nevada (Fig. 1). Paleoecological studies have been conducted on both sides of the Sierran crest, as well as from one site on the crest itself. Sedimentary deposits analyzed include lakes, meadows, marshes, packrat middens and, in one case, an archaeological excavation.

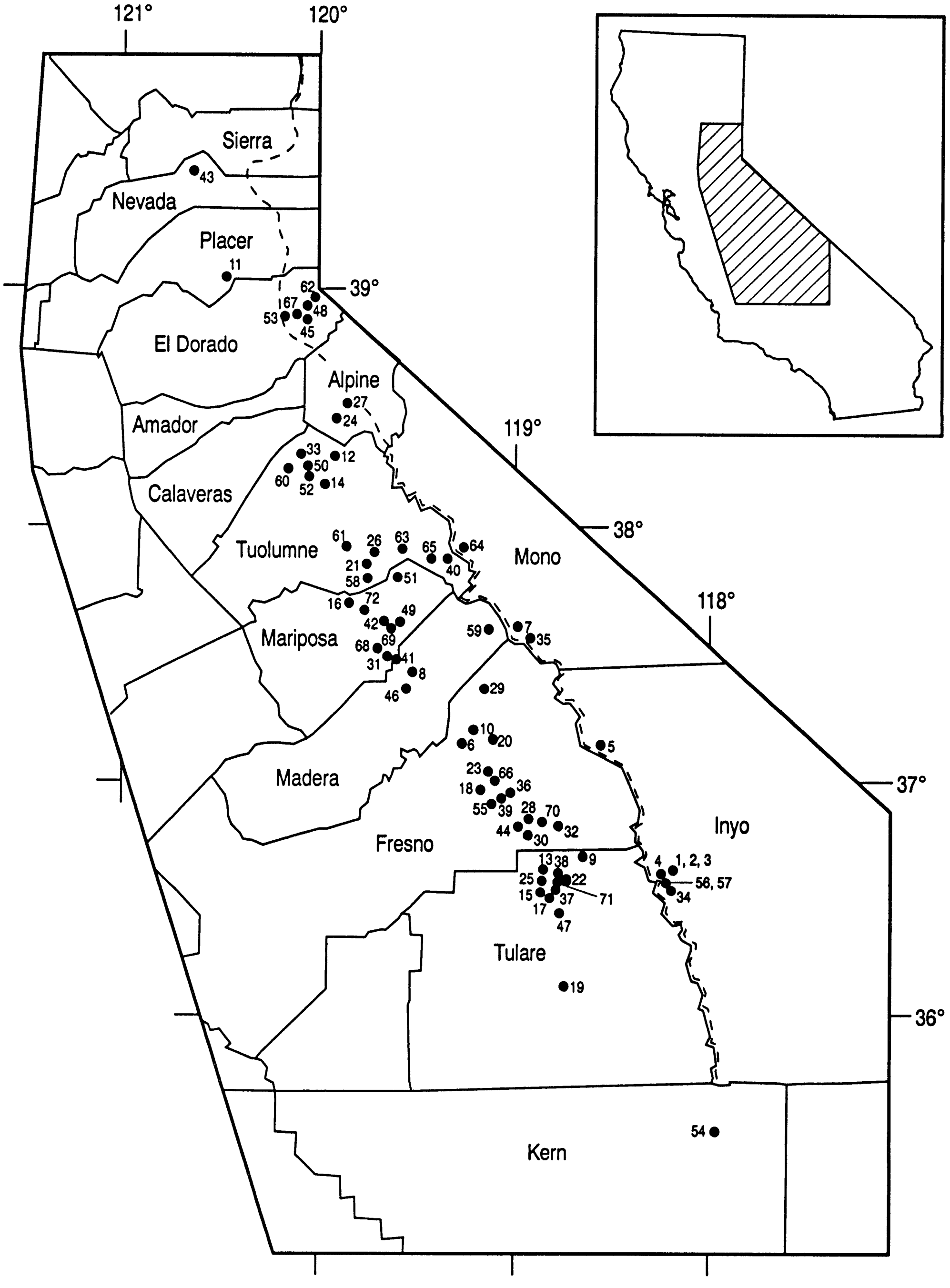


Fig. 1. Location of paleoecological sites within the Sierra Nevada. Numbers are keyed to Appendix. --- = the Sierra crest, separating the east from the west sides.

Data were compiled from 72 sites (Appendix), undoubtedly making the Sierra Nevada one of the most heavily studied regions in western North America. A total of 234 ^{14}C dates for the 72 sites have been obtained. The number of dates per record ranges from 1 (25 sites) to 12 (1 site) (Fig. 2).

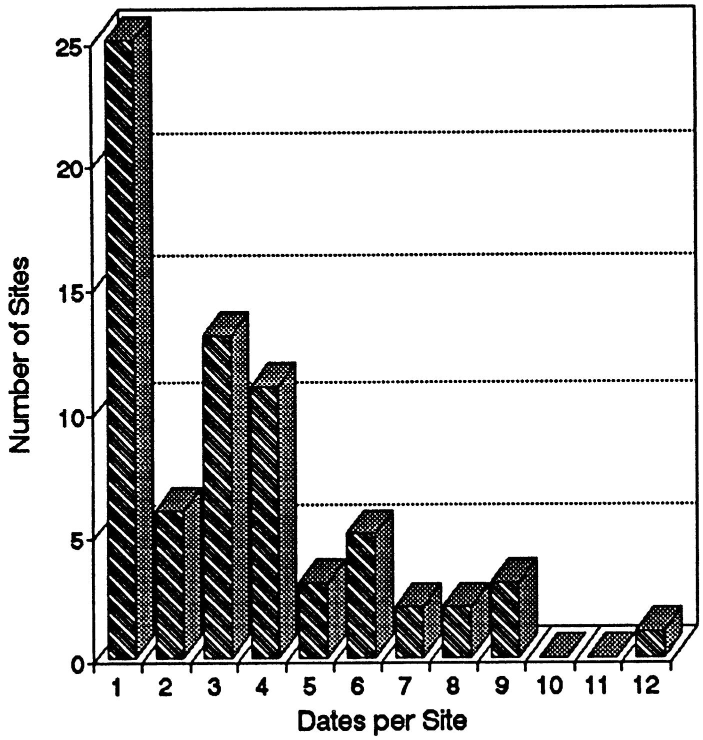


Fig. 2. Distribution of the number of sites with a given number of dates

Location of Sites

Most of the lands in the central Sierra Nevada are administered by the federal government or other governmental agencies (SNEP Science Team 1996). The locations of many paleoecological sites were chosen in order to answer questions pertaining to management of forests under government stewardship. Forty studies were conducted on lands administered by the U.S. Forest Service, and an additional 28 studies within U.S. National Parks. Portions of the Sierra Nevada lie within *ca.* 20 California counties. However, the 72 locations enumerated here occur largely within 10 counties in the central and southern Sierra (Appendix), while two sites occur in the northern Sierra.

Published *vs.* Unpublished Records

Adam (1985) pointed out that records of many of the California sites were unpublished. Data reported here show that trend has been reversed (Appendix). Only 41% of the sites have not been published (we include here M.S. and Ph.D. theses in this category). The number of published ^{14}C dates exceeds unpublished (183 *vs.* 51).

Distribution by Sediment Type

Several sediment types are available for paleoecological study in the Sierra Nevada. Analysis of cores or sections from montane meadows comprise 51% (37) of the studies conducted to date (Table 1). Thirty-three percent (24) of studies are from lakes, followed by 7% each (5) for packrat middens and marshes. However, packrat midden studies include a larger average number of individual dates per study (6.2), compared to lake (3.1), meadow (3.1) and marsh (2.5) studies. This is because each midden must be individually ^{14}C-dated, while fewer dates are generally necessary to establish a stratigraphic chronology.

The majority of dates obtained from meadows are of bulk colluvial/alluvial sediments, though wood samples have been used extensively for establishing sediment chronologies (Table 1). For packrat middens, fecal pellets and amberat (crystallized rat urine, which cements most middens) have been the preferred materials for dating.

TABLE 1. Distribution of ^{14}C Dates by Sediment Type

Sediment type	No. of dates	Total dates	No. of sites
Marsh		**11**	**5**
Peat	9		
Wood	1		
Lake	1		
Meadow		**116**	**37**
Charcoal	9		
Peat	11		
Wood	24		
Colluvial; alluvial	72		
Midden		**31**	**5**
Fecal/amberat	27		
Plant material	4		
Lake		**75**	**24**
Archaeological	1	**1**	**1**
Total		**234**	**72**

Age Distribution

Figure 3 shows bar graphs of age distribution of ^{14}C dates and calibrated ages by 1000-yr intervals. Calibration of ^{14}C ages from the present to 19,262 BP was performed using the CALIB 3.0 program of Stuiver and Reimer (1993). From 19,262 to 27,120 BP, we linearly interpolated between equivalent ^{14}C and U-Th ages given by Bard *et al.* (1990). From 27,120 to 50,000 BP, we used the relationship suggested by Mazaud *et al.* (1991) and Thouveny, Creer and Williamson (1993).

A bimodal distribution of ages is apparent, centered around 1000–4000 BP and 10,000–12,000 BP. The number of dates older than *ca.* 12,000 BP declines toward zero, with the oldest date recorded at >45,000 BP (Kings Canyon midden series). All of the dates older than 20,000 BP are from packrat midden series, whereas the oldest date from a stratigraphic sequence is *ca.* 17,000 BP. Thus, Holocene events are well represented paleoecologically, while the Pleistocene of the Sierra is much less well known.

In their analysis of 1113 packrat midden dates, Webb and Betancourt (1990) noted a similar bimodal distribution of ^{14}C dates, with maximum number of dates in the time ranges of 0–3000 and *ca.* 10,000–12,000 ^{14}C yr ago. They compared their histogram distribution with a gamma probability distribution, which largely describes frequency distributions with an apparent exponential decay. An ideal gamma distribution shows a greater number of ^{14}C dates for the youngest portion of the timescale, with an exponential decay (fewer dates) with increasing age. Webb and Betancourt's (1990) bimodal distribution was explained by a combination of researcher bias and decreased preservation potential with increasing age. Early in the development of midden analysis, middens with extralocal plant fossils were preferentially selected for analysis and dating. This created a large number of middens of latest Pleistocene age. Only later were Holocene-age middens collected and analyzed. Thus, the midden record represents two different populations—one Pleistocene and one Holocene (O. Davis, personal communication 1997).

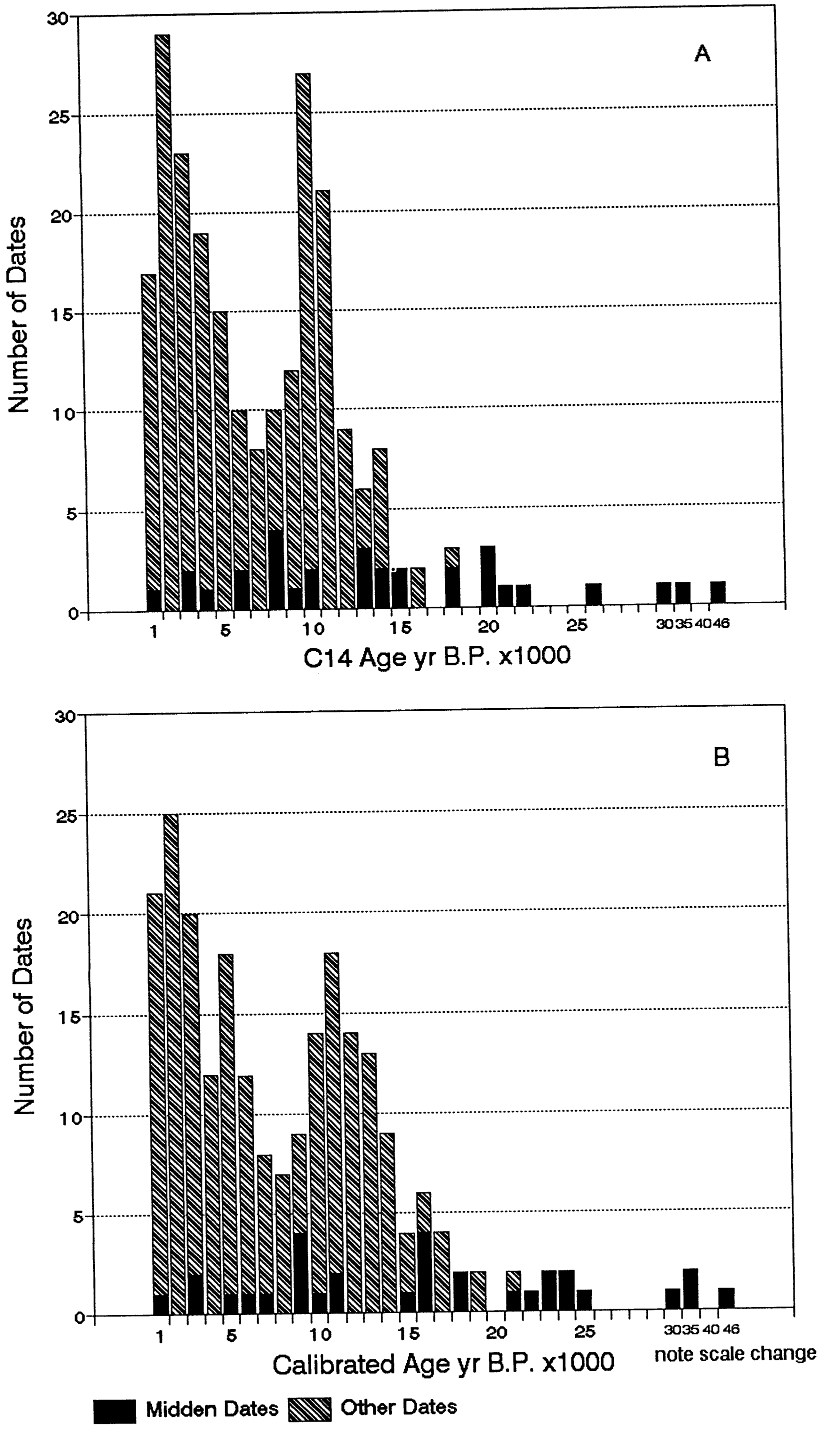


Fig. 3. Distribution of individual ^{14}C dates by 1000-yr intervals. A. Ages listed in ^{14}C yr BP; B. Ages listed in calendar years before present. Note scale change at the right of each diagram.

Graphically, the patterns identified in the Webb and Betancourt (1990) study and the present one (Fig. 3) are similar, but the explanations are different. Though fewer midden dates were collected in the present study than in Webb and Betancourt's study, temporal distribution of midden dates is approximately uniform through time (Fig. 3, black bars), minimizing the importance of collector bias or changing environmental conditions as explanations for the Sierran midden record. Stratigraphic dates account for most of the patterns seen in Figure 3. Because most of the dates come from continuous sections (Table 1), any level within the section could have been chosen for dating by the individual investigator. The peak in ^{14}C ages from *ca.* 9000 to 11,000 BP (Fig. 3A; somewhat smoothed out in the calibrated ages curve, Fig. 3B) results from dating of basal sediments. Thirty-seven percent (21) of the 57 records with basal dates occur within this 2000-yr interval (Fig. 4). Furthermore, 54% of basal dates occur between 8000 and 12,000 yr BP, suggesting that the majority of stratigraphic records in the Sierra extend back only to the early Holocene or latest Pleistocene.

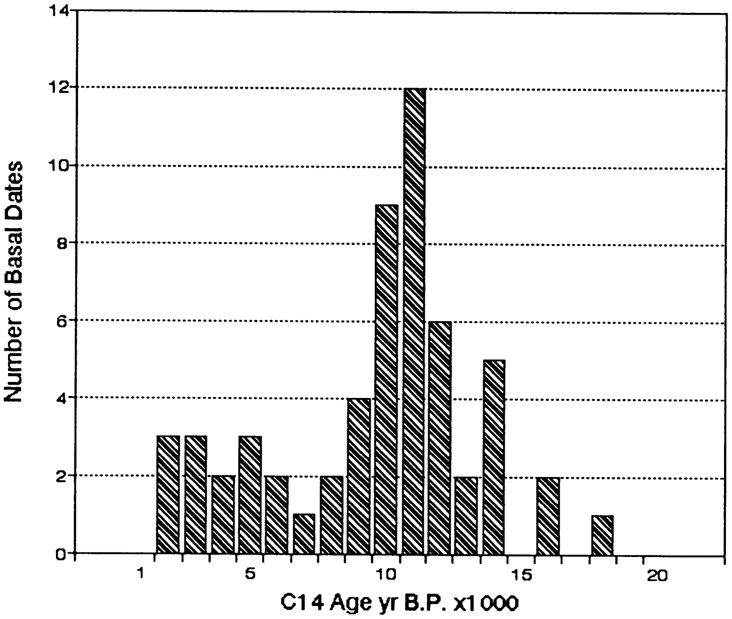
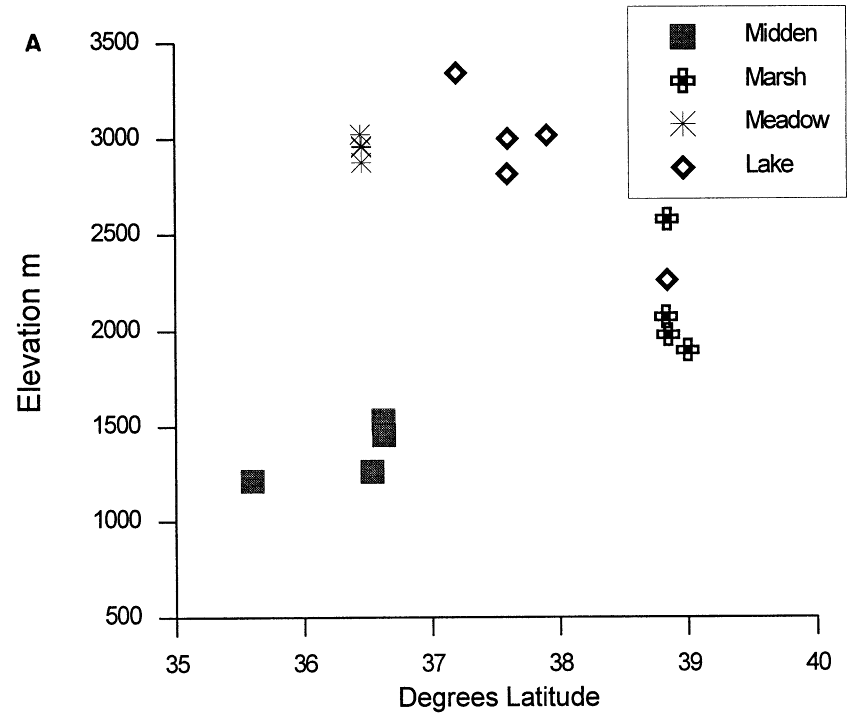


Fig. 4. Distribution of age of basal ^{14}C dates by 1000-yr intervals for stratigraphic records

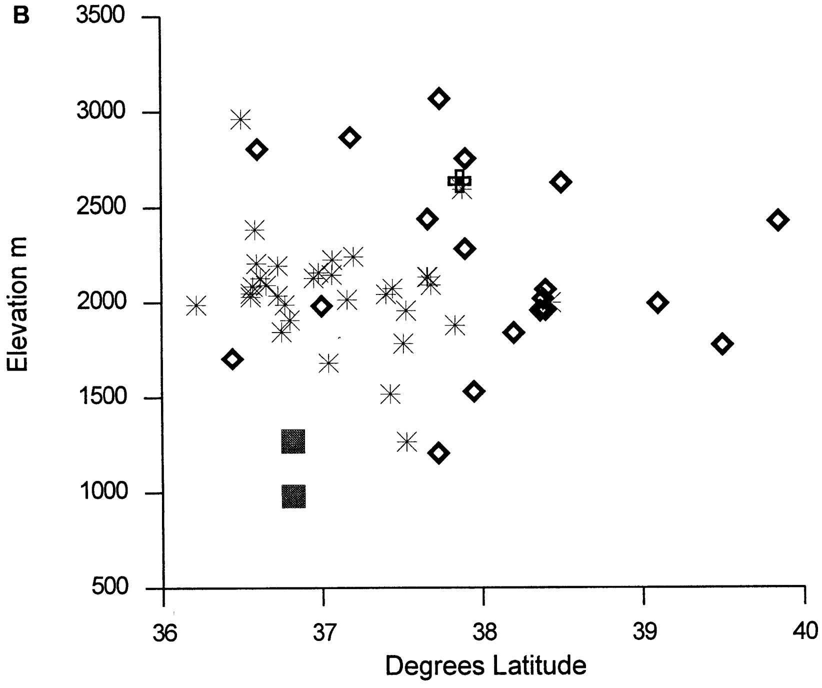
The abundance of dates between 1000 and 4000 BP almost certainly correlates with an important paleoecological change in the sedimentary column. Using pollen and sedimentary changes, Anderson and Smith (1994) showed widespread, late Holocene changes, and suggested a probable connection with the onset of the Neoglacial interval (Burke and Birkeland 1983). An alternative explanation suggests the "pull of the recent", with a greater likelihood of preservation of younger records than older ones. This explanation cannot account for all of the distribution, since 56% of sites with one or more dates in the 1000 to 4000-yr range also have basal dates of *ca.* 8000 yr or older. The patterns exhibited in Figure 3 are clearly nonrandom.

Distribution of Sites by Elevation and Latitude

Figures 5 and 6 depict plots of location of sites and ages of ^{14}C samples (and by inference the location of sites in space and time) for both the east and west sides of the Sierran crest. Far fewer paleoecological sites with associated ^{14}C dates have been analyzed on the east side of the crest (17 sites and 53 ages) than on the west side (55 and 179).

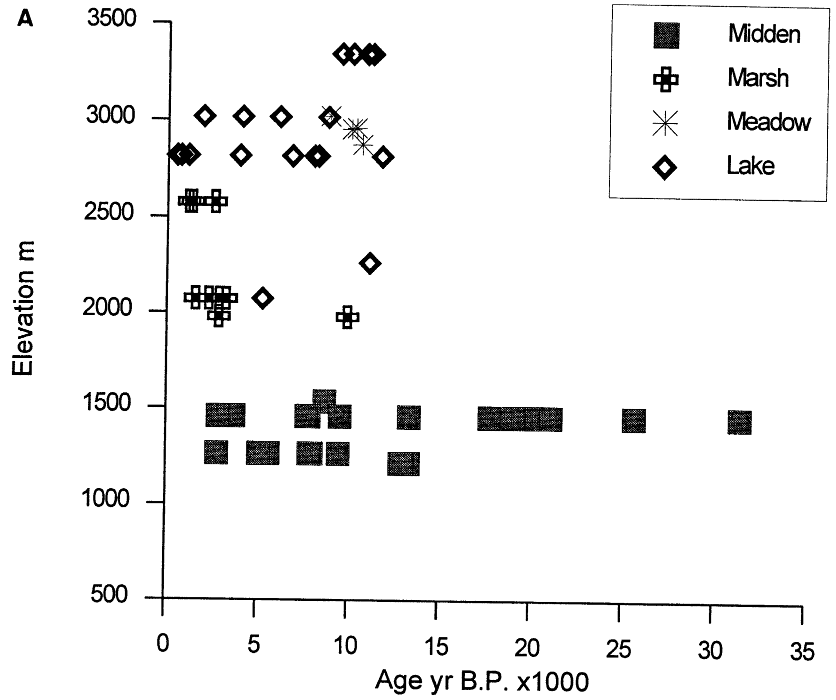


East Side Sierra Sites (n=17)

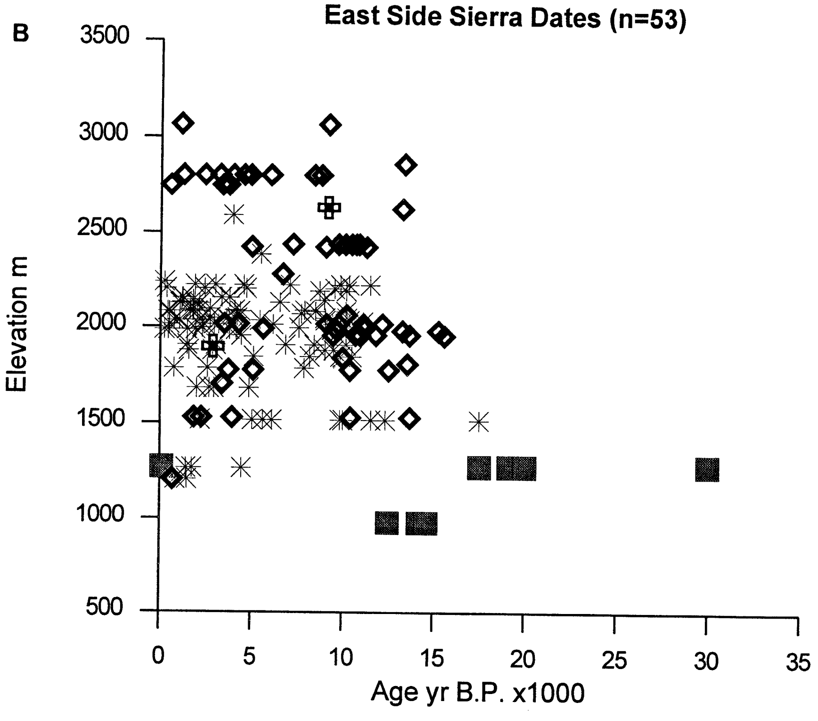


West Side Sierra Sites (n=55)

Fig. 5. Distribution of ^{14}C dates by elevation and latitude for the east side (A) and west side (B) of the Sierra crest. Sediment type is also indicated by symbols in legend.



East Side Sierra Dates (n=53)



West Side Sierra Dates (n=179)

Fig. 6. Distribution of ^{14}C dates by elevation and age for the east side (A) and west side (B) of the Sierra crest. Sediment type is also indicated by symbols in the legend.

Several factors account for this. First, the east side of the Sierra lies in a rain shadow. For any given elevation, the greater aridity of the east side results in fewer sites with wet sediment accumulation. Second, the Sierra Nevada consists of a gently sloping west slope, and a much steeper east slope that is less areally extensive. Third, because of the steepness of the east side, glaciation was confined largely to high-elevation plateaus and to major drainages, and less so to interfluves. On the west side of the crest, however, the more gently sloping topography and greater ice accumulation enabled glacial activity to produce many basins (Huber 1987).

Sites East of the Crest

Seventeen sites record paleoecological changes east of the crest (Fig. 5). However, sites are not distributed uniformly with respect to elevation. Sites are segregated into packrat midden series below 1460 m elevation, and stratigraphic deposits above 1888 m elevation. For the latter, marsh deposits occur from *ca.* 1888 m (Taylor Marsh) to *ca.* 2580 m elevation (Ralston Ridge Bog). With two exceptions, analysis of lake and meadow deposits has been confined to locations above 2816 m elevation.

The latitudinal distribution of sites is not uniform either (Fig. 5). For the east side, the three packrat midden sites (all at lowest elevations) are located at the southern end of the study area. The high-elevation meadow sites are also located toward the south, while most high-elevation lake sites are found within the northcentral part of the study area. However, the mid-elevation records between *ca.* 1900 and 2600 m elevation occur only in the northern portion, near Lake Tahoe.

Sites West of the Crest

Fifty-five sites on the west side of the crest (Fig. 5) provide somewhat greater resolution of the paleoecology of the range than that provided on the east side. As on the east side, sites are segregated by elevation with respect to sediment type, but to a lesser degree. Packrat midden series are confined to the lowest elevations, below 1275 m. Primarily lake sites have been analyzed above 2740 m. At mid-elevations, both meadow and lakes have been investigated.

The latitudinal distribution of sites with respect to elevation on the west side of the Sierra reflects a different pattern than on the east. Western Sierra sites occur over a narrower range in latitude, primarily between *ca.* 36° and 38°30′ N (Fig. 5); three outliers, Siesta, McMurray and Bunker Lakes, occur north of 39° N. In the southern portion of the study area meadow sites predominate, especially at locations between 1500 m and 2220 m; lake sites are rare within this elevational range. However, lakes in general become increasingly more abundant toward the north. Consequently, more lakes than meadows have been analyzed toward the north (Fig. 5). Lake sites are primarily distributed around 38° N latitude, in and near Yosemite National Park. Exceptions to this include Emerald Lake (2804 m) and Oriole Lake (1697 m), both located in Sequoia National Park in the south.

Though limited latitudinally, lake sites have been analyzed from nearly the entire elevational range. Meadow sites, virtually all to the south of 38° N, are concentrated over a somewhat narrower range of elevations than the lakes. The lowest-elevation meadow sites analyzed on the west side (Wawona and Nichols Meadows) are found in the central portion of the study area. In general, the lowest elevation of stratigraphic paleoecological sites increases from north to south on the west side. This may reflect a decrease in effective precipitation from north to south for any given elevation (Major 1988), and the resulting potential for accumulation of wet sediment.

IDENTIFYING GAPS IN PALEOECOLOGICAL KNOWLEDGE

The data are useful in identifying gaps in our knowledge of events in time and space for the Sierra Nevada. At present, many more gaps in the record exist for the east side than for the west side of the crest.

For the east side, the mid-Wisconsin period is known only from the Alabama Hills Two Goblin site, in the south (Fig. 6). No site older than *ca.* 11,500 BP is found above 1460 m elevation. Similarly, large gaps exist in the elevational ranges of *ca.* 1500–2000 m (4900–6600 ft) and *ca.* 2100–2600 m (6900–8500 ft). These elevations presently encompass the sagebrush and lodgepole-fir belts in the north, and the sagebrush and pinyon pine belts in the south. In addition, sites above modern treeline have not been analyzed. Low-, and additional high-, elevation sites need to be analyzed in the northern portion of the study area, while mid-elevations in the central and southern portions lack data.

On the west side, the mid-Wisconsin is known only from one low-elevation site in the south—two middens from Kings Canyon (1280 m; Fig. 6). Unlike the east side, five sites above 1500 m elevation stretch back to *ca.* 15,000–17,000 BP (Nichols Meadow, 1518 m; Swamp Lake Yosemite, 1554 m; Swamp Lake Batchelder, 1951 m; Lilypad Lake, 1980 m; and Lake Moran, 2020 m). While Nichols Meadow was apparently below the Tioga glacial limit (Alpha, Wahrhaftig and Huber 1987), the latter four sites come from glaciated terrain, and suggest early deglaciation at these elevations. Additional temporal gaps include most of the Holocene and late Pleistocene for locations below *ca.* 1500 m (4900 ft). These elevations today include the lower portion of the Sierra montane forest (including the ponderosa pine belt), the chaparral, blue oak–gray pine woodland and the valley prairie ecozones. Little information exists for *ca.* 1550–1750 m (5100–5700 ft) for the early Holocene, and *ca.* 2300–2700 (7550–8900 ft) elevation for the late Holocene. Vegetation occurring there today is part of the Sierra montane and upper montane forests, respectively. As with the east side, no sites above treeline have been analyzed. Latitudinally, information is limited north of *ca.* 38°30′N and south of 36°N latitudes.

CONCLUSION

David Adam's (1985) compilation of paleoecological sites within California provided palynologists working in western North America with a tool useful for planning future research. Adam identified significant holes in our knowledge of late Quaternary environments of California. One range in particular, the Sierra Nevada, has attracted several researchers. Though the Sierra still contains geographic and temporal gaps in our paleoenvironmental knowledge, the present compilation demonstrates that those gaps have narrowed significantly.

With respect to the latitudinal distribution of sites, our knowledge of the northern Sierra is less than that of the central or southern portions of the range. Northern Sierra vegetation has greater affinities to that of the Great Basin and the Cascade Range than does vegetation in the south. Additional study here could provide needed insight into the biogeographic connections between the more northerly regions.

Additional studies should be undertaken on the east side of the crest to partially fill gaps in our knowledge of elevational vegetation change. High-elevation studies are few in the north, and mid-elevation studies in the south are completely lacking. Though the steep escarpment there may preclude finding suitable sites, such a study in the south could illuminate the location of high-elevation conifers during the late Wisconsin in the Sierra. The midden series from the Alabama Hills (Koehler and Anderson 1995) is apparently from too low an elevation to record the occurrence of important Sierran trees during that time.

No study has been conducted at sites above modern treeline. Such an effort could illuminate potentially higher treelines during the early Holocene, when climatic conditions were at their warmest and driest (Anderson 1990, 1996). These new studies may also be important in evaluating use of the early Holocene as an analog for future greenhouse warming.

Though study of sediments from pluvial lakes (*e.g.,* Atwater *et al.* 1986; Litwin *et al.* 1997) reveals vegetation changes at the lowest elevations on both sides of the crest, efforts should be continued to identify additional packrat midden series. For instance, Cole (1983) documented the Wisconsin-age occurrence of important Sierra montane species, such as ponderosa pine, in modern chaparral, and suggested that giant sequoia *(Sequoiadendron giganteum)* may have grown nearby as much as 500 m below its modern distribution. Additional series further to the north are necessary to identify other Wisconsin-age refugia, and to complete the picture of the development of the Sierra montane forest in general.

Within the Sierra, many types of sediments are available to the paleoecologist, and the choice of sediment type depends largely upon elevation. In general, lakes are most abundant above the Sierra montane zone, though several important studies have been conducted from lower-elevation lakes (Fig. 5). Within the Sierra montane zone, where lakes are rare, meadow stratigraphies have been analyzed to a greater extent (Anderson and Smith 1994). At even lower elevations, sedimentary deposits with appropriate preservation potential are rare, and packrat midden studies predominate.

Each sediment type has advantages and disadvantages. Packrat middens often occur at the lower, more arid elevations, where other stratigraphic deposits are not found. However, individual middens represent discrete windows in space and time, and the midden series rarely represent continuous changes in vegetation. Meadow sediments provide a mid-elevation record, yet are subject to periodic desiccation. Drying events, along with periodic fires that burn the meadows, are potential causes of disconformities in the pollen stratigraphy. Lakes are abundant at high elevations, but only rarely occur below the late Wisconsin glacial limit. Using a combination of studies from each elevation allowed Anderson and Smith (1991) and Woolfenden (1996) to summarize the story of vegetation change for the Sierra.

Though many studies have appeared in the literature since 1985, more than 40% of the site reports remain unpublished. This is the mark of active research within a region. Further investigation within the range will fill additional gaps in the history of vegetation change, refining our understanding of the development of the rich vegetation assemblages that are characteristic of the Sierra Nevada. It will also undoubtedly provide the starting point for research unanticipated at present.

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APPENDIX: LOCATION OF PALEOECOLOGICAL SITES AND ^{14}C DATES WITHIN THE SIERRA NEVADA

	Site	County	Elevation		Sediment type	No. dates	References
			feet	m			
1	Alabama Hills, Corsair	Inyo	5035	1535	Midden/fecal pellets	1	Koehler & Anderson 1995
2	Alabama Hills, Lubkin Cyn.	Inyo	4146	1264	Midden/fecal pellets	6	Koehler & Anderson 1995
3	Alabama Hills, Two Goblin	Inyo	4780	1457	Midden/fecal pellets	12	Koehler & Anderson 1995
4	Atchoo Meadow	Inyo	9700	2957	Peat	1	Mezger 1986, unpubl.
5	Baboon Lakes	Inyo	10,976	3346	Lake sediment	4	Hemphill & Clark 1996
6	Balsam Meadow	Fresno	6610	2015	Meadow sediment	6	Davis *et al.* 1985
7	Barrett Lake	Mono	9240	2816	Lake sediment	8	Anderson 1990
8	Beasore Meadow	Madera	6800	2073	Wood (fir)	1	Brandau & Nokes 1975; Wood 1975
9	Boggy Meadow	Tulare	7200	2195	Wood (softwood)	2	Brandau & Nokes 1975; Wood 1975
10	Boneyard Meadow	Fresno	7350	2240	Wood	2	DeGraaf, unpubl.
11	Bunker Lake	Placer	6540	1993	Lake sediment	3	Edlund 1994
12	Burgson Lake	Tuolumne	6430	1960	Lake sediment	3	Byrne, unpubl.
13	Cabin Creek Meadow	Tulare	6860	2091	Meadow sediment	1	Anderson, unpubl.
14	Catfish Lake	Tuolumne	6040	1841	Lake sediment	1	Byrne, unpubl.
15	Circle Meadow	Tulare	6840	2085	Meadow sediment	8	Anderson 1996; Anderson & Smith 1994; Anderson & Smith 1997
16	Crane Flat	Mariposa	6180	1884	Archaeol. midden	1	Adam 1967
17	Crescent Meadow	Tulare	6660	2030	Peat	1	Anderson, unpubl.
18	Dinkey Meadow	Fresno	5520	1682	Meadow sediment	4	Davis & Moratto 1988
19	Dogwood Meadow	Tulare	6520	1987	Meadow sediment	4	Anderson 1996; Anderson & Smith 1994; Anderson & Smith 1997
20	East Lake	Fresno	9395	2864	Lake sediment	1	Power, unpubl.
21	East Meadow, Aspen Valley	Tuolumne	6170	1881	Charcoal	4	Wood 1975
22	Emerald Lake	Tulare	9200	2804	Lake sediment	9	Whitehead, unpubl.
23	Exchequer Meadow	Fresno	7300	2225	Colluvium	7	Brandau & Noakes 1975; Davis & Moratto 1988; Wood 1975
24	Gabbott Megadow	Alpine	6550	1996	Colluvium	4	Mackey & Sullivan, unpubl.; Mackey & Sullivan 1991

Site	County	Elevation		Sediment type	No. dates	References
		feet	m			
25 Halstead Meadow	Tulare	6980	2128	Meadow sediment	1	Anderson, unpubl.
26 Harden Lake	Tuolumne	7484	2281	Lake sediment	1	Batchelder, unpubl.
27 Highland Lake	Alpine	8614	2626	Lake sediment	1	Byrne, unpubl.
28 Hightop Meadow	Fresno	6260	1908	Meadow sediment	5	Anderson 1996; Anderson & Smith 1994; Anderson & Smith 1997
29 Hoffman Meadow	Fresno	6700	2042	Conifer cone	2	DeGraaf, unpubl.
30 Huckleberry Meadow	Fresno	6520	1987	Peat	6	Anderson & Smith 1997
31 J.B. Swale	Mariposa	5860	1786	Meadow sediment	3	Anderson, unpubl.; Anderson & Smith 1997
32 Kings Canyon	Fresno	4165	1269	Midden	9	Cole 1983
33 Lake Moran	Tuolumne	6620	2018	Lake sediment	6	Byrne 1988; Edlund 1991, unpubl.; Edlund & Byrne 1991
34 Last Chance Meadow	Inyo	9720	2963	Peat	1	Mezger 1986, unpubl.
35 Laurel Lakes (Lower)	Mono	9840	3000	Lake sediment	0	Pohl *et al.* 1996
36 Lily Pad Lake	Fresno	6500	1981	Lake sediment	3	Edlund 1992
37 Log Meadow	Tulare	6720	2048	Meadow sediment	4	Anderson 1994
38 Long Creek Meadow	Fresno	7080	2158	Wood (fir)	4	Brandau & Nokes 1975; Wood 1975
39 Long Meadow	Tulare	7240	2207	Meadow sediment	4	Anderson 1996; Anderson & Smith 1994; Anderson & Smith 1997
40 Lower Gaylor Lake	Tuolumne	10,060	3066	Lake sediment	2	Anderson, unpubl.
41 Mariposa Grove	Mariposa	6420	1957	Colluvium; alluvium	1	Anderson, unpubl.
42 McGurk Meadow	Mariposa	6860	2091	Meadow sediment	3	Anderson 1996; Anderson & Smith 1994
43 McMurray Lake	Nevada	5832	1778	Lake sediment	4	Edlund 1992
44 Meadow of Honor	Fresno	6060	1847	Meadow sediment	4	Anderson 1996; Anderson & Smith 1994
45 Meyers Grade Marsh	El Dorado	6800	2073	Peat	5	Dorland 1980, unpubl.; Dorland, Adam and Batchelder 1980
46 Nichols Meadow	Madera	4980	1518	Wood	9	Koehler and Anderson 1994; DeGraaf unpubl., Swetnam, unpubl.; Koehler 1993 unpubl.
47 Oriole Lake	Tulare	5600	1707	Lake sediment	1	M.B. Davis, unpubl.
48 Osgood Swamp	El Dorado	6495	1980	Peat	2	Adam 1967; Zauderer 1973 unpubl.
49 Ostrander Meadow	Mariposa	7000	2134	Meadow sediment	1	Anderson, unpubl.
50 Paradise Lake	Tuolumne	5940	1811	Lake sediment	1	Byrne, unpubl.
51 Polly Dome Lake	Mariposa	8640	2633	Marsh	1	Batch 1977, unpubl.
52 Pond 3	Tuolumne	6780	2067	Lake sediment	1	Byrne, unpubl.
53 Ralston Ridge Bog	El Dorado	8460	2579	Roots	3	Sercelj & Adam 1975
54 Robbers Roost	Kern	3985	1215	Midden	3	McCarten & Van Devender 1988
55 Ross Meadow	Fresno	6980	2128	Wood	2	DeGraaf, unpubl.
56 Round Valley Meadow	Inyo	9920	3024	Peat	1	Mezger 1986, unpubl.

Site	County	Elevation feet	Elevation m	Sediment type	No. dates	References
57 Second Chance Meadow	Inyo	9440	2877	Peat	1	Mezger 1986, unpubl.
58 Siesta Lake	Tuolumne	7950	2423	Lake sediment	3	Brunelle 1997, unpubl.
59 Starkweather Pond	Madera	8000	2438	Lake sediment	6	Anderson 1990
60 Swamp Lake (Batchelder)	Tuolumne	6420	1957	Lake sediment	3	Batchelder 1980
61 Swamp Lake, Yosemite	Tuolumne	5018	1529	Lake sediment	5	Smith 1989, unpubl.; Smith & Anderson 1992
62 Taylor Marsh	El Dorado	6229	1899	Lake sediment	1	West, unpubl.
63 Ten Lakes #3	Tuolumne	9020	2749	Lake sediment	3	Anderson 1987, unpubl.
64 Tioga Pass Pond	Mono	9900	3018	Lake sediment	4	Anderson 1990; Anderson 1996; Anderson & Smith 1994
65 Tuolumne Meadows	Tuolumne	8500	2591	Charcoal	1	Wood 1975
66 Upper Cabin Meadow	Fresno	7040	2146	Wood	3	Brandau & Nokes 1975; Wood 1975
67 Upper Echo Lake	El Dorado	7420	2262	Lake sediment	1	Adam 1985
68 Wawona Meadow	Mariposa	4150	1265	Meadow sediment	3	Anderson, unpubl.; Anderson & Carpenter 1991
69 Well Meadow	Mariposa	7000	2134	Meadow sediment	1	Anderson, unpubl.
70 Weston Meadow	Tulare	6680	2036	Meadow sediment	7	Anderson 1996; Anderson & Smith 1994; Anderson & Smith 1997
71 Willow Root Meadow	Tulare	7820	2384	Meadow organics	1	Anderson, unpubl.
72 Woski Pond	Mariposa	3955	1205	Lake sediment	3	Anderson & Carpenter 1991