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# Resource Intensification in Prehistoric Central California: Evidence from Archaeobotanical Data

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*Resource intensification models of central California prehistory have characterized Early Period populations as highly mobile foragers making use of a broad spectrum of food resources, Middle Period groups as more sedentary and acorn-focused, and Late Period populations as making intensive use of acorns in conjunction with a broader array of foods (Basgall 1987; Basgall and Bouey 1991). Plant macrofossil data from 11 central California archaeological sites show that while many of the same plant taxa were shared, Early, Middle, and Late period seed assemblages feature patterned differences in proportion and diversity. Early Period assemblages are not dominated by acorn nutshell, and include a diverse set of small seeds. Middle Period plant remains tend to be dominated by acorn, while small seed assemblages tend to be restricted. Late Period sites also contain large quantities of acorn, but are also characterized by abundant and diverse small seeds. These data are consistent with implications of current resource intensification models.*

**T**HE analysis of charred plant remains has only recently contributed to the interpretation of prehistoric subsistence and settlement systems in California (e.g., Basgall and McGuire 1988; Basgall and Hildebrandt 1989; Hammett 1991; Miksicek 1991; Hildebrandt and Mikkelsen 1993; Wohlgemuth 1993a). To a large extent, such interpretations have followed from the perceived absence of large-scale subsistence shifts associated with agricultural production elsewhere in prehistoric North America. For many years, archaeologists interested in the development of agriculture in the Southwest or Eastern Woodlands have used flotation techniques to recover plant macrofossils (e.g., Struever 1968), with the goal of documenting processes governing the domestication of local crops or the introduction of tropical cultigens (Bohrer 1970; Asch et al. 1972).

Despite long-standing evidence that plant remains are often abundantly preserved in California archaeological sites (e.g., Cook and Treganza 1950; Cook and Heizer 1951), systematic col-

lection of soil samples, use of effective flotation techniques, and thorough analysis were not applied until the 1980s (Hammett and Wohlgemuth 1982; Honeysett 1982; Davis and Miksicek 1988), when interest in models of resource intensification developed in the region. However, these techniques continue to be applied haphazardly in excavations at sites in California today, as samples are often not collected from sites containing plant remains, are too small to produce meaningful results, or are collected solely from feature contexts (Wohlgemuth 1984). This unevenness undermines the contribution that archaeobotanical data can make in addressing several important problems surrounding resource intensification in California prehistory (Hammett 1991; Miksicek 1991; Wohlgemuth 1993a), as well as the role that these studies can play in analogous situations where agricultural production developed (Olszewski 1993; McCorrison 1994).

The purpose of this paper is to attempt to apply archaeobotanical data to intensification

models that have been developed to explain subsistence and settlement pattern shifts observed in prehistoric central California. One such model (Basgall 1987) focused on changes in the importance of acorns. Although acorns were the primary staple over most of ethnographic California (see Kroeber 1925; Barrett and Gifford 1933; Gifford 1936; Baumhoff 1963), the question arises as to why their use appears to have increased substantially in the latter phases of California prehistory (as measured by an increase of mortars and pestles versus manos and milling stones over time). Contrary to what Gifford (1936) and Baumhoff (1963) have argued, Basgall (1987:26-29) maintained that the acorn economy of ethnographic central California native populations was not due to the superior quality of acorns as a food resource, the intensive use of which awaited the discovery or diffusion of mortar and pestle technology; instead, ethnographic data demonstrate that labor-intensive processing of acorns renders balanophagy a quite costly subsistence orientation. In this view:

. . . if the resource is seen as a high-cost item that should, *ceteris paribus*, be only minimally used, the emergence of balanophagy becomes a question of why it happened at all rather than why it took so long to happen.

Such a perspective does not imply that intensive acorn use brings with it no benefits. The level of subsistence production possible is extremely high, the potential for storage is great, and the nutritional payoffs are more than adequate. Accordingly, once established, such an adaptation would have had important effects on demographic patterns, on mobility strategies, and on the organization of intragroup relations . . . Conversely, intensive acorn use can be expected to emerge as a consequence of very specific socioeconomic conditions, not because of some inherent quality of the resource itself [Basgall 1987:41].

Socioeconomic conditions previously offered as antecedents to intensive acorn use are variants of population/resource imbalances, including population increase, effective environmental deg-

radation, or increased social demands. An example of increased caloric needs for social functions is the ethnographic central California Mourning Ceremony, wherein prestige-seeking males mobilized the labor of women to accumulate food stores for week-long events that might be attended by more than a thousand people (McCarthy 1993). Preparations often required production and storage of food resources for up to four years on the part of the host community. Acorns, particularly tan oak (*Lithocarpus densiflora*) and black oak (*Quercus kelloggii*), met this demand like no other indigenous California resource. Similarly, White et al. (1995) viewed economic intensification as a product of mediated interactions between adjacent social groups rather than of population/resource imbalances.

Basgall (1987:30-35) cited the spatial and temporal distribution of grinding assemblages as evidence supporting the intensification model. While not necessarily equating mortar and pestle use solely with acorn processing, or mano and milling stone use with other resources (e.g., "hard seeds"), Basgall (1987:30) assumed that: (1) mortars and pestles were primarily used with acorns; (2) an abundance of mortars and pestles in an artifact assemblage "reflects a major concern with acorns"; and (3) the proportion of these tools in milling assemblages is a measure of relative acorn reliance, albeit imperfect. Grinding tool assemblages were examined in the Central Valley, San Francisco Bay Area, southern North Coast Ranges, and Sierra Nevada. In the Central Valley, manos and milling stones appear more commonly in the Early Period (ca. 4,500 to 2,800 B.P.), while mortars and pestles became more abundant, and were often exclusive, in Middle Period (ca. 2,800 to 1,200 B.P.) and Late Period (ca. 1,200 to 100 B.P.) sites (Johnson 1984:445-447). In the Bay Area, sites attributed to the Berkeley Pattern, dating ca. 4,500 to 1,500 B.P. (Fredrickson 1973), feature virtually exclusive use of mortars and pestles, indicating earlier inception of acorn exploitation

than in the Central Valley. Deposits predating ca. 2,800 to 2,500 B.P. in the southern North Coast Ranges are characterized by manos and milling stones, while post-2,500 B.P. sites are dominated by mortars and pestles (Fredrickson 1973; White 1984; Hildebrandt and Swenson 1985; Basgall and Bouey 1991). In the southern Sierra Nevada, the use of bedrock mortar and pestle technology appears to begin substantially later, varying from 1,650 to 450 B.P. (Moratto 1984:317).

The markedly different dates for the appearance of milling assemblages dominated by mortars and pestles, and by inference of intensive acorn use, argue against the technological breakthrough or diffusion model; if acorns were a high-quality resource and all that was needed for their use was mortar and pestle technology, mortars and pestles should have diffused rapidly throughout California into all areas with viable oak stands. In at least one region, the Central Valley-Delta, evidence of a population increase after the Early-Middle Period transition accompanies the shift in milling technology (Heizer and Baumhoff 1956; Doran 1980; Moratto 1984). In this area, then, acorn intensification appears to be related to greater population density, where population/resource imbalances and attendant territorial reduction are seen as the primary factors leading to balanophagy (Basgall 1987:43-45).

Basgall's (1987) ideas were further developed in investigations at Warm Springs Dam in northern Sonoma County (Basgall and Bouey 1991), a multiyear program wherein over 380 m.<sup>3</sup> of deposit were excavated from 61 archaeological sites, yielding more than 10,000 formed artifacts. The earliest Skaggs Phase (5,000 to 2,500 B.P.) is represented by seven sites, six of them located along primary drainages. With the exception of a single larger residential base, Skaggs Phase sites are small, with weak midden development and low density of lithic debris. Milling equipment is dominated by manos ( $n =$

9) and milling stones ( $n = 10$ ) (only three pestles and no mortars were recovered from Skaggs Phase deposits). The Skaggs Phase is thought to represent small populations employing a broad spectrum economy, where extensive use was made of a diversity of resources in a highly mobile seasonal round (Basgall and Bouey 1991: 199-200).

Components dating to the subsequent Dry Creek Phase (2,500 to 700 B.P.) were found at 22 sites, 14 along primary drainages, and four each along secondary and tertiary drainages. Settlement types are more varied than in the Skaggs Phase, ranging from sites containing well-developed middens with features and socio-technic artifacts, to sites with low assemblage diversity and weak middens. Mortar and pestle technology dominates Dry Creek Phase components (26 mortars and 37 pestles), with manos and milling stones present in smaller numbers (23 and 16, respectively). The Dry Creek Phase is believed to mark a shift to a more sedentary lifestyle, with an economy based on the intensive gathering, use, and storage of acorns, while use of other seed resources appears to have decreased in importance (Basgall and Bouey 1991:201).

The Smith Phase (700 to 100 B.P.) is represented at 28 site locations, over 40% of them in secondary or tertiary drainage settings. Smith Phase components exhibit the most variability, ranging from large residential bases with high assemblage diversity, to deposits with weak middens and few artifacts. Groundstone assemblages feature near-equal amounts of manos and milling stones (25 and 17, respectively) and mortars and pestles (4 and 28, respectively). Basgall and Bouey (1991:203-204) argued that subsistence practices became more diversified during the Smith Phase, with the acorn-focused economy of the Dry Creek Phase supplanted by an economy making use of a broader array of plant resources in a wider range of habitats, although acorn use and storage continued to be important.

While carbonized plant remains can play a pivotal role in testing hypotheses concerning economic change, they did not figure in either the Basgall (1987) or the Basgall and Bouey (1991) studies. The meager archaeobotanical data available (Fredrickson 1973; Schulz and Johnson 1980; Schulz 1981; Johnson 1984) were insufficient to address the problem of economic shifts in prehistoric central California (Basgall 1987). Plant remains were minimally recovered from Warm Springs Dam sites (Basgall and Bouey 1991:138), and few California archaeological excavations from this era (the late 1970s) incorporated systematic macrofossil sampling and recovery. Data available from Warm Springs Dam indicate that many site deposits, particularly the older ones, lacked abundant plant remains. The focus on grinding tools in studies of subsistence change cited above follows in large part from this dearth of archaeobotanical data.

Although milling assemblages provide some interesting insights regarding subsistence change, they may not necessarily reflect changes in plant use. The association of mortar and pestle technology with acorn and soft food processing, and mano and milling stone technology with "hard seeds," has by no means been established. Although ethnographic data show that acorns were processed with mortars and pestles throughout California (Kroeber 1925; Gifford 1936; Driver and Massey 1957; Baumhoff 1963), and milling stones and manos were generally used with other "dry seeds" (Kroeber 1925:411), there is no assurance of such a clear-cut correspondence archaeologically (Schulz 1981; Basgall 1987), particularly for earlier time periods. In fact, archaeobotanical and groundstone associations from Shasta County provide several challenges to these assumptions. Numerous Late Period sites in Redding contain abundant mortars and pestles, and lack manos and milling stones completely (Sundahl 1982). Many of these sites have rich seed assemblages containing an abun-

dance of acorns, but also found are dense accumulations of manzanita pits, gray pine nutshell, and a wide variety of small seeds (Wohlgemuth 1991). Conversely, Early and Middle period deposits north of Shasta Lake feature hundreds of milling stones and manos to the virtual exclusion of mortars and pestles (Basgall and Hildebrandt 1989). Acorn nutshells, along with manzanita and gray pine, however, are found in all samples collected from these older deposits (Wohlgemuth 1989), clearly indicating that acorns and other resources were processed in the absence of mortars and pestles.

This study is an initial attempt to use archaeobotanical data from the North Coast Ranges and the Central Valley to test hypotheses derived from the aforementioned models. Research with milling tools and settlement data in these regions suggests that acorn-intensive economies arose in the Middle Period from Early Period broad spectrum strategies, while Late Period economies appear to have intensified use of additional plant foods, as well as acorns. As there are reasons to question the assumptions correlating grinding tool forms and resource characteristics, an examination of more direct evidence of plant food use is in order.

## METHODS

Evaluation of the economic importance of plant resources represented by charred plant macrofossils has been a major topic of study for archaeobotanists (Hastorf and Popper 1988; Pearsall 1989). Many of these studies have shown that the frequency of macrofossils is not necessarily related directly to dietary importance, as there are numerous taphonomic factors contributing to macrofossil abundance. For example, due to different structures, as well as different processing techniques, taxa will vary in their potential for charring, and in their capacity to preserve once they are burned and deposited (Miksicek 1987). A critical distinction made throughout this paper is between large seed re-

mains, comprised mostly of dense, inedible nutshell or berry pits, and small seed remains, which are mostly digestible food products. Whereas large seed residue is the robust, fragmented refuse of taxa often processed with fire (such as gray pine [*Pinus sabiniana*] or bay nut [*Umbellularia californica*]; Barrett and Gifford 1933), small seed remains are more delicate, and often represent whole items accidentally lost during cleaning or parching. In addition to differential paths into the archaeological record and variable potential for preservation, large seed residue is best quantified by weight, due to the propensity for fragments to become smaller with age, while small seeds are best quantified by count (Wohlgemuth 1989).

While it may be fruitful to model the differential potential for charring and preservation for taxa commonly recovered from the archaeological record, it seems possible to circumvent the effects of varying taphonomic processes by adopting a comparative perspective that assumes that similar depositional and decomposition processes operated at open air sites. In this view, clear-cut distinctions in the relative frequency or proportion of taxa over time probably relate to shifting dietary patterns, although the absolute contribution of various taxa to the diet remains unknown. It is also important to note that the majority of widespread, archaeologically common seed residues are well-described native Californian foodstuffs (Chesnut 1902; Barrett and Gifford 1933; Duncan 1963; Bocek 1984).

Because all sites considered in this study are located in interior settings of oak woodland or savanna, habitats where both acorns and economically important small seeds could be gathered in quantity, the following analyses focus on these taxa. Other important plant resources (e.g., manzanita, gray pine, hazelnut) are excluded from the initial analysis because their presence in the archaeological record varies from site to site due to local environmental conditions. These latter taxa, although impor-

tant for developing local sequences of subsistence change, are not appropriate here due to the interregional scale of this study. Instead, the simple ratio of acorn nutshell (in milligrams) to small seeds (identified at least to family taxonomic level, by count of identifiable fragments) is used as a measure of changing economic strategies, assuming that groups making greater use of acorn should produce more burned acorn debris relative to small seeds than people consuming less acorn. If the intensification models are correct, Middle Period sites should have the highest acorn to small seeds ratio, followed by a lower ratio among Late Period sites, while Early Period sites should have the lowest ratio of all.

Measures of assemblage diversity are also significant to the analysis of resource focus and intensification, and are calculated using Shannon-Weiner diversity statistics (Grayson 1984:159-160; Magurran 1988). The diversity index combines class richness (in this case, number of seed taxa) and evenness, the degree to which frequencies of different classes are concentrated or dispersed. For example, a sample of 100 seeds having 10 identified taxa with frequencies of 10 each is more diverse than a similar sample where one taxon has a frequency of 91, and the remainder only one each. This statistic is used in favor of other, more typical measures of archaeobotanical taxon abundance, such as ubiquity, which is problematic for sites where few soil samples have been analyzed (Popper 1988).

When using diversity indices, the effects of low numbers of soil samples for some sites are somewhat mitigated by their high frequency of identified seeds. The assumption is that people making more intensive use of acorns may have sacrificed some other resources in favor of acorns, in contrast to groups using a more diverse gathering strategy. Groups making more intensive use of plant resources in addition to acorns also are predicted to have more varied seed assemblages. Therefore, Middle Period

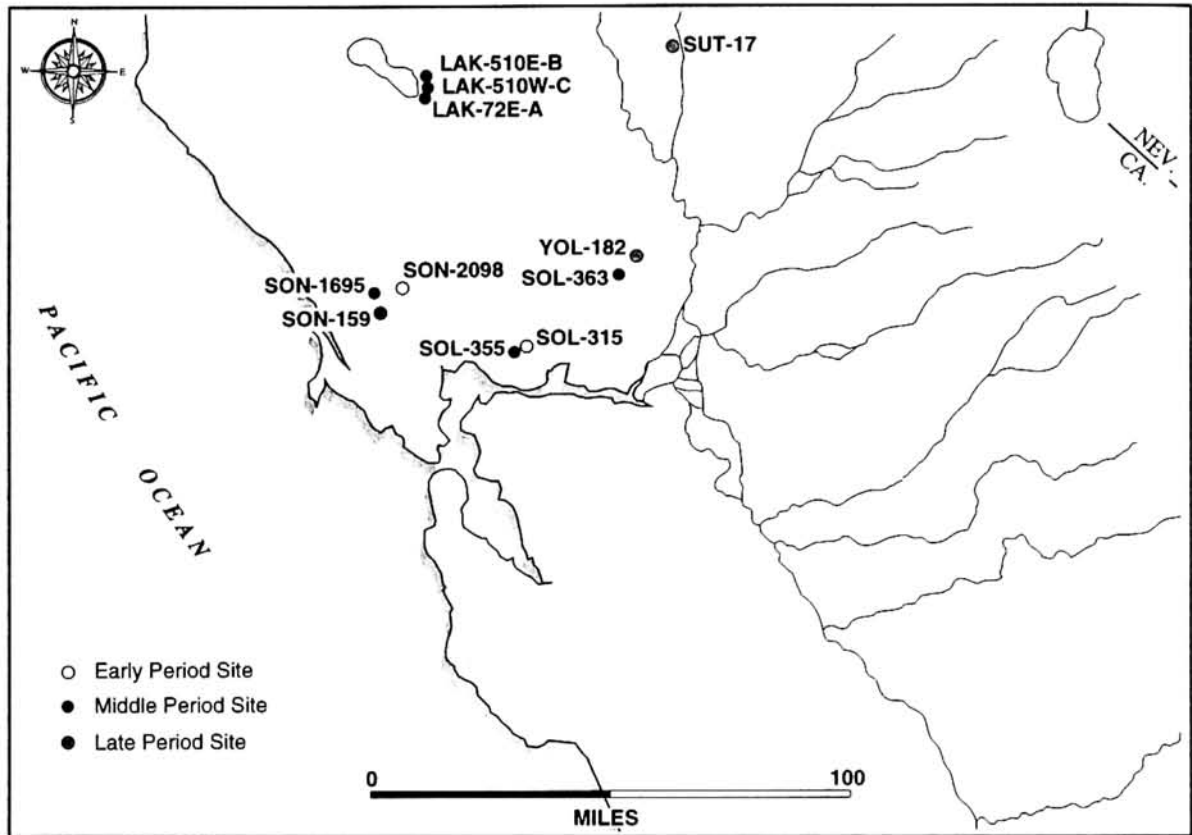


Fig. 1. Archaeological sites discussed in text.

sites should have the lowest diversity, while Early and Late period deposits should show use of a broader array of seeds. Diversity indices were calculated for both large and small seeds.

#### ARCHAEOLOGICAL SITE CONTEXTS

Data are available from 11 central California archaeological sites excavated as part of cultural resource management projects (Fig. 1, Table 1). These sites were selected because: (1) they feature well-differentiated, single-component areas; (2) all are residential sites with midden deposits, all have features, and several contain domestic structures, human burials, or formal cemeteries; (3) virtually all were intensively excavated, and site structure and occupation chronology is well understood; (4) all are located within a 40-mile radius, and include habitats with extensive oak

savanna; and (5) all are located in the North Coast Ranges or adjacent Central Valley, regions where the transition from milling stone and mano technology to a predominance of mortars and pestles occurred at roughly the same time (ca. 2,800 to 2,500 B.P., but see discussion for CA-LAK-510W-C below).

Early Period data are available from CA-SOL-315 in Green Valley, Solano County (Wi-berg 1992), and from CA-SON-2098 in Santa Rosa (Origer 1993). Uncalibrated radiocarbon dates on charcoal recovered from two features at CA-SOL-315 that were analyzed for plant remains were  $430 \pm 105$  RCYBP and  $1,850 \pm 90$  RCYBP, but the much fresher condition of wood charcoal in these features than in 13 other flotation samples examined from CA-SOL-315 indicated that these dates were clearly intrusive, as

Table 1  
SITE CONTEXTS AND ARCHAEOBOTANICAL  
SAMPLING PARAMETERS FROM STUDIED SITES

| Site                          | Cubic Meters Excavated |                   | Features Excavated   | No. of Soil Samples | Horizontal Proveniences Sampled | No. of Identified Large Seeds | No. of Identified Small Seeds <sup>a</sup> |
|-------------------------------|------------------------|-------------------|--|---------------------|---------------------------------|-------------------------------|--|
|                               | Hand Excavated         | Monitored Grading |  |                     |                                 |                               |  |
| <b>Early Period</b>           |                        |                   |  |                     |                                 |                               |  |
| CA-SOL-315<br>(Green Valley)  | 9.3                    | 2,000             | FAR <sup>b</sup> clusters, pits, mortar clusters, interments                           | 13                  | 12                              | 284                           | 998  |
| CA-SON-2098<br>(Santa Rosa)   | 10.0                   | 38                | FAR clusters   | 5                   | 5                               | 704                           | 1,181                                      |
| <b>Middle Period</b>          |                        |                   |  |                     |                                 |                               |  |
| CA-SOL-355<br>(Green Valley)  | 9.8                    | >500              | FAR clusters, mortar cluster, burned shell lens, interments                            | 8                   | 8                               | 2,293                         | 234  |
| CA-SOL-363<br>(Dixon)         | 27.7                   | >500              | FAR clusters, pits, ash lens, interments   | 8                   | 8                               | 1,079                         | 410  |
| CA-SON-1695<br>(Sebastopol)   | 10.3                   | --                | <i>Tresus</i> shell lens   | 5                   | 1                               | 1,253                         | 71   |
| CA-LAK-72E-A<br>(Lower Lake)  | 77.0                   | --                | structures, FAR clusters, flake heaps, milling stone cairn, baking feature, interments | 12                  | 12                              | 2,326                         | 74   |
| CA-LAK-510E-B<br>(Lower Lake) | 66.8                   | --                | structures, interments   | 3                   | 1                               | 8,067                         | 324  |
| CA-LAK-510W-C<br>(Lower Lake) | 27.0                   | --                | extensive occupation surface, rock pile  | 6                   | 6                               | 373                           | 52   |
| <b>Late Period</b>            |                        |                   |  |                     |                                 |                               |  |
| CA-SON-159<br>(Cotati)        | >10                    | --                | structures, FAR clusters with ash and shell  | 3                   | 1                               | >2,000                        | 3,029                                      |
| CA-SUT-17<br>(Marysville)     | 3.7                    | --                | structures, ash lenses, interment  | 5                   | 1                               | 8,507                         | 1,017                                      |
| CA-YOL-182<br>(Davis)         | 2.0                    | >200              | structure, FAR clusters, ash lenses, interments  | 15                  | 6                               | 597                           | >4,000                                     |

<sup>a</sup> Identified at least to family level.

<sup>b</sup> Fire-altered rock.

is an additional date of  $360 \pm 60$  RCYBP. A date of  $2,420 \pm 60$  RCYBP may derive from the terminus of most intensive site occupation, as 75 Napa obsidian hydration rim values show clustering between 4.2 and 7.5 microns, approximately 4,600 to 2,500 B.P. (Wiberg 1992). The 13 samples summarized here have degraded seed and wood charcoal constituents, and most likely represent this older occupation.

While CA-SOL-315 is a near-surface deposit from which plant remains show the ravages of time, CA-SON-2098 is buried under 2.5 m. of

alluvium. The site appears to have been occupied during two periods, the first dating between 5,500 and 3,000 B.P., based on calibrated radiocarbon assays of  $5,110 \pm 150$  RCYBP,  $5,465 \pm 80$  RCYBP, and  $5,450 \pm 110$  RCYBP from charcoal in the deposit, and Napa obsidian hydration rim measurements ranging between 4.2 and 5.5 microns. The second phase of occupation dates from ca. 2,000 to 1,100 B.P., based on Annadel obsidian hydration rim values ranging between 1.8 and 2.6 microns (converting to 2.3 to 3.4 microns, following Tremaine [1989]).



The well-preserved plant remains, which are of comparable condition to those of Middle or Late period deposits, are considered to date to the earliest site occupation inasmuch as two of the five flotation samples summarized here were the source of the Mid-Holocene radiocarbon dates cited above (Origer 1993). Identified faunal remains were absent from CA-SON-2098, and only eight of 961 bones could be identified to genus or species at CA-SOL-315.

Middle Period data are available from six sites, all featuring midden deposits with rich faunal assemblages. CA-SOL-355 (Wiberg 1993) is located some 500 m. west of CA-SOL-315. Time-sensitive artifacts recovered with numerous burials date mostly between 1,800 and 1,200 B.P., corresponding for the most part to the clustering of 21 Napa obsidian hydration rim values (3.2 to 4.5 microns) indicative of occupation from 2,300 to 1,300 B.P. Uncalibrated radiocarbon dates of  $3,380 \pm 105$  RCYBP and  $2,890 \pm 70$  RCYBP on charcoal from the base of the deposit appear to predate the bulk of site materials (Wiberg 1993). CA-SOL-363, near Dixon, appears to date to between approximately 1,500 and 1,300 B.P. (Rosenthal and White 1994). Occupation at CA-SON-1695, located near Sebastopol, dates between 2,000 and 900 B.P. (Gmoser 1994).

Three Middle Period sites were excavated at Anderson Flat, south of the outlet of Cache Creek near Lower Lake (White et al. 1995). CA-LAK-72E-A dates to the Late Houx Phase, or 2,000 to 1,200 B.P., CA-LAK-510E-B dates to 2,800 to 2,000 B.P., and CA-LAK-510W-C was occupied during the Creager Phase, approximately 3,500 to 2,800 B.P. CA-LAK-510W-C is considered to be a Middle Period site because it dates to the earliest defined phase of the Houx Tradition, a Middle Period construct outlined by Fredrickson (1974).

Late Period data are limited to three sites, all deep middens with rich artifact and ecofact assemblages. Both CA-SON-159 (Gmoser 1994),

near Cotati, and CA-SUT-17 (Bouey 1993), south of Marysville along the Lower Feather River, are dated between 900 and 150 B.P. Occupation at CA-YOL-182, in Davis, is limited to Phase 2 of the Late Period (350 to 150 B.P.; Shapiro and Tremaine 1995).

The key data are those from all or part of Middle to Late Holocene chronological sequences in specific localities, as there is minimal influence of environmental variability on the content of archaeobotanical assemblages in these places. The most complete data are from Santa Rosa, where Early, Middle, and Late period deposits are within a five-mile radius. At Green Valley, Early Period CA-SOL-315 and Middle Period CA-SOL-355 are within 500 meters of each other. In the Davis-Dixon portion of the western Sacramento Valley, Middle Period CA-SOL-363 is some eight miles southwest of Late Period CA-YOL-182.

## RESULTS

Ratios of acorn nutshell to small seeds, as well as diversity calculations for both large and small seeds, are shown in Tables 2 and 3. Details of site seed and fruit assemblages are shown in Tables 4 and 5. Beginning with the Green Valley data, the acorns to small seeds ratio is over 200 times larger at CA-SOL-355 (11.54) than at adjacent CA-SOL-315 (0.05). Inasmuch as the ratios at Green Valley mirror trends in Early to Middle period acorn proportion (14.5% of the identified large seeds at CA-SOL-315 versus 46.1% at CA-SOL-355 [Wohlgemuth 1993a]), it is possible to posit the utility of the current measure for sites where acorn proportion is not appropriate. Paralleling the Green Valley data, the ratio at the Santa Rosa locality Middle Period site CA-SON-1695 (11.87) is 66 times that of Early Period CA-SON-2098 (0.18), and is over 11 times that of Late Period CA-SON-159 (1.07). As at Green Valley, the Santa Rosa ratio data mirror trends in acorn proportion, which jumps from 31.3% of large seeds at CA-

Table 2  
ACORNS TO SMALL SEEDS RATIO AND DIVERSITY CALCULATIONS  
FOR LARGE SEEDS AT STUDIED SITES

| Site                 | Acorns to Small<br>Seeds Ratio | Diversity<br>Index | Evenness<br>Index | Richness | Number of<br>Seeds <sup>a</sup> |
|----------------------|--------------------------------|--------------------|-------------------|----------|---------------------------------|
| <b>Early Period</b>  |                                |                    |                   |          |                                 |
| CA-SOL-315           | 0.05                           | 1.04               | 0.65              | 5        | 284                             |
| CA-SON-2098          | 0.18                           | 1.04               | 0.58              | 6        | 704                             |
| <b>Middle Period</b> |                                |                    |                   |          |                                 |
| CA-SOL-355           | 11.54                          | 0.88               | 0.55              | 5        | 2,293                           |
| CA-SOL-363           | 0.93                           | 0.11               | 0.08              | 4        | 1,079                           |
| CA-SON-1695          | 11.87                          | 0.13               | 0.07              | 6        | 1,253                           |
| CA-LAK-72E-A         | 8.32                           | 0.72               | 0.44              | 5        | 2,326                           |
| CA-LAK-510E-B        | 11.29                          | 0.46               | 0.29              | 5        | 8,067                           |
| CA-LAK-510W-C        | 2.79                           | 0.98               | 0.61              | 5        | 373                             |
| <b>Late Period</b>   |                                |                    |                   |          |                                 |
| CA-SON-159           | 1.07                           | 0.65               | 0.41              | 5        | >2,000                          |
| CA-SUT-17            | 12.49                          | 0.06               | 0.05              | 3        | 8,507                           |
| CA-YOL-182           | 0.26                           | 0.30               | 0.27              | 3        | 597                             |

<sup>a</sup> Identified to genus level.

SON-2098 to 89.0% at CA-SON-1695, and 86.4% at CA-SON-159 (Table 4). While not nearly the magnitude of the difference at Green Valley or Santa Rosa, Middle Period CA-SOL-363 has a ratio (0.93) over three times that of nearby Late Period CA-YOL-182 (0.26).

The same tendencies are apparent when considering data by time period for the entire sample of 11 sites. For the most part, Middle Period deposits have the highest ratios, and Early Period sites the lowest, with Late Period sites having intermediate values. Not shown with the acorn to small seeds ratio, however, is the staggering amount of acorn at two of the Late Period sites; acorn nutshell densities (mg. per liter of sediment) for CA-SUT-17 and CA-SON-159 are 715.6 and 126.9, respectively

(Wohlgemuth 1993b, 1994). By contrast, acorn nutshell density at the three Middle Period sites with the richest middens, CA-SOL-355, CA-LAK-72E-A, and CA-LAK-510E-B, is 31.5, 3.5, and 27.8, respectively (Wohlgemuth 1993a, 1995). There is no doubt that acorns were very important food resources at CA-SON-159 and CA-SUT-17. However, acorns may not have been as important at CA-YOL-182, where small seeds are very abundant but acorn density is only 24.2 mg.

The results of diversity statistic calculations for large seeds (Table 2) mirror the findings of the ratio and proportion analyses. In the Santa Rosa locality, the diversity index is greatest for Early Period CA-SON-2098, lowest for Middle Period CA-SON-1695, and intermediate for Late

Table 3  
ACORNS TO SMALL SEEDS RATIO AND DIVERSITY CALCULATIONS  
FOR SMALL SEEDS AT STUDIED SITES

| Site                 | Acorns to Small<br>Seeds Ratio | Diversity<br>Index | Evenness<br>Index | Richness | Number of<br>Seeds <sup>a</sup> |
|----------------------|--------------------------------|--------------------|-------------------|----------|---------------------------------|
| <b>Early Period</b>  |                                |                    |                   |          |                                 |
| CA-SOL-315           | 0.05                           | 1.40               | 0.61              | 10       | 89                              |
| CA-SON-2098          | 0.18                           | 2.06               | 0.76              | 15       | 544                             |
| <b>Middle Period</b> |                                |                    |                   |          |                                 |
| CA-SOL-355           | 11.54                          | 2.18               | 0.79              | 16       | 154                             |
| CA-SOL-363           | 0.93                           | 1.54               | 0.60              | 13       | 282                             |
| CA-SON-1695          | 11.87                          | 1.17               | 0.60              | 7        | 49                              |
| CA-LAK-72E-A         | 8.32                           | 1.94               | 0.93              | 8        | 19                              |
| CA-LAK-510E-B        | 11.29                          | 1.78               | 0.91              | 7        | 93                              |
| CA-LAK-510W-C        | 2.79                           | 1.26               | 0.78              | 5        | 13                              |
| <b>Late Period</b>   |                                |                    |                   |          |                                 |
| CA-SON-159           | 1.07                           | 1.99               | 0.70              | 17       | 1,298                           |
| CA-SUT-17            | 12.49                          | 2.12               | 0.66              | 25       | 626                             |
| CA-YOL-182           | 0.26                           | 2.10               | 0.65              | 25       | 3,749                           |

<sup>a</sup> Identified to genus level.

Period CA-SON-159. Similar patterns are found in Green Valley, where the Early Period CA-SOL-315 diversity value exceeds that of Middle Period CA-SOL-355, and in the Davis-Dixon area, where the Middle Period CA-SOL-363 diversity value is lower than at Late Period CA-YOL-182. Given the higher acorn to small seeds ratios and acorn proportions at all of the Middle Period sites, it is apparent that the high frequency of acorn in deposits dating to this era accounts for the lower diversity and evenness values. Large seed richness does not seem to vary much by time period for any of the three localities, due to the relatively few large seed resources available in each locality. Large seed diversity values for the other sites considered seem to be a function of local plant community

diversity: Middle Period sites near Lower Lake have much higher diversity and evenness indices than Late Period CA-SUT-17, due to the presence of several foothill nut and berry taxa absent in the Sacramento Valley bottom.

Diversity statistics demonstrate somewhat different patterning for small seeds (Table 3, Fig. 2). The same trends observed for large seeds are found with small seeds for Santa Rosa and Davis-Dixon. Diversity values are highest for CA-SON-2098, lowest for CA-SON-1695, and intermediate for CA-SON-159. Similarly, CA-SOL-363 has a diversity index lower than CA-YOL-182. Only in Green Valley do the small seed data break from trends found for large seeds, as diversity at Early Period CA-SOL-315 is much less than at Middle Period

**Table 4**  
**COUNTS AND WEIGHTS (mg.) OF LARGE SEEDS PER LITER**  
**OF SEDIMENT FROM STUDIED SITES**

| Taxon  | Common Name       | Early      |             |            | Middle     |             |              |               |               |            | Late      |            |                 |
|--|-------------------|------------|-------------|------------|------------|-------------|--------------|---------------|---------------|------------|-----------|------------|-----------------|
|  |                   | CA-SOL-315 | CA-SON-2098 | CA-SOL-355 | CA-SOL-363 | CA-SON-1695 | CA-LAK-72E-A | CA-LAK-510E-B | CA-LAK-510W-C | CA-SON-159 | CA-SUT-17 | CA-YOL-182 |                 |
| <i>Quercus</i> sp.                             | oak acorn         | No.        | 0.63        | 2.42       | 25.20      | 9.44        | 29.52        | 10.33         | 56.39         | 6.57       | 208.28    | 433.70     | 12.74           |
|  |                   | Wt.        | 0.24        | 1.68       | 31.50      | 3.60        | 22.31        | 3.54          | 27.78         | 1.98       | 126.87    | 715.60     | 24.16           |
| <i>Arctostaphylos</i> sp.                      | manzanita nutlets | No.        | 0.24        | 0.20       | 2.80       | 0.04        | 0.07         | 2.69          | 1.13          | 0.30       | --        | --         | .. <sup>a</sup> |
|  |                   | Wt.        | 1.07        | 0.72       | 15.80      | 0.02        | 0.18         | 1.41          | 5.47          | 0.77       | --        | --         | .. <sup>a</sup> |
| <i>Marah</i> sp.                               | wild cucumber     | No.        | 0.23        | 2.86       | 5.20       | 0.15        | 0.05         | 0.80          | 2.35          | 0.32       | 9.84      | 0.50       | 1.07            |
|  |                   | Wt.        | 0.32        | 1.60       | 10.82      | 0.26        | 0.10         | 0.98          | 2.08          | 0.52       | 8.43      | 0.60       | nd <sup>b</sup> |
| <i>Umbellularia californica</i>                | bay               | No.        | 0.01        | 0.20       | 2.70       | --          | 0.24         | 0.09          | 1.02          | 0.08       | 9.96      | --         | --              |
|  |                   | Wt.        | 0.01        | 0.12       | 3.20       | --          | 0.16         | 0.04          | 0.64          | 0.04       | 6.97      | --         | --              |
| <i>Pinus sabiniana</i>                         | Gray pine         | No.        | --          | 0.02       | --         | --          | --           | 0.98          | 1.94          | 0.75       | --        | --         | .. <sup>a</sup> |
|  |                   | Wt.        | --          | 0.01       | --         | --          | --           | 2.76          | 12.24         | 1.99       | --        | --         | .. <sup>a</sup> |
| <i>Aesculus californica</i>                    | buckeye           | No.        | 0.05        | --         | 0.10       | --          | --           | --            | --            | --         | 0.65      | --         | --              |
|  |                   | Wt.        | 0.04        | --         | 0.20       | --          | --           | --            | --            | --         | 0.10      | --         | --              |
| <i>Vitis californica</i>                       | wild grape        | No.        | --          | --         | --         | 0.01        | --           | --            | --            | --         | --        | 4.10       | 0.05            |
|  |                   | Wt.        | --          | --         | --         | 0.01        | --           | --            | --            | --         | --        | 9.20       | nd              |
| <i>Corylus cornuta</i> var. <i>californica</i> | hazelnut          | No.        | --          | 0.12       | --         | --          | 0.24         | --            | --            | --         | 0.65      | --         | --              |
|  |                   | Wt.        | --          | 1.17       | --         | --          | 2.31         | --            | --            | --         | 4.20      | --         | --              |
| <b>Totals</b>                                  |                   | No.        | 1.16        | 5.82       | 36.00      | 9.64        | 30.12        | 14.89         | 62.83         | 8.02       | nd        | 438.30     | 13.86           |
|  |                   | Wt.        | 1.68        | 5.37       | 61.52      | 3.89        | 25.06        | 8.73          | 48.20         | 5.30       | 146.57    | 725.40     | nd              |
| <i>Brodiaea/Dichelostemma</i> sp.              | Brodiaea bulbs    | No.        | --          | 0.04       | 0.10       | 0.04        | 0.05         | --            | 0.03          | 0.01       | --        | --         | --              |

<sup>a</sup> Found in field screens but not in flotation samples.

<sup>b</sup> No data available.

CA-SOL-355. However, the Green Valley data cannot be taken at face value. Small seeds are more abundant, if less easily identified, at CA-SOL-315 than at CA-SOL-355 (identified [at

least to family level] seed counts/liter of sediment of 4.35 and 2.82, respectively). This not only illustrates the degradation of fragile small seeds at CA-SOL-315, it also implies that

Table 5  
 COUNTS OF IDENTIFIED SMALL SEEDS PER LITER OF SEDIMENT FROM STUDIED SITES

| Taxon                    | Common Name        | Early       |             |             |             | Middle      |              |               |               |               | Late         |              |  |
|--------------------------|--------------------|-------------|-------------|-------------|-------------|-------------|--------------|---------------|---------------|---------------|--------------|--------------|--|
|                          |                    | CA-SOL-315  | CA-SON-2098 | CA-SOL-355  | CA-SOL-363  | CA-SON-1695 | CA-LAK-72E-A | CA-LAK-510E-B | CA-LAK-510W-C | CA-SON-159    | CA-SUT-17    | CA-YOL-182   |  |
| <i>Amaranthus</i> sp.    | pigweed            | 0.005       | --          | --          | 0.02        | --          | --           | --            | --            | 0.40          | 0.20         | --           |  |
| cf. <i>Amsinckia</i> sp. | fiddleneck         | --          | 0.17        | 0.05        | 0.01        | --          | 0.005        | 0.04          | 0.08          | 0.40          | 0.50         | 0.07         |  |
| <i>Aristida</i> sp.      | Three awn grass    | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.02         |  |
| <i>Atriplex</i> sp.      | saltbush           | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.07         |  |
| <i>Bromus</i> sp.        | brome grass        | --          | --          | --          | --          | --          | 0.03         | 0.08          | --            | 1.50          | 2.50         | 0.23         |  |
| <i>Calandrinia</i> sp.   | redmaids           | 0.005       | 0.07        | 0.05        | 0.78        | --          | --           | --            | --            | --            | 4.70         | 9.42         |  |
| <i>Carex</i> sp.         | sedge              | --          | --          | --          | --          | --          | --           | --            | --            | --            | 0.20         | --           |  |
| <i>Chenopodium</i> sp.   | goosefoot          | 0.01        | 0.10        | 0.33        | 1.30        | 0.80        | 0.02         | 0.09          | --            | 9.50          | 1.50         | 37.14        |  |
| <i>Clarkia</i> sp.       | Farewell to spring | --          | 1.27        | 0.53        | 0.10        | --          | 0.03         | 0.16          | 0.01          | 1.67          | 16.80        | 0.91         |  |
| <i>Claytonia</i> sp.     | Miner's lettuce    | --          | 0.01        | --          | 0.05        | --          | --           | --            | --            | 0.23          | --           | 0.65         |  |
| <i>Deschampsia</i> sp.   | hairgrass          | 0.01        | 0.27        | 0.13        | 0.02        | 0.02        | 0.01         | 0.09          | 0.01          | 13.63         | --           | 3.81         |  |
| <i>Eleocharis</i> sp.    | spikerush          | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.02         |  |
| <i>Elymus</i> sp.        | wild rye           | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 3.91         |  |
| <i>Eriogonum</i> sp.     | wild buckwheat     | --          | --          | --          | 0.01        | --          | --           | --            | --            | --            | 0.20         | --           |  |
| <i>Eriophyllum</i> sp.   | none               | --          | --          | --          | --          | --          | --           | --            | --            | --            | 0.40         | --           |  |
| <i>Gallium</i> sp.       | bedstraw           | 0.06        | 0.30        | 0.07        | --          | 0.02        | --           | --            | 0.04          | 0.03          | 0.10         | 0.02         |  |
| <i>Helianthus</i> sp.    | sunflower          | --          | --          | 0.01        | --          | --          | --           | --            | --            | --            | 0.30         | --           |  |
| <i>Hemizonia</i> sp.     | tarweed            | --          | --          | --          | --          | --          | --           | --            | --            | 0.73          | 0.10         | --           |  |
| <i>Hordeum</i> sp.       | wild barley        | --          | 0.03        | 0.01        | --          | --          | --           | --            | --            | 2.33          | 0.20         | 5.84         |  |
| <i>Lasthenia</i> sp.     | goldfields         | --          | --          | 0.04        | --          | --          | --           | --            | --            | --            | --           | --           |  |
| <i>Lotus</i> sp.         | Spanish clover     | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.42         |  |
| <i>Lupinus</i> sp.       | lupine             | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.28         |  |
| <i>Madia</i> sp.         | tarweed            | --          | 0.81        | 0.02        | --          | --          | --           | 0.01          | --            | 2.17          | 0.40         | 4.12         |  |
| <i>Melica</i> sp.        | melic grass        | 0.005       | --          | 0.01        | --          | --          | --           | --            | --            | --            | --           | --           |  |
| <i>Mentzelia</i> sp.     | Blazing star       | --          | --          | --          | --          | 0.07        | --           | --            | --            | --            | --           | --           |  |
| <i>Nemophila</i> sp.     | none               | --          | --          | --          | --          | --          | --           | --            | --            | --            | 0.10         | --           |  |
| <i>Panicum</i> sp.       | panic grass        | --          | --          | --          | --          | --          | --           | --            | --            | --            | 2.40         | --           |  |
| <i>Phacelia</i> sp.      | wild heliotrope    | --          | 0.05        | --          | --          | --          | --           | --            | --            | --            | --           | --           |  |
| <i>Phalaris</i> sp.      | maygrass           | 0.08        | 0.82        | 0.23        | 0.15        | 0.10        | --           | --            | --            | 2.87          | 4.20         | 5.00         |  |
| <i>Poa</i> sp.           | bluegrass          | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.23         |  |
| <i>Ranunculus</i> sp.    | buttercup          | 0.005       | 0.42        | --          | --          | 0.10        | --           | --            | --            | 1.73          | 0.30         | 0.16         |  |
| <i>Rosa</i> sp.          | wild rose          | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | --           |  |
| <i>Rubus</i> sp.         | blackberry         | 0.005       | --          | --          | --          | --          | --           | --            | --            | --            | 0.20         | --           |  |
| <i>Rumex/Polygonum</i>   | dock or knotweed   | --          | --          | --          | 0.07        | --          | --           | --            | --            | --            | --           | 0.42         |  |
| <i>Sambucus</i> sp.      | elderberry         | --          | 0.02        | --          | --          | --          | --           | --            | --            | --            | 0.40         | 14.26        |  |
| <i>Scirpus</i> sp.       | tule               | --          | 0.01        | 0.07        | 0.03        | 0.07        | 0.005        | --            | --            | 0.13          | 0.20         | 0.09         |  |
| <i>Solanum</i> sp.       | nightshade         | --          | --          | --          | 0.15        | --          | --           | --            | --            | 0.17          | 2.30         | --           |  |
| <i>Stipa</i> sp.         | needlegrass        | --          | --          | 0.01        | --          | --          | --           | --            | --            | --            | 0.20         | --           |  |
| cf. <i>Trifolium</i> sp. | probably clover    | --          | --          | 0.16        | --          | --          | 0.01         | 0.04          | 0.04          | nd            | 0.20         | 2.37         |  |
| <i>Urtica</i> sp.        | nettle             | --          | --          | --          | --          | --          | --           | --            | --            | --            | --           | 0.02         |  |
| <i>Vulpia/Festuca</i>    | fescue grass       | 0.21        | 0.14        | 0.05        | 0.04        | --          | 0.005        | 0.23          | --            | 13.33         | 1.90         | 2.67         |  |
| Asteraceae               | Sunflower family   | 0.005       | 1.20        | 0.06        | 0.04        | 0.05        | 0.06         | 0.13          | 0.02          | 5.67          | 5.10         | nd           |  |
| Fabaceae                 | Bean family        | 0.02        | 1.46        | 0.06        | 0.42        | 0.07        | 0.01         | 0.14          | 0.15          | 8.30          | 1.20         | nd           |  |
| Poaceae                  | Grass family       | 4.10        | 2.45        | 0.84        | 0.68        | 0.58        | 0.24         | 1.45          | 0.36          | 54.13         | 10.50        | nd           |  |
| <b>Total Identified</b>  |                    | <b>4.52</b> | <b>9.60</b> | <b>2.73</b> | <b>3.87</b> | <b>1.88</b> | <b>0.43</b>  | <b>2.46</b>   | <b>0.71</b>   | <b>118.92</b> | <b>57.30</b> | <b>92.15</b> |  |

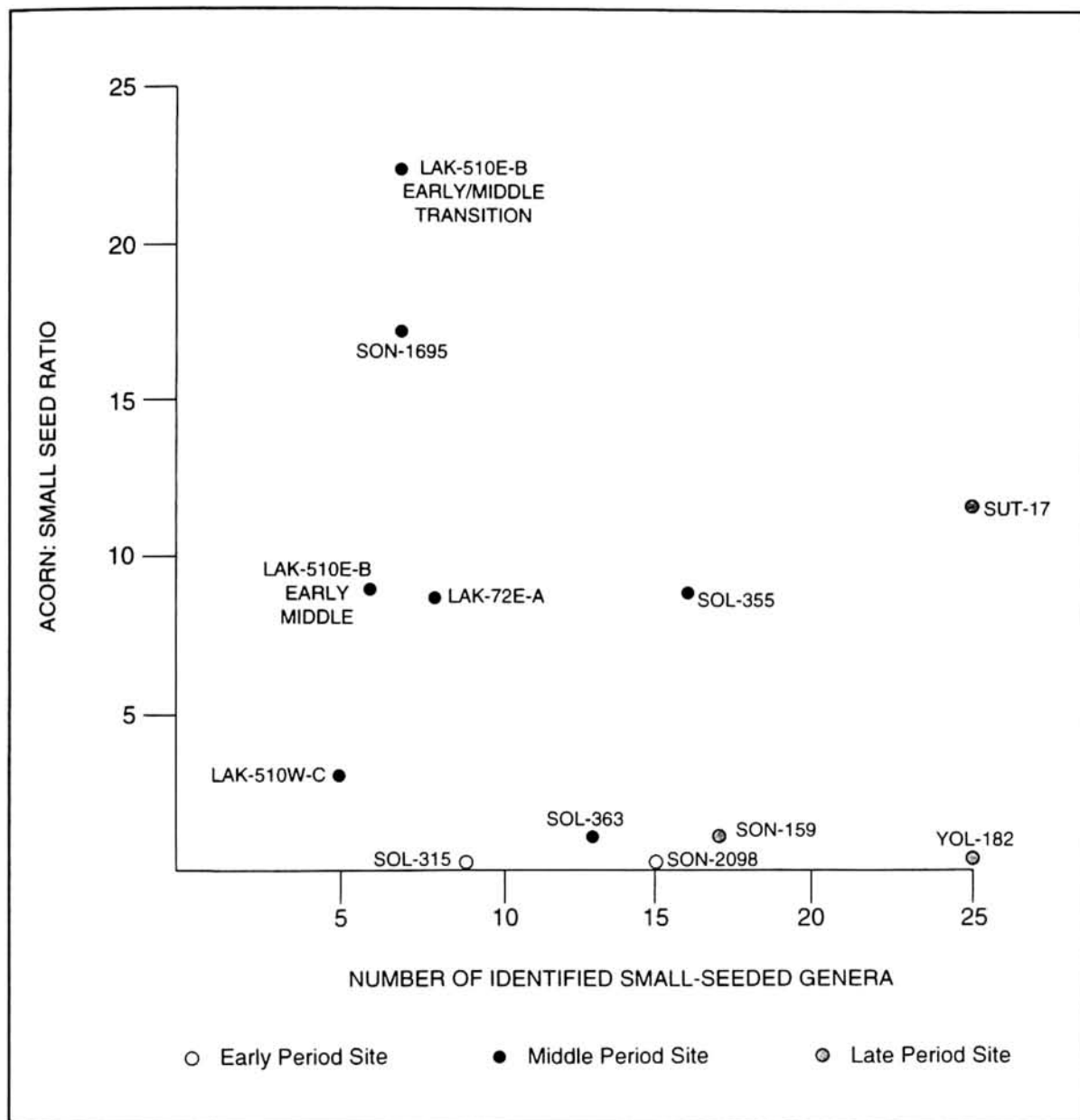


Fig. 2. Acorns to small seeds ratio by small seed richness for 11 central California sites.

small seeds were used more often than at CA-SOL-355 (Wohlgemuth 1993a).

While numerous large seeds were identified from all sites, the widely varying number of identified small seeds (from 13 at CA-LAK-510W-C to over 4,000 at CA-YOL-182) raises concerns about the relationship of sample size to diversity values (Grayson 1984). A regression

of log values of diversity by log values of sample size was calculated for small seeds (Fig. 3), which demonstrates that diversity is indeed predicted with 95% confidence by sample size, with t test values significant at  $p=0.0533$ . As discussed in more detail below, in those cases where there is a relationship between low small seed counts and low diversity values, the overall

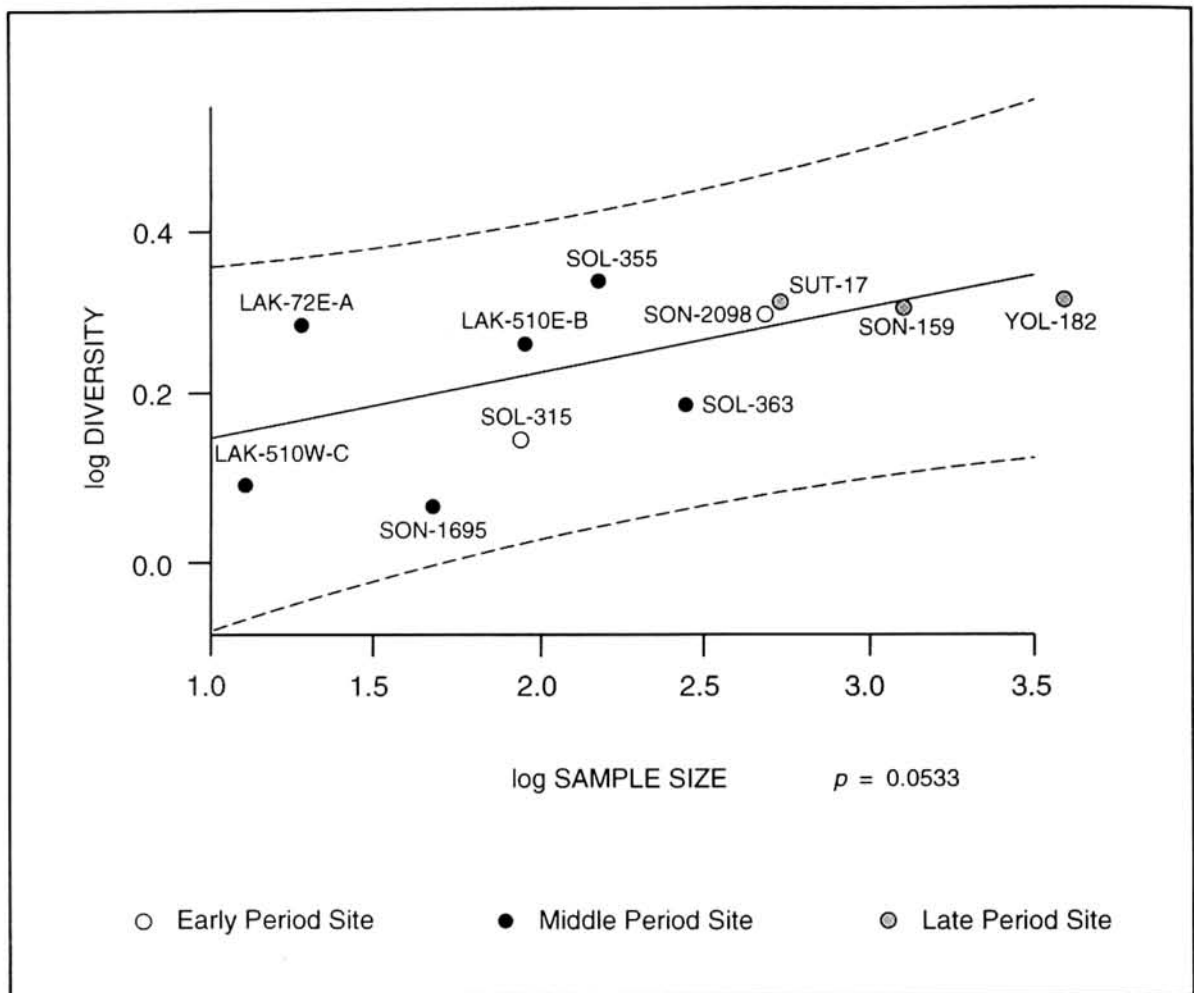


Fig. 3. Regression plot and 95% confidence limits of small seed diversity by sample size.

sample of seeds (i.e., both large and small seeds) is quite large, demonstrating the low utility of small seeds in Middle Period contexts.

Milling tool data from the sites in question are summarized in Table 6. No obvious patterning of the type noted previously is apparent in this sample (Basgall 1987; Basgall and Bouey 1991). There are too few specimens from any of the Santa Rosa or Davis-Dixon sites to shed light upon the hypotheses. At Green Valley, both CA-SOL-315 and CA-SOL-355 are dominated by mortars and pestles, the latter exclusively, indicating little variation through time. Of interest here is the observation that most

mortars at CA-SOL-315 are quite shallow (Wiberg 1992), whereas most of the CA-SOL-355 mortars are deeper (Wiberg 1993).

When viewed by period, the data remain unenlightening. Except for CA-SOL-315, milling tools are scant from both the Early and Late periods; the dearth in the Late Period sites stems in part from the small volume of excavated deposits compared to the earlier sites. While large samples of seed remains can be recovered from limited testing, milling tools often are found in quantity only in larger scale excavations. Of interest is the change in Lower Lake Middle Period sites from earlier assemblages, with a pre-

Table 6  
MILLING TOOL ASSEMBLAGES FROM STUDIED SITES

| Site                 | Mortars | Pestles | Millingstones | Manos |
|----------------------|---------|---------|---------------|-------|
| <b>Early Period</b>  |         |         |               |       |
| CA-SOL-315           | 300     | 92      | 4             | 5     |
| CA-SON-2098          | 3       | 1       | 2             | 4     |
| <b>Middle Period</b> |         |         |               |       |
| CA-SOL-355           | 14      | 11      | —             | —     |
| CA-SOL-363           | —       | 1       | —             | —     |
| CA-SON-1695          | 2       | 6       | 2             | —     |
| CA-LAK-72E-A         | 5       | 18      | —             | 6     |
| CA-LAK-510E-B        | 8       | 21      | 6             | 12    |
| CA-LAK-510W-C        | 2       | 12      | 7             | 24    |
| <b>Late Period</b>   |         |         |               |       |
| CA-SON-159*          | 1       | 2       | 3             | —     |
| CA-SUT-17            | —       | —       | —             | —     |
| CA-YOL-182           | —       | 3       | 1             | —     |

\* Data not available from extensive excavations in the 1970s.

ponderance of milling stones and manos (CA-LAK-510W-C), to later deposits dominated by mortars and pestles (CA-LAK-72E-A). Data from the remaining Middle Period sites are sparse and uninformative. This is not surprising, given that milling tool analyses from many sites in restricted areas often reveal broad patterns not borne out at individual sites of particular time periods (Basgall and Bouey 1991). More associated archaeobotanical and milling tool data than are presently available are needed to assess the relationship of plant remains to tool forms.

## DISCUSSION

The data clearly show that the two Early Period sites lack accumulations of acorn nutshell found in most Middle and Late period deposits. The apparent low small seed diversity in three of the Middle Period sites, in contrast to the apparent high diversity found in Early and Late

period sites, is shown by regression to be merely a function of variation in sample size. However, the presence of robust samples of large seeds in all sites, even those with few small seeds, demonstrates that the dearth of small seeds in all Middle Period sites, relative to Early and Late period assemblages (Tables 4 and 5), is genuine, and not an artifact of sample bias.

That the relatively low frequency of small seeds in Middle Period sites is not a function of differential preservation versus large seeds is illustrated by the number of small seed genera identified from CA-SOL-355 and CA-SOL-363, as well as the good condition of small seeds in these and all other Middle Period sites considered. It is also unlikely that the dearth of small seeds in most Middle Period sites is due solely to changes in processing technology. Small seed preparation typically involves gathering, winnowing and cleaning, parching, and grinding (Chesnut 1902; Barrett and Gifford 1933; Dun-



can 1963; Bocek 1984); the latter stages of processing provide ample opportunities for loss and charring. It is difficult to conceive how Middle Period processing could deviate from this sequence to the extent that small seeds would become rare in site deposits, while being abundant in Early and Late period deposits. The lack of small seeds in Middle Period deposits, then, probably reflects variability in subsistence practices.

The substantial sample of large seeds in sites with few small seeds also has implications for assemblage diversity. While they have different pathways to the archaeological record and different methodological treatment, carbonized large and small seeds are not truly independent data sets; each reflects seed processing and consumption. In this view, the larger sample of combined large and small seeds permits an assessment of diversity in the total seed assemblage not available from the small seed diversity values. Examining diversity for the entire seed assemblage (Tables 2 through 5), it is clear that at four of the six Middle Period sites (CA-LAK-72E-A, CA-LAK-510E-B, CA-LAK-510W-C, and CA-SON-1695), few types of small seeds were regularly processed and consumed. This is in marked contrast to all Late Period sites, to CA-SON-2098, and to Middle Period sites CA-SOL-355 and CA-SOL-363; but this issue is cloudy for the degraded assemblage from CA-SOL-315. Although data from many more sites are necessary to corroborate these trends, the data conform to predictions following from the intensification models outlined above (Basgall 1987; Basgall and Bouey 1991). In this sample of sites, the intensive use of acorns appears to begin in the Middle Period, and continues throughout the Late Period. The use of small seed resources seems to decline from the Early to Middle periods, and expands again in the Late Period.

There are, however, some potential problems with the intensification hypotheses, particu-

larly when considering the nature, distribution, and seasonality of California plant resources. Following Baumhoff (1963), McCarthy (1993) has shown that acorns of different species were viewed quite distinctly by native Californians. Two species, black oak (*Quercus kelloggii*) and tan oak (*Lithocarpus densiflora*) were preferred by all groups having access to them, while other species were seldom used for food at all, particularly the scrub oaks (e.g., *Quercus dumosa*, *Q. john-tuckeri* [Hickman 1993:661]). The preferred species are notable for far better long-term storage than less favored species (McCarthy 1993). Tan oak and black oak, however, are not distributed throughout California. The presence or absence of the preferred species no doubt influenced the date of adoption of acorn-intensive economies in particular regions.

Unfortunately, it is not yet possible to distinguish acorn species by charred nutshell fragments. Although there have been some species-level identifications made with archaeological attachment scar disks, which connect acorns to acorn cups (Hammett 1991; Wohlgemuth 1993c, 1994), these are seldom recovered in sufficient quantity to be significant. It should also be recognized that small seed resources are not all similar, and exhibit differences of habitat, gathering constraints, and to some extent, seasonal availability. Finally, no real scheduling conflict exists in gathering acorns and small seed resources, since acorns drop in the fall, while most small seeds ripen in the late spring or summer. Native Californians were not faced with a scheduling choice of gathering acorns or small seeds, unlike the decision which many groups may have been forced to make between the acorn crop and the heavy fall salmon run (McCarthy 1993:134).

If there is no scheduling conflict between acorns and small seeds, how is the virtual absence of small seed remains in most Middle Period sites explained, particularly in light of the stark contrast to the high frequency of acorn and

often other large seeds? This pattern may be evidence of site occupation seasonality, resource preference, and/or differential storage. Manzanita, wild cucumber, wild grape, and hazelnut ripen in the summer, while acorns, gray pine, bay, and buckeye ripen in the fall. If the majority of small seeds ripen in late spring, the Lower Lake sites and CA-SON-1695 may have been occupied primarily in summer, fall, and winter, but seasonally vacated in the spring. Alternatively, some resource focus other than small seeds may have obviated or precluded the use of late spring seeds; a likely candidate in this scenario may be fish runs, especially hitch (*Livinia* sp.) in the Anderson Flat locality, where Middle Period deposits contain abundant fish bone (White et al. 1995). Fish bone is also common at CA-SON-1695 (Gmoser 1994).

In this light, it is interesting that the two Middle Period sites with more abundant small seeds (CA-SOL-363 and CA-SOL-355) are located in habitats with poorer fish resources than Lower Lake. Indeed, fish are minor components of faunal assemblages at those sites, where artiodactyl bones are dominant (48.1% of the number of identified specimens [NISP] at CA-SOL-355, 54.2% of NISP at CA-SOL-363 [Wiberg 1993; Rosenthal and White 1994]). Furthermore, the later phases of the Berkeley Pattern of the Middle Period have been hypothesized as featuring an economy based on hunting more than the preceding Early Period, supported by high Middle Period projectile point to milling tool ratios in many deposits (Rosenthal and White 1994; White et al. 1995).

There are also interesting implications for winter storage in these data, in that the discovery of house floors at two Middle Period sites (CA-LAK-72E-A and CA-LAK-510E-B) points to winter occupation; Kroeber's (1925:175, 312, 340, 407, 447) studies of several central California groups suggest that substantial houses were occupied only during the winter, as people lived outside or in flimsy shelters in warmer seasons.

Winter occupation at CA-SOL-363 is supported by the complete absence of immature animal bone (total identified NISP = 322) indicative of spring residence (Rosenthal and White 1994:70). At least at CA-LAK-72E-A and CA-LAK-510E-B, it is clear that small seeds were not important winter stores, while *Chenopodium* sp. (goose-foot), *Calandrinia* sp. (redmaids), and *Clarkia* sp. (farewell to spring) may have been stored at CA-SOL-363.

Seasonality data for Early and Late period sites exhibit quite different patterns than for most Middle Period deposits. Given the degraded small seeds at CA-SOL-315, reliable Early Period seasonality data are available only at CA-SON-2098. Summer- and fall-ripening large seeds are common. The most common small taxon, *Clarkia* sp., ripens in very late spring or early summer, and the next most abundant taxa, maygrass and tarweed, are summer-ripening. These three taxa, plus hairgrass, another summer-ripening taxon, account for 72.3% of the diagnostic small seed assemblage. Seeds of taxa ripening earlier in spring are present in lower numbers, comprising the remaining 27.7% of the small seed assemblage. It may be that occupation at CA-SON-2098 was primarily during summer and fall seasons. As no structures were found, it is uncertain whether the site was occupied in winter. Unfortunately, comparative data are not available from nearby Middle Period CA-SON-1695, as insufficient small seeds diagnostic to season were recovered; the most common taxon, *Chenopodium* sp., includes both spring- and summer-ripening species (Munz 1968).

By contrast, Late Period CA-SON-159 features near-equal proportions of seeds diagnostic of summer (including *Clarkia* sp.) and spring seasons (52.3% and 47.7%, respectively). In addition to containing much more acorn, CA-SON-159 differs from CA-SON-2098 chiefly in this more even seasonal distribution of small seeds. Like CA-SON-159, Late Period CA-

SUT-17 also contains a superabundance of acorn, a relatively even seasonal distribution of summer (62.1%, again including *Clarkia* sp.) and spring (37.9%) small seeds, and house floors indicative of winter occupation.

There are at least two alternative explanations for the differences between these two Late Period sites and Early Period CA-SON-2098. The presence of richer and more balanced small seed assemblages may stem from more sedentary populations occupying locations for longer spans of the annual cycle, perhaps an outgrowth of greater territorial circumscription. Alternatively, the abundance of several small seed taxa may imply that at least some of these were foodstuffs stored for winter, along with acorns. CA-YOL-182 also has a balanced seasonal distribution, with 56.1% of summer-ripening seeds (including *Clarkia* sp.), versus 43.9% of spring seeds, but this site lacks the dense acorn residue found at the other Late Period sites.

Whether it reflects greater sedentism or storage of spring-ripening small seeds, a different economic strategy seems to have been followed in the Late Period than in the Middle Period. Regardless of the origin of the sparse small seed assemblages of most Middle Period sites, whether it be scheduling conflicts or seasonal movement, the three Late Period sites show signs of an economic shift, as various small seeds became more valuable food resources. This shift may have taken several forms, such as different work group organization (McGuire and Hildebrandt 1994; Jones 1995), with specific task groups (perhaps organized by gender) targeting the small seed harvest, while others were employed in other activities, such as fishing. The Late Period data are consistent with the notable diversity of ethnographic Native Californian subsistence strategies, in marked contrast to the heavy reliance of Native Americans elsewhere in North America on staples such as salmon, corn, or bison (Kroeber 1925:523-525).

Part of this Late Period strategy may have

been to increase production of small-seeded, disturbance-following plants through managed burning (Bean and Lawton 1973; Lewis 1973; Hammett 1991). It is possible that this production mode may have been emerging in the Late and Protohistoric periods as an incipient agricultural subsistence regime, perhaps analogous to preagriculturalists of the Mesolithic and early Neolithic Near East, or the pre-maize "Eastern Agricultural Complex" of eastern North America (Miksicek 1991). Ultimately, nut crops such as acorns cannot support progressively increasing populations; while technological and organizational modifications can increase the amount of acorns collected, processed, and stored, there is little that can be done to increase the amount produced (McCarthy 1993; Wohlgenuth 1993a). This may explain the relative abundance of acorns and other nuts earlier and their scarcity later in cultural sequences in regions where cultivation was adopted and a more complex social organization developed, such as eastern North America (Johannessen 1988) and Mexico (Flannery 1986).

Through the use of fire and clearing, however, it is possible to increase the extent of disturbed habitat and promote the spread of small-seeded, disturbance-following plant resources within restricted territories (Ford 1985:17). Demonstrating the native use of fire to increase production of disturbance-following seed plants remains a challenge for California archaeology; potentially valuable approaches include changes in seed morphologies (Hammett 1991; Miksicek 1995), increases in frequency of disturbance-following taxa (Wohlgenuth 1993a), and changes in local pollen profiles (Weigel 1993; West 1993). Preliminary data from CA-YOL-182 indicate that several taxa (wild barley [*Hordeum pusillum*], maygrass [*Phalaris* sp.], and goosefoot [*Chenopodium* sp.]) appear to be larger than typically found in California sites. This may be evidence of altered gene pools for these taxa resulting from human intervention

(Miksicek 1995). In any case, the dearth of small seeds in most Middle Period assemblages demonstrates that this hypothesized proto-agricultural system was not a part of Middle Period adaptive strategies; if this production system ever did arise in prehistoric central California, it appears to have been restricted to the Late and Protohistoric periods.

Finally, documentation of long-term regional economic shifts should be based on sampling from long chronological sequences at several localities in order to account for differences in habitat, site function, season of occupation, and processing techniques. Given these considerations, it is significant that data most consistent with the intensification models are from adjacent sites of differing age in the Green Valley, Santa Rosa, and western Sacramento Valley localities. In each case, the data exhibit similar relative trends by time period, with particular diversity values varying by locality; these parallel, relative trends appear to support the intensification hypotheses. The distinctions between CA-SOL-363 and other Middle Period sites (except possibly CA-SOL-355) parallel those between CA-YOL-182 and the other Late Period sites. For both time periods, acorn to small seed ratios at the Davis-Dixon locality are substantially less than in the other areas. This may be evidence of long-term differentiation in economic strategies on the open plains of the western Sacramento Valley from other central California populations. Whether this is based on environmental or sociocultural factors will become apparent only as more research is conducted.

### CONCLUSIONS

The relative nature of these trends underscores the adaptive diversity of California native populations, as they may be evidence of different responses that native Californians made in adapting to the heterogeneous habitats of central California. The association of dense acorn accumulations with rich small seed assemblages at

CA-SUT-17 and CA-SON-159 seems quite distinct from the abundance of small seeds and the low acorn density at CA-YOL-182. The latter may reflect a proto-agricultural system based on managed burning hypothesized for southern California (Bean and Lawton 1973; Hammett 1991). This burning-based production system, however, would not necessarily work throughout central California. For example, McCarthy's (1993) description of an acorn-intensive economy for the historic Western Mono of the montane southern Sierra Nevada may be accentuated by the dearth of small, seed-rich, open grasslands or savannas in their wooded habitat when contrasted with the lower foothills and valleys to the west.

Testing broad regional models offered by Basgall (1987) and Basgall and Bouey (1991) will require data from many other localities, and new data will no doubt refine the models as they are applied to various environmental and cultural contexts. The implications of the preliminary data presented herein are sufficient to mandate collection of reliable plant macrofossil samples from all future excavations of deep sites in central California.

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### REFERENCES

- Asch, Nancy B., Richard I. Ford, and David L. Asch  
1972 Paleoethnobotany of the Koster Site: The Archaic Horizons. Illinois State Museum, Reports of Investigations No. 24.

- Barrett, Samuel A., and Edward W. Gifford  
1933 Miwok Material Cultural. *Bulletin of the Milwaukee Public Museum* 2(4):117-376.
- Basgall, Mark E.  
1987 *Resource Intensification Among Hunter-Gatherers: Acorn Economies in Prehistoric California*. In: *Research in Economic Anthropology*, Vol. 9, Barry L. Isaac, ed., pp. 21-52. Greenwich, CN: JAI Press.
- Basgall, Mark E., and Paul D. Bouey  
1991 *The Prehistory of North-Central Sonoma County: Archaeology of the Warm Springs Dam—Lake Sonoma Locality*. Report on file at the Northwest Information Center, Sonoma State University.
- Basgall, Mark E., and William R. Hildebrandt  
1989 *Prehistory of the Sacramento River Canyon, Shasta County, California*. Center for Archaeological Research at Davis, Publication No. 9.
- Basgall, Mark E., and Kelly R. McGuire  
1988 *The Prehistory of Southern Owens Valley: Archaeological Excavations at CA-INY-30*. Report on file at the Eastern Information Center, University of California, Riverside.
- Baumhoff, Martin A.  
1963 *Ecological Determinants of Aboriginal California Populations*. University of California Publications in American Archaeology and Ethnology 49(2).
- Bean, Lowell J., and Harry W. Lawton  
1973 *Some Explanations for the Rise of Cultural Complexity in Native California with Comments on Proto-Agriculture and Agriculture*. In: *Patterns of Indian Burning in California: Ecology and Ethnohistory*, by Henry T. Lewis, pp. v-xlvi. Ballena Press Anthropological Papers No. 1.
- Bocek, Barbara R.  
1984 *Ethnobotany of Costanoan Indians, California, Based on Collections by John Harrington*. *Economic Botany* 38(2):240-255.
- Bohrer, Vorsila L.  
1970 *Ethnobotanical Aspects of Snaketown, A Hohokam Village in Southern Arizona*. *American Antiquity* 35(3):413-430.
- Bouey, Paul D.  
1993 *Cultural Resources Test Excavations, Sacramento Systems Evaluation, Phase II, Butte and Sutter Counties, California*. Report on file at the Northeast Information Center, California State University, Chico.
- Chesnut, V.K.  
1902 *Plants Used by the Indians of Mendocino County, California*. Washington: Contributions from the U. S. National Herbarium 7:294-422.
- Cook, Sherburne F., and Robert F. Heizer  
1951 *The Physical Analysis of Nine Indian Mounds of the Lower Sacramento Valley*. University of California Publications in American Archaeology and Ethnology 40(7).
- Cook, Sherburne F., and Adan E. Treganza  
1950 *The Quantitative Investigation of Indian Mounds*. University of California Publications in American Archaeology and Ethnology 40(5).
- Davis, Owen K., and Charles H. Miksicek  
1988 *Macrofossil Analysis of CA-FRE-1671, and Archaeobotanical Analysis*. In: *Archaeological Excavations at Site CA-FRE-1671, Fresno County, California: Final Report*, Michael J. Moratto, ed., pp. 593-603. Report on file at the Southern San Joaquin Information Center, California State University, Bakersfield.
- Doran, Glen H.  
1980 *Paleodemography of the Plains Miwok Ethnolinguistic Area*. Ph.D. dissertation, University of California, Davis.
- Driver, Harold E., and William C. Massey  
1957 *Comparative Studies of North American Indians*. *Transactions of the American Philosophical Society* 47(2).
- Duncan, John W.  
1963 *Maidu Ethnobotany*. Master's thesis, California State University, Sacramento.
- Flannery, Kent V.  
1986 *Food Procurement Area and Pre-ceramic Diet at Guila Naquitz*. In: *Guila Naquitz: Archaic Foraging and Early Agriculture in Oaxaca, Mexico*, Kent V. Flannery, ed., pp. 303-317. Orlando: Academic Press.
- Ford, Richard I.  
1985 *The Processes of Plant Food Production in Prehistoric North America*. In: *Prehistoric Food Production in North America*, Richard I. Ford, ed., pp. 1-18. University of Michigan Museum of Anthropology, Anthropological Papers No. 75.

- Fredrickson, David A.  
 1973 Early Cultures of the North Coast Ranges, California. Ph.D. dissertation, University of California, Davis.
- 1974 Cultural Diversity in Early Central California: A View from the North Coast Ranges. *The Journal of California Anthropology* 1(1):41-53.
- Gifford, Edward W.  
 1936 California Balanophagy. In: Essays Presented to A. L. Kroeber, Robert H. Lowie, ed., pp. 87-98. Berkeley: University of California Press.
- Gmoser, Glenn  
 1994 Preliminary Results of Archaeological Testing at Sites CA-SON-921, CA-SON-1695, and CA-SON-159. Report on file at the Northwest Information Center, Sonoma State University.
- Grayson, Donald K.  
 1984 Quantitative Zooarchaeology: Topics in the Analyses of Archaeological Faunas. Orlando: Academic Press.
- Hammett, Julia E.  
 1991 The Ecology of Sedentary Societies Without Agriculture: Paleoethnobotanical Indicators from Native California. Ph.D. dissertation, University of North Carolina, Chapel Hill.
- Hammett, Julia E., and Eric Wohlgemuth  
 1982 Charred Plant Remains from *Talepop*, CA-LAn-229. In: Archaeological Investigations at *Talepop* (CA-LAn-229), Vol. 3, Chester King and Christopher Pierce, eds., pp. 9-1 to 9-95. Report on file at the South Coast Information Center, University of California, Los Angeles.
- Hastorf, Christine A., and Virginia S. Popper (eds.)  
 1988 Current Paleoethnobotany. Chicago: University of Chicago Press.
- Heizer, Robert F., and Martin A. Baumhoff  
 1956 California Settlement Patterns. Viking Fund Publications in Anthropology 23:32-44.
- Hickman, James C. (ed.)  
 1993 The Jepson Manual: Higher Plants of California. Berkeley: University of California Press.
- Hildebrandt, William R., and Patricia J. Mikkelsen  
 1993 Archaeological Test Excavations at Fourteen Sites Along Highways 101 and 152, Santa Clara and San Benito Counties, California: Volume 1, Prehistory. Report on file at the Northwest Information Center, Sonoma State University.
- Hildebrandt, William R., and Laurie K. Swenson  
 1985 Prehistoric Archaeology. In: Ethnography and Prehistory of the North Coast Ranges, California, Helen McCarthy, William R. Hildebrandt, and L. K. Swenson, eds., pp. 88-152. Center for Archaeological Research at Davis, Publication No. 8.
- Honeysett, Elizabeth A.  
 1982 Floral Analysis of Flotation Samples. In: Archaeological Test Excavations at Oyer Springs and Pi Pi Valley, by S. Lindstrom, pp. 340-345. Report on file at the North Central Information Center, California State University, Sacramento.
- Johannessen, Sissel  
 1988 Plant Remains and Culture Change: Are Paleoethnobotanical Data Better Than We Think? In: Current Paleoethnobotany, Christine A. Hastorf and Virginia S. Popper, eds., pp. 145-166. Chicago: University of Chicago Press.
- Johnson, Jerald J.  
 1984 Ground Stone Assemblages in Northeastern California. Ph.D. dissertation, University of California, Davis.
- Jones, Terry L.  
 1995 Transition in Prehistoric Diet, Mobility, Exchange, and Social Organization Along California's Big Sur Coast. Ph.D. dissertation, University of California, Davis.
- Kroeber, Alfred L.  
 1925 Handbook of the Indians of California. Bureau of American Ethnology Bulletin 78.
- Lewis, Henry T.  
 1973 Patterns of Indian Burning in California: Ecology and Ethnohistory. Ballena Press Anthropological Papers No. 1.
- Magurran, Anne E.  
 1988 Ecological Diversity and Its Measurement. Princeton: Princeton University Press.
- McCarthy, Helen  
 1993 A Political Economy of Western Mono Acorn Production. Ph.D. dissertation, University of California, Davis.
- McCorriston, Joy  
 1994 Acorn Eating and Agricultural Origins: California Ethnographies as Analogies for

- the Ancient Near East. *Antiquity* 68(258): 97-107.
- McGuire, Kelly R., and William R. Hildebrandt  
1994 The Possibilities of Women and Men: Gender and the California Milling Stone Horizon. *Journal of California and Great Basin Anthropology* 16(1):41-59.
- Miksicek, Charles H.  
1987 Formation Processes of the Archaeobotanical Record. In: *Advances in Archaeological Method and Theory*, Vol. 10, Michael B. Schiffer, ed., pp. 211-247. New York: Academic Press.  
1991 Beyond Acorns, Anadromous Fish, and Artiodactyls: The Potential for Archaeobotany in California Archaeology. Paper presented at the annual meetings of the Society for American Archaeology, New Orleans.  
1995 On the Cusp of History: Archaeobotanical Remains from CA-YOL-182. Appendix K of *Archaeological Investigations at CA-YOL-182, Located on the University of California, Davis Campus, Yolo County, California*, by Lisa Shapiro and Kim Tremaine. Report on file at the Northwest Information Center, Sonoma State University.
- Moratto, Michael J.  
1984 *California Archaeology*. Orlando: Academic Press.
- Munz, Philip A.  
1968 *A California Flora and Supplement*. Berkeley: University of California Press.
- Olszewski, Deborah I.  
1993 Subsistence Ecology in the Mediterranean Forest: Implications for the Origins of Cultivation in the Epipaleolithic Southern Levant. *American Anthropologist* 95(2): 420-435.
- Origer, Thomas M.  
1993 The Archaeology of CA-SON-2098: A Buried Archaeological Site in Santa Rosa, Sonoma County, California. Report on file at the Northwest Information Center, Sonoma State University.
- Pearsall, Deborah  
1989 *Paleoethnobotany: A Handbook of Procedures*. New York: Academic Press.
- Popper, Virginia S.  
1988 Selecting Quantitative Measurements in Paleoethnobotany. In: *Current Paleoethnobotany*, Christine A. Hastorf and Virginia S. Popper, eds., pp. 53-71. Chicago: University of Chicago Press.
- Rosenthal, Jeffrey S., and Greg White  
1994 *Archaeological Investigations at the Pheasant Run Site: CA-SOL-363*. Report on file at the Northwest Information Center, Sonoma State University.
- Schulz, Peter D.  
1981 *Osteoarchaeology and Subsistence Change in Prehistoric Central California*. Ph.D. dissertation, University of California, Davis.  
Schulz, Peter D., and Jerald J. Johnson  
1980 An Early Acorn Cache from Central California. *Journal of California and Great Basin Anthropology* 2(1):127-128.
- Shapiro, Lisa, and Kim Tremaine  
1995 *Archaeological Investigations at CA-YOL-182, Located on the University of California, Davis Campus, Yolo County, California*. Report on file at the Northwest Information Center, Sonoma State University.
- Struever, Stuart  
1968 Flotation Techniques for the Recovery of Small-Scale Archaeological Remains. *American Antiquity* 33(3):353-362.
- Sundahl, Elaine M.  
1982 *The Shasta Complex in the Redding Area, California*. Master's thesis, California State University, Chico.
- Tremaine, Kim  
1989 *Obsidian as a Time Keeper: An Investigation in Absolute and Relative Dating*. Master's thesis, Sonoma State University.
- Weigel, Lawrence E.  
1993 Prehistoric Burning in Northwestern California. In: *There Grows a Green Tree: Papers in Honor of David A. Fredrickson, Greg White, Pat Mikkelsen, William R. Hildebrandt, and Mark E. Basgall, eds.*, pp. 237-241. Center for Archaeological Research at Davis, Publication No. 11.
- West, G. James  
1993 The Late Pleistocene-Holocene Pollen Record and Prehistory of California's North Coast Ranges. In: *There Grows a Green Tree: Papers in Honor of David A. Fredrickson, Greg White, Pat Mikkelsen, William R. Hildebrandt, and Mark E. Basgall, eds.*, pp. 219-236. Center for

Archaeological Research at Davis, Publication No. 11.

White, Greg

- 1984 The Archaeology of LAK-510, Near Lower Lake, Lake County, California. Report on file at the Northwest Information Center, Sonoma State University.

White, Greg, David A. Fredrickson, David G. Bieling, Jefferson Haney, Jack Meyer, Sunshine Psota, Nancy French, Nadine Thomas, Wendy Dworkin, Charles Whatford, Michael Love, and Seana Searle

- 1995 Final Report of the Anderson Flat Project, Lower Lake, Lake County, California. Report on file at the Northwest Information Center, Sonoma State University.

Wiberg, Randy

- 1992 Archaeological Data Recovery at Sites CA-SOL-69 and CA-SOL-315, Green Valley, Solano County, California. Report on file at the Northwest Information Center, Sonoma State University.
- 1993 Archaeological Data Recovery at Prehistoric Site CA-SOL-355/H, Green Valley, Solano County, California. Report on file at the Northwest Information Center, Sonoma State University.

Wohlgemuth, Eric

- 1984 Some Perspectives on Sampling for Botanical Remains from Archaeological Sites. Paper presented at the annual meetings of the Society for California Archaeology, Salinas.
- 1989 Archaeobotanical Remains. In: Prehistory of the Sacramento River Canyon, Shasta County, California, by Mark E. Basgall and William R. Hildebrandt, pp. H1-H37. Center for Archaeological Research at Davis, Publication No. 9.
- 1991 Analysis of Plant Remains. In: Archaeological Investigations at CA-SHA-47 and

CA-SHA-236, on the Sacramento River, Redding, Shasta County, California, by Trudy Vaughan, pp. 105-141. Report on file at the Northeast Information Center, California State University, Chico.

- 1993a Acorn Intensification and Disturbance Enhancement in Central California: Diachronic Evidence from Two Localities. Paper presented at the annual meetings of the Society for California Archaeology, Asilomar.
- 1993b Seed and Fruit Remains from CA-SUT-17. In: Cultural Resources Test Excavations, Sacramento Systems Evaluation, Phase II, Butte and Sutter Counties, California, by Paul D. Bouey, pp. 65-75. Report on file at the Northeast Information Center, California State University, Chico.
- 1993c Floral Remains from CA-SON-2098. In: The Archaeology of CA-SON-2098: A Buried Archaeological Site in Santa Rosa, Sonoma County, California, by Thomas Origer, pp. 74-97. Report on file at the Northwest Information Center, Sonoma State University.
- 1994 Macrofloral Remains from CA-SON-159 and CA-SON-1695. Report on file at the Northwest Information Center, Sonoma State University.
- 1995 Floral Remains. In: Final Report of the Anderson Flat Project, Lower Lake, Lake County, California, by Greg White, David A. Fredrickson, David G. Bieling, Jefferson Haney, Jack Meyer, Sunshine Psota, Nancy French, Nadine Thomas, Wendy Dworkin, Charles Whatford, Michael Love, and Seana Searle. Unpaginated draft report on file at the Northwest Information Center, Sonoma State University.

