CHAPTER 10

The Central Valley: A View from the Catbird's Seat

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The Central Valley of California is one of the world's largest intermontane basins (Dupre et al. 1991), extending 650 kilometers between the Siskiyou Mountains on the north and the Tehachapis on the south. The Coast and Transverse Ranges lie to the west and the high peaks of the Sierra Nevada and Cascade Ranges are to the east (Figure 10.1). The region is warm and well watered, one of the most diverse and productive environmental zones in California. Early in prehistory, people of the Central Valley settled in villages where they created a sophisticated material culture, became the nexus of an extensive trade system involving a wide range of manufactured goods from distant and neighboring regions, and developed population densities and village sizes equaled only by agricultural societies in the southwestern and southeastern United States. As reflections of these developments, the archaeological record of the Central Valley is among the most fascinating in western North America, spanning the full sweep of hunter-gatherer adaptations; from the earliest, technologically conservative, low-density colonizers to the most recent, technologically elaborate, and densely packed populations present at historic contact.

Professional archaeologists and avocationalists alike have been drawn to the extensive mound sites of the valley for more than a century. Unlike other places in California, however, archaeological research in the region has waned over the past 20 years. Since Moratto's (1984) summary of Central Valley archaeology, basic understanding of culture history in the region has progressed very little, and we continue to lack well-grounded chronologies for large segments of the valley. Extant collections reveal a diverse and complex archaeological record, yet few modern studies have redressed past errors in interpretation or synthesized the considerable archaeological information available for this region.

Despite these problems, archaeological research conducted in the Central Valley remains among the most important in the state. Over the past two decades, the region's archaeological record has been a proving ground for theories that have advanced a new understanding of prehistoric California. This research has been at the highest order—the causes and consequences of prehistoric culture change (Basgall 1987; Beaton 1991c; Cohen 1981).

ENVIRONMENTAL CONTEXT

The Central Valley is divided into two major physiographic provinces separated by the expansive Sacramento/San Joaquin Delta. To the north lies the Sacramento Valley, drained by the southward-flowing Sacramento River, and to the south lies the San Joaquin Valley, drained by the northward-flowing San Joaquin River. Near the central outlet, the principal waterways merge with the westward-flowing drainages of the Mokelumne and Cosumnes Rivers. Around this confluence, the vast marshes and sloughs of the Sacramento/San Joaquin Delta developed over the past 7,000 years in response to worldwide advances in sea level (Atwater 1980; Goman and Wells 2000; Shlemon and Begg 1975). The extreme southern end of the Central Valley is separated from the northern outlet by prominent Late Pleistocene alluvial fans formed by the Kings River and Los Gatos Creek (Atwater et al. 1986). South of this divide, all drainages empty into the shallow basins formed by ancient Tulare, Buena Vista, and Kern Lakes. In the past, these now dry lake basins frequently overflowed northward, feeding the San Joaquin River.

Quaternary landscapes are fairly uniform throughout the Great Valley, descending in age from a fringe of weathered and rolling piedmonts to the active basins and floodplains of the valley bottom. The piedmonts are composed of a combination of early Tertiary fluvial sediments forming benchlike deposits, as well as incised Pleistocene fans associated with stream and river debouches at the base of the foothills. The valley bottom is made up of younger, active alluvial fans, alkali basins composed of deep beds of clay and silt, and river floodplains consisting of well-sorted silt, sand, and gravel. The floodplains contain elevated natural levees that were favored as prehistoric habitation areas.

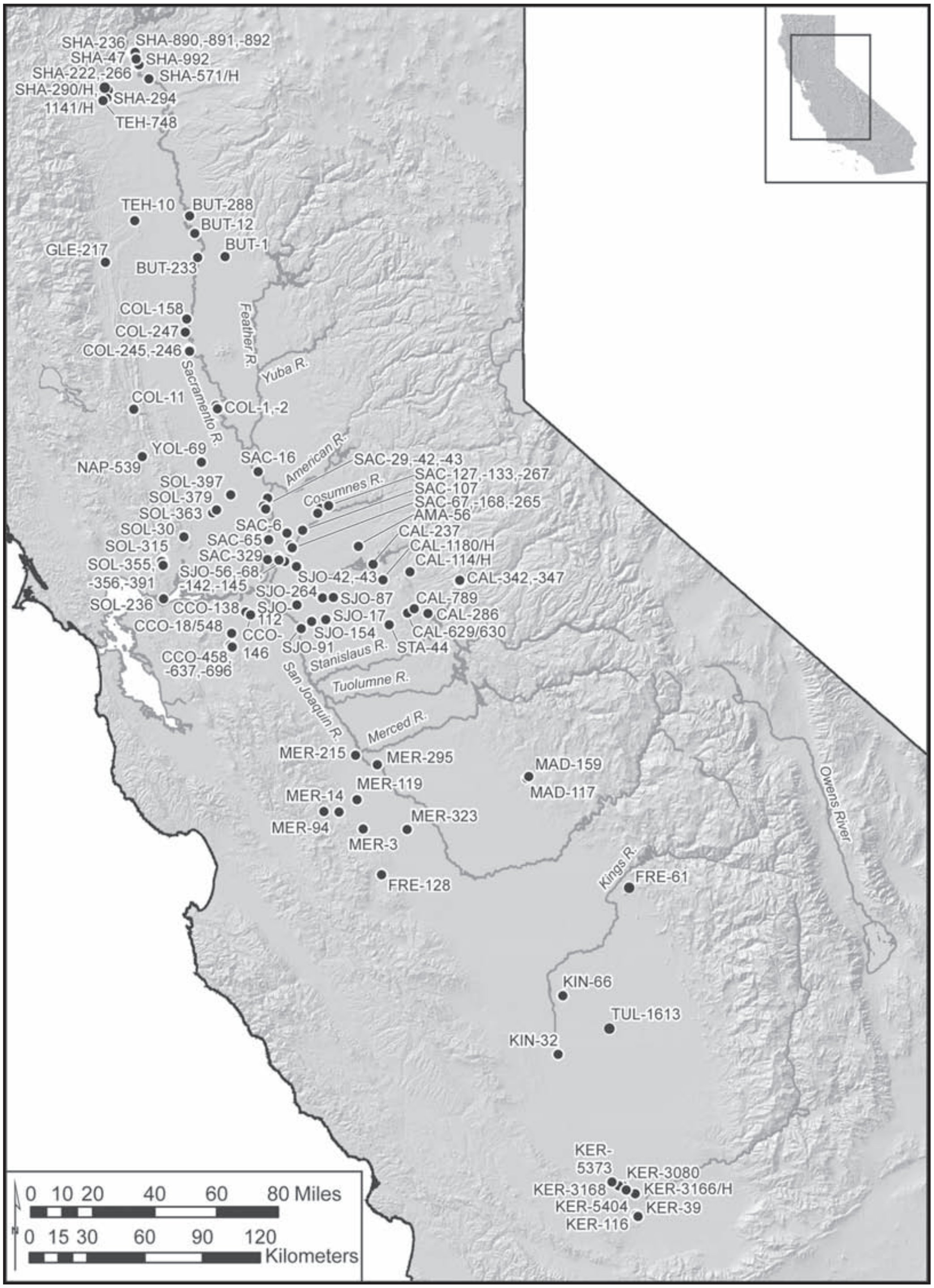

Figure 10.1. **Archaeological sites and locations of the Central Valley.**

The axial Sacramento and San Joaquin Rivers drain a combined watershed of over 122,000 square kilometers, accounting for 40 percent of the state's freshwater runoff. There is a significant latitudinal gradient in precipitation, with increasingly arid conditions prevailing to the south. Thus the Sacramento Valley is comparatively well watered while the San Joaquin Valley is a semiarid steppe. Due to the rain shadow effect of the Coast Ranges, there is also a significant longitudinal precipitation gradient. Most of the region's freshwater originates from the Sierra and Cascade slopes, emptying into the east side of the valley. Drainages on the west side are comparatively small and widely dispersed.

Central Valley habitats included riparian forest, marsh, alkali basins, oak savanna, and foothill woodland communities. Because the valley is narrow along its entire length, and vegetation communities are arranged longitudinally along soil, elevational, and hydrological gradients, at least some of each habitat is accessible within a day's walk from anywhere in the basin. In the Sacramento and northern San Joaquin Valleys, wide swaths of multitiered riparian forest lined the deep floodplain soils bracketing major waterways (Burcham 1957; Kuchler 1977). In the central Sacramento Valley and portions of the San Joaquin, extensive seasonal wetlands and alkali basins flanked the active floodplains. In the delta, marshlands covered more than 200,000 hectares (500,000 acres), including open water and dense stands of tule and bulrush. The shallow lakes of Tulare basin also supported a comparable area of marshland. Broad piedmonts rimming the valley floor supported bunch grass prairie and dispersed oaks in the Sacramento Valley, and a treeless plain with patchy, alkali-tolerant annual forbs and grasses in the San Joaquin Valley.

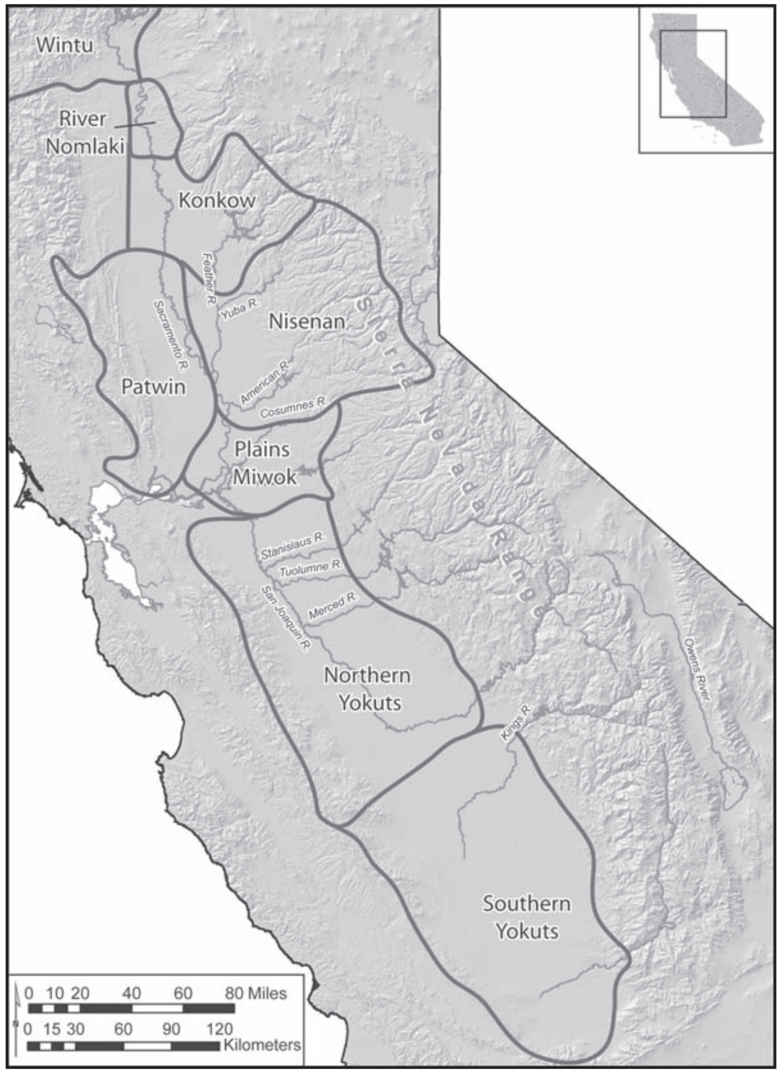

Figure 10.2. Approximate location of tribal groups, Central Valley.

NATIVE PEOPLES AT CONTACT

An estimated 100,000 people, about one-third of the state's native population, lived in the Central Valley when Europeans first ventured into the region between A.D. 1772 and 1821 (Cook 1955, 1976, 1978; Moratto 1984:171). These people spoke seven distinct languages of the Penutian stock (Figure 10.2), five in the Sacramento Valley (Wintu, Nomlaki, Konkow, River Patwin, and Nisenan) and two in the San Joaquin Valley (Miwok and Yokuts). Common linguistic roots indicate these groups had a related history and regular interaction (see Chapter 6 in this volume). A shared heritage is also indicated by common technological, economic, ceremonial, and sociopolitical characteristics described by twentieth-century anthropologists who identified the Central Valley as the core of the California Culture area (Figure 10.3) (Goldschmidt 1951b; Klimek 1935; Kroeber 1936, 1939).

THE CENTRAL VALLEY ARCHAEOLOGICAL RECORD

Persistent problems have hindered Central Valley archaeological research over the past two decades. There have been few opportunities for new investigation, as most surface sites have been destroyed. Early-twentieth-century records indicate a density of one mound site for every two to three miles of major waterway (Schenck and Dawson 1929; White 2003b). Most, and in some areas all, of these mounds have been destroyed by agricultural development, levee construction, and river erosion. At the same time, over the past 20 years, most new information has come from a handful of small-scale investigations. There have been few large cultural resource management–sponsored projects, and only two Ph.D. dissertations have focused on Central Valley archaeology (Hartzell 1992; White 2003a). Published studies have mostly reworked old data or

Figure 10.3. Big Head dancer and round house, Grindstone Rancheria, May 1923. (Courtesy of the Bancroft Library, University of California–Berkeley, photograph by C. Hart Merriam, cat. no. 1978.008T/195/Pl no. 35.)

stayed on a traditional theoretical plane (Basgall 1987; Beaton 1991c).

Further, existing collections are rife with sampling biases. In the early twentieth century, teams of mostly untrained but energetic investigators explored numerous mound sites (Lillard et al. 1939; Schenck and Dawson 1929). These initial explorations culminated in professional investigations, including Depression-era salvage efforts at several key sites, and publication of synthetic studies on major artifact types, features, and cultural sequences (Gifford 1940, 1947; Heizer 1941b, 1949; Lillard et al. 1939; Wedel 1941). All this early fieldwork, however, was marked by a focus on artifact and burial recovery and a frank indifference to dietary remains and technological features, thus hampering modern attempts at reanalysis (Bouey 1995; Hartzell 1992).

Last, the Central Valley's archaeological record, as we know it today, is biased by natural processes of landscape evolution. Surface sites are embedded in young sediments set within a massive and dynamic alluvial basin, while most older archaeological deposits have been obliterated or buried by ongoing alluvial processes. Consequently archaeologists have had to struggle to identify and explain long-term culture change in portions of the Central Valley where available evidence spans only the past 2,500 years or in rare cases 5,500 years.

Chronological Framework

As it stands, there is no single cultural-historical framework that accommodates the entire prehistoric record of the Central Valley. Detailed cultural chronologies exist for some portions of the basin (e.g., the lower Sacramento Delta region), while the timing and nature of cultural succession in other regions remains poorly defined (e.g., the northern Sacramento and San Joaquin Valleys). In many cases, local sequences were built on few (if any) radiocarbon dates (Kowta 1988; Olsen and Payen 1969; Sundahl 1992; Warren and McKusick 1959), relying instead on the cross-dating of stylistically distinct artifact types and other cultural patterns (e.g., burial mode). To this time, however, there have been few attempts to update and evaluate the relevance of these chronologies, although the ages of many diagnostic artifacts have been significantly refined (e.g., shell beads) (Bennyhoff and Hughes 1987; Groza 2002).

Moratto's (1984) synthesis of Central Valley archaeology relied heavily on the taxonomic framework developed in a series of mostly unpublished papers by Bennyhoff and Fredrickson (Elsasser 1978; Fredrickson 1973, 1974a). Hughes (editor, 1994) compiled these important manuscripts, making them widely available. While the comparative framework established by Bennyhoff and Fredrickson (1994) and Fredrickson (1973, 1974a) is designed to incorporate a wide range of local and regional traditions, it has not been systematically applied outside the Sacramento Valley. As a result, the following discussion uses a simple classification based on Fredrickson's (1973, 1974a) California adaptation of the Willey and Phillips (1958) period and stage integrative scheme.

Fredrickson (1973, 1974a) proposed three basic periods: the Paleo-Indian, Archaic, and Emergent. New radiocarbon determinations (Groza 2002; Lajeunesse and Pryor 1996; Meyer and Rosenthal 1997), adjusted with modern calibration curves, are used here to make the following divisions: Paleo-Indian (11,550 to 8550 cal B.C.), Lower Archaic (8550 to 5550 cal B.C.), Middle Archaic (5550 to 550 cal B.C.), Upper Archaic (550 cal B.C. to cal A.D. 1100), and Emergent (cal A.D. 1100 to Historic).[1]

Paleo-Indian (11,550 to 8550 cal B.C.)

Recent geoarchaeological studies have shown that periodic episodes of erosion and deposition during the Holocene have removed or buried large segments of the Late Pleistocene landscape (Rosenthal and Meyer 2004a,b; White 2003b). Archaeological deposits associated with these ancient landforms either have been destroyed or lie buried beneath more recent alluvial deposits. In certain zones, Late Pleistocene landforms are common near the surface, but these are generally associated with landscapes that would have attracted only limited human use (e.g., the arid piedmonts on the valley margin).

Most claims for very ancient human occupation in California had effectively been dismissed through radiocarbon dating when Moratto (1984) published his chapter on the first Californians. One exception is the Farmington Complex from the lower Calaveras River (Treganza 1952; Treganza and Heizer 1953) and adjacent drainages (Johnson 1967:283–284), thought to be evidence of a pre–projectile point occupation in California (Krieger 1964). The Farmington Complex remained undated (but see Ritter et al. 1976) until geoarchaeological investigations in the vicinity of type site STA-44 (Dalldorf and Meyer 2004) demonstrated that this assemblage of cobble cores, biface rough-outs, and stone-working debris is contained in Holocene alluvial terraces and not Pleistocene glacial outwash (Dalldorf and Meyer 2004; Moratto 1984:63; Rosenthal and Meyer 2004b:96).

Currently the earliest accepted evidence of human occupation in the Central Valley comes from the basally thinned and fluted projectile points found at scattered surface locations, primarily in the southern portion of the basin. Often compared to Clovis points, these distinctive projectiles are well dated elsewhere in North America to a brief interval between about 11,550 and 9550 cal B.C. (Fiedel 1999). To date, only three localities in the San Joaquin Valley have produced early concave base points (see Chapter 5 in this volume), including Tracy Lake, the Woolfsen mound (MER-215), and the Tulare Lake basin (Heizer 1938; Moratto 1984; Peak and Weber 1978). A single possible fluted point was reported from the Sacramento Valley near Thomes Creek (Dillon and Murphy 1994). All of these artifacts were recovered from remnant features of the Pleistocene landscape.

At the Witt site (KIN-32) in the southern San Joaquin Valley, hundreds of early concave base points have been discovered along a remnant shoreline occupied during a Late Pleistocene lowstand of Tulare Lake (a local expression of the "Clovis drought") (Davis 1999a; Haynes 1991; Willig 1991). Uranium series (^{230}Th) dates were obtained on human bone fragments and extinct fauna from this shoreline, providing some preliminary evidence for the maximum age of human occupation in the Central Valley. The human bone from KIN-32 produced uncalibrated dates of 11,379, 11,380, and 15,802 RCYBP, while the fauna returned dates of 10,788, 15,696, and 17,745 years RCYBP (West et al. 1991). Unfortunately there is no clear association between the extinct fauna, human bone, and projectile points from Tulare Lake (Fenenga 1992; West et al. 1991).

Lower Archaic (8550 to 5550 cal B.C.)

As a result of climate changes at the end of the Pleistocene, alluvial fans and floodplains throughout the lowlands of central California responded with a significant period of deposition beginning about 9050 cal B.C. This episode of landscape evolution covered many Late Pleistocene alluvial landforms and resulted in a clear stratigraphic boundary between sediments from the Late Pleistocene and Holocene (Rosenthal and Meyer 2004a). Another period of climate change at the beginning of the Middle Holocene, around 5550 cal B.C., initiated a second cycle of widespread fan and floodplain deposition. This latter episode buried many of the earliest archaeological deposits known from central California (Meyer and Rosenthal 1997; Rosenthal and Meyer 2004a,b).

Like the Paleo-Indian Period, Lower Archaic occupation of the Central Valley is mostly represented by isolated finds. Stemmed points, chipped stone crescents, and other distinctive flaked stone artifacts are commonly found on the ancient shore of Tulare Lake, alongside early concave base points (Fenenga 1992; Wallace and Riddell 1991). In the Sacramento Valley, an isolated flaked stone crescent was found on an ancient alluvial fan west of Orland (Johnson et al. 1984:65). Only one Lower Archaic archaeological deposit (KER-116) has been identified in the Central Valley proper, associated with a deeply buried soil uncovered on the ancient shoreline of Buena Vista Lake (Fredrickson and Grossman 1977; Hartzell 1992).

KER-116 produced radiocarbon dates on freshwater mussel shell ranging between 7175 and 6450 cal B.C. (Fredrickson and Grossman 1977; Hartzell 1992). Salvage investigations at KER-116 produced a small artifact assemblage including three chipped stone crescents, a stemmed projectile point fragment, a carved stone atlatl spur, and a few small flaked stone implements. The deposit also yielded a human skull fragment and a small yet diverse faunal assemblage that included freshwater fish, waterfowl, freshwater mussels, and a few fragments of artiodactyl bone (Hartzell 1992). No milling tools or plant remains were identified at KER-116, so the nature of plant use during the Early Archaic remains unknown. Thick Coso obsidian hydration rims from KER-5373/H and Early Holocene radiocarbon dates of 6360 cal B.C. and 5650 cal B.C. on *Tivela* disk beads from KER-3168 (Jackson et al. 1998) indicate Lower Archaic occupation in the Elk Hills, just west of Buena Vista Lake.

Lower Archaic artifacts from Tulare Lake basin include stemmed points similar to Borax Lake wide-stemmed points from the North Coast Ranges, as well as Lake Mojave, Silver Lake, and Pinto points similar to those found in the Great Basin. Chipped stone crescents are also a common element of Lower Archaic components (Fenenga 1992). The three crescents from KER-116 are among the only examples from dated stratigraphic contexts in California (Fenenga 1992; Fredrickson and Grossman 1977; Hartzell 1992). Bipointed "humpies" are another common flaked stone tool found alongside crescents and early wide-stem points on the southwestern shores of Tulare Lake (Sampson 1991).

Despite the dearth of large mammal remains from the lone sampled site (KER-116), the common occurrence of large, heavily reworked projectile points has led to the interpretation that hunting artiodactyls was a focus of Early Archaic economies (Wallace 1991). While milling implements, subsidiary processing tools, and other direct evidence of plant foods are largely absent from valley floor assemblages, recent investigations in the adjoining Sierra Nevada and Coast Range foothills have documented Lower Archaic sites with abundant milling equipment and other indications of a reliance on plant foods (Meyer and Rosenthal 1997). Contrary to earlier studies, which have argued for the use of small seeds (Basgall 1987; McGuire and Hildebrandt 1994), nut crops associated with expanding woodlands may have been the primary target of seasonal plant exploitation (Lajeunesse and Pryor 1996; Rosenthal and McGuire 2004), based on the dominance of acorn and pine nutshell in Early Holocene strata at the Skyrocket site (CAL-629/630; Rosenthal and McGuire 2004) and at Los Vaqueros (CCO-696; Meyer and Rosenthal 1997). These foothill sites, often marked by dense accumulations of handstones, millingslabs, and various cobble-core tools, appear to represent frequently visited camps in a seasonally structured settlement system (Basgall and True 1985; Hale 2001; Lajeunesse and Pryor 1996; McGuire and Hildebrandt 1994; Meyer and Rosenthal 1997; Moratto 2002; Rosenthal and McGuire 2004; Sundahl 1992).

Relationships between foothill and valley floor adaptations are relatively unknown and can only be solved by discovery and investigation of additional valley sites. Distinctly divergent valley floor and foothill adaptations and cultural traditions are evident in the Middle Archaic record, and it is possible that these distinctions first emerged in the Lower Archaic. On the other hand, large stemmed projectile points found at Lower Archaic sites CAL-342 and CAL-629/630 in the Sierra foothills are similar to those recovered from the Witt site in the Tulare basin, suggesting that valley and foothill sites could be seasonal expressions of the same adaptation.

Regional interaction spheres appear to have been well established in the Lower Archaic. Marine shell beads from California are found in Early Holocene deposits in the western and central Great Basin (Bennyhoff and Hughes 1987; Fitzgerald et al. 2005), and obsidian from the eastern Sierra makes up a large proportion of nonlocal flaked stone tools and tool-making debris from Lower Archaic sites on both sides of the Central Valley (e.g., CAL-629/630 and CCO-696). Obsidian was not reported, however, from the basal stratum at KER-116 in the Buena Vista Lake basin and appears to be rare among the many stemmed points from Tulare Lake (Wallace and Riddell, eds. 1991).

Middle Archaic (5550 to 550 cal B.C.)

The beginning of the Middle Archaic was characterized by a substantial change in climate, with warmer, drier conditions prevailing throughout central California. Tulare Lake shrank in size and eventually desiccated, matching similar declines in other western lakes (Benson et al. 2002; Davis 1999a; White et al. 2002). At the same time, an important new wetland habitat formed in the Central Valley as rising sea levels pushed inland and led to the development of the Sacramento/San Joaquin Delta (Atwater and Belknap 1980; Goman and Wells 2000). The wider Central Valley landscape also changed significantly. Following an initial period of deposition (about 5550 cal B.C.), fans and floodplains stabilized. This period of landscape stability is represented by Middle Holocene buried soils found in alluvial landforms throughout central California (Meyer 1996; Meyer and Rosenthal 1997; Rosenthal and Meyer 2004a,b). Many of the best documented Middle Archaic deposits (5550 to 550 cal

B.C.) are associated with these buried land surfaces, including CCO-18/548, CCO-637, COL-247, CAL-342, CAL-286, CAL-347, CAL-789, CAL-629/630 (Atwater et al. 1990; Lajeunesse and Pryor 1996; Meyer 2005; Meyer and Rosenthal 1998; Morattto and Arguelles 1984; O'Brien 1984; Peak and Crew 1990; Rosenthal and McGuire 2004; Rosenthal and Meyer 2004b; White 2003b).

A growing body of evidence indicates there were two distinct settlement-subsistence adaptations operating in central California beginning in the Middle Archaic, one centering on the foothills and the other on the valley floor (Fredrickson 1994c:102–103; Rosenthal and McGuire 2004:161–163).

FOOTHILL TRADITIONS In contrast to the paucity of evidence from the valley floor, Middle Archaic sites dating between about 4050 and 2050 cal B.C. are comparatively common in the foothills, particularly in buried contexts (Basgall and Hildebrandt 1989; Lajeunesse and Pryor 1996; Meyer and Rosenthal 1997; Milliken et al. 1997; Peak and Crew 1990; Rosenthal and McGuire 2004; Rosenthal and Meyer 2004b; Sundahl 1992). These deposits are characterized by an abundance of expedient cobble-based pounding, chopping, scraping, and mulling tools, continuing a pattern first observed in the Early Holocene. Archaeobotanical assemblages from foothill sites CAL-789, CAL-629/630, and FRE-61 confirm that acorn and pine nuts were targeted plant foods (McGuire 1995; Rosenthal and McGuire 2004; Wohlgemuth 2004).

Closely similar functional assemblages have been identified as far north as SHA-1169 in the Sacramento River canyon (Basgall and Hildebrandt 1989) and as far south as FRE-61 on the Kings River fan in the southern San Joaquin Valley (McGuire 1995). Examples from the North Coast Ranges foothills, such as SOL-315 and GLE-217, are associated with the Mendocino Pattern, an upland adaptive strategy featuring high residential mobility that persisted well into the Upper Archaic (Fredrickson 1974a; White and Weigel 2006; White et al. 2002; Wiberg 1992).

Foothill tradition artifact assemblages are composed almost exclusively of flaked and ground stone tools used in food procurement and processing. Few bone or shell artifacts, beads, or ornaments have been encountered. Tabular pendants, incised slate, and perforated stone plummets are uncommon but widespread (Basgall and Hildebrandt 1989; Rosenthal and McGuire 2004; Sundahl 1992; White and Weigel 2006; Wiberg 1992). Projectile points include notched, stemmed, thick-leaf, and narrow concave base darts, with a high degree of local and regional morphological variability. Source materials are also variable, owing primarily to a reliance on local toolstone supplemented by a small percentage of obsidian derived from the nearest quarries in the North Coast Ranges, Cascades, and eastern Sierra. Rock-filled hearths and ovens are common (White and Weigel 2006; Wiberg 1992), while several graves have been identified capped by cairns of unmodified rock and milling equipment, including examples at CAL-1180/H, FRE-61, GLE-217, MRP-181, and SOL-315 (Fitzwater 1962; McGuire 1995; Milliken et al. 1997; White and Weigel 2006; Wiberg 1992).

VALLEY TRADITIONS Cultural deposits associated with the early Middle Archaic (ca. 5550 to 2050 cal B.C.) are rare in the Central Valley, due in part to geomorphic changes described above. In the Sacramento Valley, only traces of human occupation older than 2050 cal B.C. have been discovered, and all occur in buried contexts (White 2003a, 2003b). In the San Joaquin Valley, the oldest of the classic Windmiller sites (SJO-68), dating to 3050 cal B.C., was discovered on a relict landform (Ragir 1972:27, 39). Only four dated components and a few isolated artifacts are associated with this time period, primarily found in buried contexts. In the Sacramento Valley, augers dug at the Reservation Road site, COL-247, encountered a buried midden at 3.0 to 3.5 meters below surface dating to 4020 cal B.C. The component was not excavated (White 2003a, 2003b). In the San Joaquin Valley, the stratigraphically deepest occupation at SJO-68 dates to a minimum of 3050 cal B.C. (Lillard et al. 1939:31–32; Ragir 1972:27, 39), and two buried sites in the northern Diablo Range (CCO-637 and CCO-18/548) have been dated between 4950 and 3050 cal B.C. (Meyer 2005; Meyer and Rosenthal 1998).

Sites and site components associated with later portions of the Middle Archaic (post-2550 cal B.C.) are comparatively well represented in the Sacramento Valley (Figure 10.4) and Delta, and northern San Joaquin Valley. Sites of this age have produced elaborate material culture and diverse technological and dietary assemblages, including BUT-233, CAL-237, CCO-18/548, CCO-637, COL-247, SJO-68, SJO-112, SJO-142, SJO-145, and SAC-107 (Heizer 1949; Meacham 1979; Meyer and Rosenthal 1998; Olsen and Wilson 1964; Ragir 1972; Schulz 1981; Welden 1990; White 2003a,b; Wiberg and Clark 2004).

The late Middle Archaic record reveals a distinct adaptive pattern reflecting the emergence of logistically organized subsistence practices and increas-

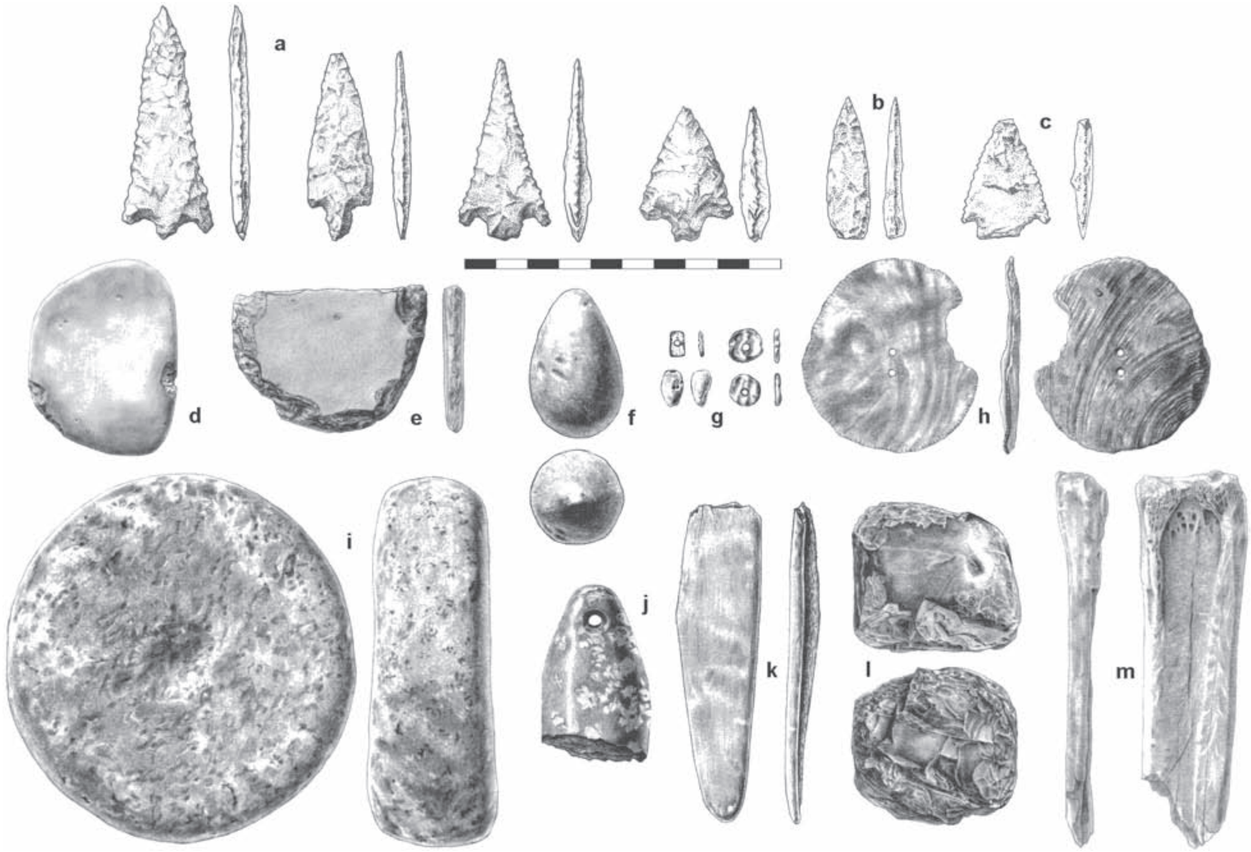

Figure 10.4. Late Middle Archaic assemblage from the Colusa Reach of the Sacramento, COL-247, Stratum 2. (a) Willits side-notched point; (b) contracting-stemmed, small blade points; (c) Mendocino and Martis corner-notched points; (d) domed scraper; (e) pebble hammer; (f) ceramic egg shape; (g) *Olivella* L2 rectangular and Class A (spire-lopped) series, bird bone tube bead; (h) *Haliotis cracherodii* disk ornament; (i) perforated plummets; (j) disk-shaped handstone; (k) wedge-shaped handstone; (l) meta-sedimentary core tool; (m) elk cannon bone dagger (after White 2003a:Figs. 112–113).

ing residential stability along river corridors of the Sacramento and San Joaquin Valleys. This riverine adaptation appears to have been fully in place by perhaps 6,000 years ago; however, the origins, spatial extent, and regional variability of the pattern are as yet poorly known. Extended residential settlement at these sites is indicated by refined and specialized tool assemblages and features, a wide range of nonutilitarian artifacts, abundant trade objects, and plant and animal remains indicative of year-round occupation (Moratto 1984; Ragir 1972; Schulz 1970, 1981; White 2003a,b).

The archetypical Middle Archaic expression, identified as the Windmiller Pattern (Fredrickson 1973, 1974a; Moratto 1984), was first recognized at a handful of sites found on old levee ridges adjacent to freshwater marshes and well-watered riparian settings near the confluence of the Mokelumne and Cosumnes Rivers in the delta region (Heizer 1949; Lillard et al. 1939; Olsen and Wilson 1964; Ragir 1972). With the exception of an early component at SJO-68, Windmiller sites in the Central Valley date between 1850 and 750 cal B.C. (Olsen and Wilson 1964; Ragir 1972; Rosenthal and Meyer 2004b; Schulz 1981).

Windmiller settlements are unique in their prevalence of westerly oriented, ventrally and dorsally extended burials, along with sophisticated material culture found primarily as grave offerings (Heizer 1949; Olsen and Wilson 1964; Ragir 1972). New finds show that Windmiller sites were widespread in the San Joaquin Valley during the Middle Archaic and did not necessarily spread from the delta region, as previously assumed by Beardsley (1954) and Heizer (1958:7). Several sites, including CCO-18/548, CCO-637, CAL-237, and CAL-629/630, found on the margins of the northern Diablo Range and Sierra Nevada, contain ventrally and dorsally extended burials contemporaneous with Windmiller settlements in the eastern delta (Farris et al. 1988; Johnson 1967; Lajeunesse and Pryor 1996; Meyer and Rosenthal 1997; Wiberg and Clark 2004). In fact, the earliest extended burials found in the northern Diablo

Range at CCO-637 are 700 to 800 years older than those reported from SJO-68 (Meyer and Rosenthal 1998; Ragir 1972), suggesting this lowland tradition has an origin considerably earlier than previously demonstrated. Further, a tradition of extended burial posture can now be recognized throughout the San Joaquin Valley as far south as Buena Vista Lake, at sites dating from the Middle through Upper Archaic Periods (Bennyhoff 1994c, 1994d; Delacorte 2001; Dougherty and Werner 1993; Fenenga 1973; Fredrickson and Grossman 1977; Moratto 1984:210–211; Peak and Weber 1978; Pritchard 1970, Warren and McKusick 1959; Wedel 1941).

In the Sacramento Valley, a general absence of Middle Archaic sites makes it difficult to identify a dominant mode of interment. However, flexed and extended burials were identified in Middle Archaic strata at Reservation Road (COL-247; White 2003a, 2003b), and only flexed burials were found farther north at Llano Seco (BUT-233; Welden 1990).

As early as 4050 cal B.C., mortars and pestles were used at sites in the lowlands of central California, particularly in marsh side and riparian settings in the northern San Joaquin and southern Sacramento valleys, at sites such as COL-247 and SJO-68, and in the northern Diablo Ranges at CCO-637 (Basgall 1987; Meyer and Rosenthal 1998; Ragir 1972; Rosenthal and McGuire 2004; Schulz 1981; White 2003b). Various lines of evidence suggest that the shift to mortar and pestle accompanied more intensive subsistence practices and greater residential stability (Basgall 1987). However, the adoption of this technology does not track with changes in the types of plant foods processed. Acorn and pine nut shells are common in virtually all Middle Archaic archaeobotanical assemblages at sites with and without the mortar and pestle (e.g., BUT-233, CCO-18/548, COL-247; FRE-61; SOL-391; CCO-637, CCO-18/548, CAL-789; Basgall 1987; McGuire 1995; Meyer 2005; Meyer and Rosenthal 1997; Rosenthal and McGuire 2004; White 2003b; Wiberg and Clark 2004; Wohlgemuth 2004).

Fishing may have also taken on new importance to Central Valley groups during the Middle Archaic, as new fishing technologies such as gorge hooks, composite bone hooks, and spears, along with abundant fish remains, are represented in Middle Archaic lowland assemblages from such sites as CCO-18/548, CCO-637, COL-247, SAC-107, SJO-56, and SJO-68 (Broughton 1988; Heizer 1949; Meyer 2005; Meyer and Rosenthal 1997; Ragir 1972; Schulz 1981; White 2003a; Wiberg and Clark 2004).

Several other technologies common in later time periods are first apparent in the archaeological record of the northern San Joaquin Valley and the southern Sacramento Valley during the Middle Archaic. These include baked-clay impressions of fine twisted cordage and twined basketry, basketry awls, simple pottery and other baked clay objects found at sites such as COL-247 and SJO-68. A variety of finely made stone plummets and perforated "pencils," bird bone tubes, shell beads, and other personal adornments have also been recovered from Middle Archaic deposits (Olsen and Wilson 1964; Ragir 1972; White 2003a,b; Wiberg and Clark 2004).

Faunal assemblages recovered from CCO-18/548, CCO-637, COL-247, SJO-68, and SJO-112 reflect a heavy reliance on the emerging mosaic of marshes, riparian forests, and grasslands in central California. Tule elk, mule deer, and pronghorn are all represented, as are small and large fish, rabbits and hares, waterbirds, other terrestrial carnivores, raptors, and rodents (Broughton 1994a; Meyer 2005; Meyer and Rosenthal 1997, 1998; Olsen and Wilson 1964; Ragir 1972:159; Taite 1999; White 2003a,b).

Exchange of commodities such as obsidian, shell beads and ornaments, as well as perhaps other perishable items, was widespread during the Middle Archaic. People living in the Central Valley became important consumers of obsidian quarried on the east side of the Sierra Nevada at Bodie Hills, Casa Diablo, Coso, and Mount Hicks; from the North Coast Ranges at Napa Valley and Borax Lake; and from the southern Cascades at the Tuscan source (Bouey 1995; Ericson 1981; Jackson 1974; Meyer and Rosenthal 1998; Sundahl 1992; White 2003a; Wiberg and Clark 2004). Two types of individually made wall beads cut from the shell of *Olivella biplicata* are first found in Middle Archaic contexts, marking the beginning of a manufacturing industry and exchange network that would develop through the Late Holocene (Bennyhoff and Hughes 1987; Groza 2002; Milliken and Bennyhoff 1993). Grooved-rectangle beads found at KER-3166/H and KER-5404 in the southern San Joaquin Valley are the earliest of these wall beads, consistently dating older than 3050 cal B.C. (Jackson et al. 1998:144; Siefken 1999:55; Vellanoweth 2001). Early *Olivella* rectangle beads found at CCO-637 and CCO-18/548 are slightly younger, dating between 2520 and 1630 cal B.C.

Upper Archaic (550 cal B.C. to cal A.D. 1100)

The beginning of the Upper Archaic Penriod corresponds roughly with the onset of Late Holocene environmental conditions, marked by an abrupt turn to cooler, wetter, and more stable climate. Western lakes that dried or diminished during later parts of the Middle Holocene returned to spill levels by 1050 cal B.C. (Benson et al. 2002; Sims et al. 1988). Decreased salinity and bayward migration of alkaline-adapted plants in the delta indicate greater freshwater flows in the Sacramento/San Joaquin watershed during this period (Goman and Wells 2000). Climatic changes also resulted in renewed fan and floodplain deposition and soil formation in the Central Valley. In most regions, the current surface soils formed in deep Late Holocene alluvium capping the erratic, heavily weathered Middle Holocene landscape (Rosenthal and Meyer 2004a:29; Waters 2002; White 2003a,b).

The Upper Archaic archaeological record is better represented and understood than previous time periods. Cultural diversity was more pronounced and is clearly reflected in a geographically complex mosaic of distinct sociopolitical entities marked by contrasting burial postures, artifact styles, and other elements of material culture (Bennyhoff 1977; Bennyhoff and Fredrickson 1994; Kowta 1988; Rosenthal 1996; Sundahl 1992).

The Upper Archaic witnessed the development and proliferation of many specialized technologies, including new types of bone tools and other bone implements (e.g., wands, tubes, ornaments), as well as widespread manufactured goods like saucer and saddle-shaped *Olivella* beads, *Haliotis* ornaments, obsidian bifacial rough-outs, and well-made ceremonial blades (Bennyhoff and Fredrickson 1994; Fredrickson 1974a; Moratto 1984). Polished and ground stone plummets are common in regions surrounding the rivers and marshlands of the delta and southern San Joaquin Valley, and are occasionally found in arranged caches (Seals 1993; Shapiro and Tremaine 1995; Sutton 1996b).

Economies varied regionally, focused on seasonally structured resources that could be harvested and processed in bulk, such as acorns, salmon, shellfish, rabbits, and deer. In the delta region and adjacent portions of the Sacramento and San Joaquin Valleys, use of mortars and pestles along with a rich archaeobotanical record reflect a heavy reliance on acorns (Basgall 1987; Fredrickson 1974a:125; Moratto 1984:209; White 2003a,b; Wohlgemuth 1996, 2004). On the margins of the valley, handstones and millingslabs are dominant in Upper Archaic assemblages (Basgall and Hildebrandt 1989; Kowta 1988; Moratto 1972; Siefken 1999; Sundahl 1982, 1992), along with acorn hulls and pine nut shells (Wohlgemuth 1996, 2004).

Beginning after 2,700 years ago, large mounded villages developed in the delta region of the lower Sacramento Valley (e.g., Bouey 1995; Lillard et al. 1939; Ragir 1972; Schenck and Dawson 1929; Schulz 1981) related to a cultural tradition originally termed the Middle Horizon and identified by Fredrickson (1973, 1974a) as the Berkeley Pattern. Berkeley Pattern sites of the lower Sacramento Delta region contain extensive accumulations of habitation debris and features, especially fire-cracked rock heaps, shallow hearths, rock-lined ovens, house floors, and flexed burials—all reflecting long-term residential occupation (Bouey 1995:348–349). Although the most significant Berkeley Pattern deposits were excavated long ago, more recent analysis of sites in the lower Sacramento Valley (e.g., COL-247, SAC-42, SAC-43, SAC-133, SAC-265, SOL-355, SOL-363, SOL-379) has added important information, particularly on economic aspects of the pattern (Bouey 1995; Bouey and Waechter 1992; Milliken 1995b; Peak et al. 1984; Peak and Associates 1984; Rosenthal and White 1994; Shapiro and Tremaine 1995; Sheeders 1982; Wiberg 1993; Wohlgemuth 2004).

Only in the eastern delta at SAC-107 does stratigraphic succession indicate that the Berkeley Pattern replaced an earlier Windmiller tradition. Descendants of the Windmiller culture continued to occupy the San Joaquin Valley during the Upper Archaic (Bennyhoff 1994c,d). Their sites, distinguished by a common extended burial posture, are found along the western and southern edges of the delta (e.g., CCO-146, SJO-91) and along the side streams and axial marshes of San Joaquin and Merced Counties (e.g., SJO-17, SJO-87, SJO-106, SJO-154, SJO-264, MER-3, MER-215, MER-323) until sometime between 1,000 and 800 years ago (Bennyhoff 1994c,d; Delacorte 2001; Dougherty and Werner 1993; Fenenga 1973; Milliken et al. 1997:35; Moratto 1984:210–211; Peak and Weber 1978; Pritchard 1970).

The lower foothill woodlands of the San Joaquin Valley appear to have been a boundary area. Judging by clusters of extended Upper Archaic burials found at sites as far east as San Andreas (CAL-114/H; Stewart and Gerike 1994), Copperopolis (CAL-629/630; Lajeunesse and Pryor 1996), and Buchannan reservoir (Chowchilla Phase; MAD-117, MAD-159; Moratto 1972, 1984), valley people may have periodically colonized riparian and other well-watered foothill habitats along the base of the Sierra. On the western margins of the San Joaquin Valley, discrete cemeteries of either extended (e.g., CCO-696 East, MER-3) or flexed burials (e.g., CCO-696 West, MER-94) date to the Upper Archaic (Meyer and Rosenthal 1997; Olsen and Payen 1969; Pritchard 1970), and probably represent alternating occupation by groups originating in the valley and adjacent coast ranges.

Little is known about Upper Archaic cultures in the southern San Joaquin Valley (Siefken 1999:56–57). Hartzell (1992) reports year-round villages at KER-116 and KER-39 on Buena Vista Lake. These deposits incorporate a variety of residential features, including house floors, and extensive accumulations of dietary debris that reflect exploitation of both aquatic and terrestrial environments (Hartzell 1992:304–305).

In the far northern part of the Sacramento Valley, few Upper Archaic sites have been investigated. All appear to be related to the Whiskeytown Pattern (e.g., SHA-47, SHA-571/H, SHA-890, SHA-891, SHA-892, SHA-992), a technologically conservative and mobile adaptation found throughout the adjoining foothills (Sundahl 1982, 1992). In contrast to later Shasta Complex sites, Upper Archaic deposits associated with the Whiskeytown Pattern lack developed middens and residential features, and fish bone and other riverine resources are rare or absent (Hildebrandt et al. 2005:50–52). Although it was once thought that substantial Upper Archaic villages should be located along the northern Sacramento River (Basgall and Hildebrandt 1989:450), such sites have not yet been identified (Hildebrandt et al. 2005:50–52).

In the northeastern Sacramento Valley, Upper Archaic sites appear to be more substantial village settlements (Deal 1987). The lower component at mound site BUT-288 produced several domestic and processing features, human graves, and a variety of bone implements and marine shell beads and ornaments. The faunal assemblage reflects spring through winter occupation (Deal 1987). Similar features and artifact and dietary assemblages are reported from BUT-233, BUT-294, and GLE-101 (Welden 1990; White 2003a; Zancanella 1987).

People living in the San Joaquin Valley during the Upper Archaic remained important consumers of obsidian obtained from the east side of the Sierra. Stone workers at three main quarries—Bodie Hills, Casa Diablo, and Coso—manufactured bifacial blanks that were transported over the mountains along well-defined, east-west travel corridors (Bouey and Basgall 1984; Ericson 1981; Jackson et al. 1994). In the southern Sacramento Valley, obsidian was obtained primarily from quarries to the west in the North Coast Ranges, at Borax Lake and the upper end of Napa Valley. Specialist stone workers living near these quarries manufactured lanceolate-shaped bifaces that were widely traded throughout the Central Valley (Carpenter and Mikkelsen 2005; White 2003a; White et al. 2002). In the northern and eastern valley, obsidian was obtained primarily from Tuscan and Medicine Lake Highlands quarries, with the former becoming more important over time (Deal 1987; Sundahl 1992; Zancanella 1987).

Emergent Occupation (cal A.D. 1000 to Historic)

The relatively stable climatic regimes established at the outset of the Late Holocene appear to have prevailed throughout much of the Emergent Period, but several flood and drought events have been identified locally. These include pulses of floodplain deposition between cal A.D. 950 and 650 and again at about cal A.D. 1350 (Meyer and Rosenthal 1997; Rosenthal and Meyer 2004a,b; White 2003a,b), a major delta flood dating to cal A.D. 1420 (Goman and Wells 2000), and a significant drought in the Sacramento River watershed between cal A.D. 1585 and 1575 (Meko 2001; Meko et al. 2001). It isn't clear, however, if these were unusual events or simply products of the comparatively profound resolution of more recent paleoenvironmental evidence.

The Emergent Period is associated with the Augustine Pattern (Fredrickson 1994c) in the lower Sacramento Valley/Delta region (previously known as the Late Horizon), and the Sweetwater and Shasta Complexes in northern Sacramento Valley (Fredrickson 1973, 1974a; Kowta 1988; Sundahl 1982). Sporadic research in the San Joaquin Valley has resulted in few named Emergent Period components or phases. Only the Pacheco Complex from the western edge of the valley has been formally defined (Olsen and Payen 1968, 1969, 1983; Pritchard 1970).

The Emergent Period archaeological record is the most substantial and comprehensive available for any period, and the assemblages and adaptations represented are the most diverse (Bennyhoff 1977; Fredrickson 1974a, Kowta 1988; Sundahl 1982, 1992). After cal A.D. 1000, many archaic technologies and cultural traditions disappeared throughout the Central Valley. Each region witnessed the onset of cultural traditions similar to those existing at the time of European-American contact. The Emergent Period is marked by the introduction of the bow and arrow, which replaced the dart and atlatl as the favored hunting implement between about cal A.D. 1000 and 1300 (Bennyhoff 1994a). A change from less to more complex social forms is indicated by increased variation in burial type and furnishings (Atchley 1994; Bennyhoff and Fredrickson 1994; Milliken and Bennyhoff 1993). In the Sacramento Valley, large, populous towns developed at points along the river where fish weirs were constructed (e.g., COL-1, COL-2, SHA-222, SHA-266; Sundahl 1982; White 2003a). Similar mound villages and smaller hamlets were established in the delta region and along major tributaries (e.g., BUT-1, BUT-12, BUT-288, CCO-138, COL-11, SAC-16, SAC-127, SAC-267, SAC-29, SOL-397, TEH-10, YOL-69; Atchley 1994; Derr 1983; Eugster 1990; Johnson 1976; Johnson and Dondero 1990; Olsen 1963; Peak et al. 1984; Schenck and Dawson 1929; Shapiro and Tremaine 1999; White 2003a; Wulf 1997). In the San Joaquin Valley, villages and smaller residential communities developed along the many sidestreams of the foothills and along the river channels and sloughs of the valley bottom (e.g., FRE-128, MER-3, MER-119, KIN-66, TUL-1613; Dillon et al. 1991; Olsen and Payen 1968; Pritchard 1970, 1983; Siefken 1999).

Two broad phases are widely recognized during the Emergent Period: the Lower and Upper. The Lower Emergent is marked by the first appearance of banjo-type *Haliotis* ornaments in the southern Sacramento Valley/Delta region, as well as elaborately incised bird bone whistles and tubes, flangedsoapstone pipes, and rectangular *Olivella* sequin beads. Upper Emergent artifacts include small corner-notched and desert series arrow points, *Olivella* lipped and clam disk beads and bead drills, magnesite cylinders, hopper mortars, and village sites with house pits often attributable to known ethnographic settlements (Beardsley 1954:77–79; Bennyhoff, in Elsasser 1978:44; Fredrickson 1984; Moratto 1984:213; Pritchard 1970, 1983). Other new traits that distinguish the Augustine Pattern in the delta region include preinterment grave pit burning with tightly flexed burials. Cremation was apparently reserved for high-status individuals during the Lower Emergent but was widespread during the Upper Emergent (Fredrickson 1974a:127; Moratto 1984:211).

Grave offerings such as shell beads and ornaments regularly occur with utilitarian items including pestles and mortars often "killed" before burial. In the Sacramento Valley area, fishing equipment is more common, elaborate, and diverse than in earlier phases and includes several types of harpoons, bone fish hooks, and gorge hooks (Beardsley 1954:78; Bennyhoff, in Elsasser 1978:44; Moratto 1984:211; Sundahl 1982). Twined and coiled basketry, netting, and other perishables were preserved at MER-3, SAC-29, SOL-236, TEH-10, and YOL-69 (Johnson and Dondero 1990; Pritchard 1970; Polanich 2005), while house floors and other structural remains are commonly preserved at Emergent Period sites throughout the valley and adjoining foothills (e.g., CAL-1180/H, CCO-458, COL-11, KER-39, MER-3, MER-113, MER-215, MER-295, SAC-29, SAC-267, SHA-222, SHA-266, SHA-294, SHA-1141/H; Dondero and Johnson 1988; Hartzell 1992; Johnson 1976; Meyer and Rosenthal 1997; Milliken et al. 1997; Olsen 1963; Maniery and Brown 1994; Peak and Weber 1978; Pritchard 1970, 1983; Sundahl 1982; White 2003a). A local form of pottery known as Cosumnes brownware was made in the lower Sacramento Valley, represented at several sites including SAC-6, SAC-67, SAC-107, SAC-127, SAC-265, SAC-267, and SAC-329 (Johnson 1990; Kielusiak 1982). In the Tulare basin, pottery was obtained through trade from groups living in the foothills to the east (Wallace 1990). Baked clay balls, probably used for cooking, are a common constituent in Central Valley sites where stone is absent (e.g., SAC-16, SAC-265, SAC-267) (Derr 1983:92; Johnson 1976:301–319; Moratto 1984:213; Sheeders 1982:81–94). Human and animal effigies of baked clay are known from several sites in the lower Sacramento Valley and Delta regions (e.g., SAC-6, SAC-16, SAC-29, SAC-267, SJO-42, SJO-43) (Johnson 1976:301–319; Kielusiak 1982; Schenck and Dawson 1929).

During the Lower Emergent Period, the most unique arrow point style in California was developed in the delta or adjacent regions to the west, known as the Stockton serrated point (Dougherty 1990). While other arrow point styles found in the Central Valley have morphological similarities to widespread types found in adjacent regions and may have been adopted from neighboring groups, the Stockton serrate is clearly an independently developed point type. This may be taken as evidence that changes in other aspects of culture in the southern delta represent internal developments and not the in-migration of new people. South of the delta in Merced, Stanislaus, and Fresno Counties, there is little evidence for the first arrow point styles, but by perhaps 500 years ago, the Panoche side-notched point, a variant of the desert side-notched, was in use on the western side of the San Joaquin Valley, and cottonwood points are found in the Tulare and Buena Vista basins (Hartzell 1992:173; Moratto 2002; Olsen and Payen 1983; Pritchard 1970; Siefken 1999:152–154). In the northern Sacramento Valley, Gunther-barbed points were introduced as early as cal A.D. 770 (Basgall and Hildebrandt 1989:123;

Jaffke 1997). By the end of the local sequence, desert side-notched points were in use, just as they were in many places in the Central Valley, often alongside other local arrow point types (Baumhoff and Byrne 1959; Dougherty 1990; White 2003b).

The emphasis of Emergent Period economies was regionally variable, although fishing and plant harvesting appear to have increased in importance over time throughout the Central Valley. Most residential sites dating to the Emergent Period include large quantities of fish bone and a diverse assortment of mammal and bird remains evidenced by collections from numerous sites (e.g., AMA-56, BUT-1, COL-158, COL-245/H, KIN-66, MER-215, SAC-133, SAC-329, SHA-266, SHA-290/H, SHA-294) (Bouey and Waechter 1992; Broughton 1988; Dondero and Johnson 1988; Furlong 2004; Schulz et al. 1976; Siefken 1999; Simons 1978; Soule 1976; Valente 1998a; White 2003a). Throughout the Central Valley, mortars and pestles predominate after 1,000 years ago. Small seeds became increasingly important in deposits from the lower Sacramento Valley/Delta region (e.g., CCO-458, COL-245, SOL-356, SOL-397, SUT-17, YOL-69) while the greater size of certain grass seeds may indicate incipient horticulture (Miksicek 1999; Wohlgemuth 2004). Acorn, pine nut, and manzanita are abundant throughout the Emergent Period in the large village middens of the northern Sacramento Valley, including SHA-47, SHA-236, SHA-222, SHA-290/H, and TEH-748 (Dondero and Johnson 1988; Wohlgemuth 2004:104–106), while little is known about plant use in the San Joaquin Valley (Wohlgemuth 2004).

Sometime during the past 800 years, there was a significant change in the nature of obsidian production in central California. Bifaces were no longer commonly manufactured at centralized quarry workshops or nearby villages. Instead, raw obsidian cobbles and flake blanks were moved out of the Napa Valley to consumers in neighboring regions. This resulted in substantial changes in manufacturing residues at Emergent Period sites in the lower Sacramento Valley (e.g., CCO-138, YOL-69) and Diablo Ranges (CCO-458) (Bieling 1996; Bloomer 2005; Fredrickson 1968, 1969; Meyer and Rosenthal 1997).

Decentralization in the production of shell beads is also evident in Emergent Period sites. During the past 800 to 500 years, *Olivella* bead blanks and manufacturing refuse from interior central California sites, such as CCO-458, KIN-66, NAP-539, and SOL-356 (Hartzell 1992; Meyer and Rosenthal 1997; Siefken 1999; Wiberg 1996b), marks the beginning of local bead-making industries. By about 300 years ago, clam shell disk beads became widely used and clam shell manufacturing waste and bead blanks are found throughout Upper Emergent sites exclusively in the lower Sacramento Valley west of the Sacramento River (e.g., SOL-30, SOL-397, YOL-69). This tradition of bead manufacture may be related to the adoption of a monetized system of exchange (Chagnon 1970; King 1978).

CULTURE CHANGE IN THE CENTRAL VALLEY

In the years leading up to publication of *California Archaeology* (Moratto 1984), most researchers had arrived at the view that native people in the Central Valley had achieved high population densities and cultural elaboration as the result of a relatively affluent environment stocked with abundant and predictable foodstuffs (Baumhoff 1963; Moratto 1984:171). This view began to change in the early 1980s, as a growing radiocarbon database demonstrated that sites more than 2,500 years old were rare in the Central Valley, which was interpreted as evidence for a sharp increase in human population during the Upper Archaic (Breschini 1983; Schulz 1981). Several studies also concluded that the devices associated with pursuit and processing of ethnographic staples (e.g., the mortar and pestle related to acorn processing, and net weights, spears, and hooks needed for fishing) were relatively recent innovations that came into widespread use only after 2,500 years ago (Fredrickson 1973, 1974a; Gould 1964; Ragir 1972; Schulz 1981). To explain these developments, archaeologists started thinking about the record in new ways, first exploring causal relationships between population density and the emergence of social stratification (Fredrickson 1974b; T. King 1970, 1974b, 1978; Moratto 1972) and later turning to the broader concepts of late prehistoric *intensification*, demographic forcing, and optimality theory.

Intensification

Cohen (1981) introduced the new concept of intensification, arguing that California's late prehistoric diets were not efficient and balanced but were encumbered by higher processing costs when compared to earlier diets, and that reliance on these costly foods (such as acorns) had actually been forced by late prehistoric population increase. Basgall (1987) built on the notion of demographic forcing, arguing that imbalances between human population and available resources might result from a variety of different kinds of events, such as local population growth, in-migration of new populations, resource depletion due to human overharvest, or declines in productivity due to climate change. Basgall (1987) proposed that regional variation in central California was a product of differences in the rate at which these various demographic thresholds were breached. Beaton (1991c) also sought to strengthen the intensification model by introducing a distinction between intensification as "the sum of additional labor and material devoted to increasing the yield of currently exploited resources within the residential estate" versus extensification as "the sum of additional labor and material devoted to the capture of new resources either within or without the estate" (Beaton 1991c:951).

Despite the predictive and synthetic potential demonstrated by initial efforts to develop intensification theory, during the 1990s it became clear that the theory had progressed well beyond the existing archaeological record. First, the theory relied on claims of population increase but no quantitative evidence was forthcoming. Second, the theory claimed that certain foods were inefficient but no one provided actual data on nutritional returns versus processing costs. Third, the proponents of demographic forcing claimed that prehistoric diets had changed, but they provided little evidence in support of this position. Fortunately a new generation of studies has addressed these shortcomings.

Demographic Forcing

With the goal of developing an indirect measure of population pressure, researchers have begun to study the enormous collections of human skeletal remains from the Central Valley to identify changes in health status. These studies consistently show that pathologies associated with poor nutrition and interpersonal violence are more frequent and age/sex dependent over time, implying that Central Valley groups were often stressed (Dickel 1985; Dickel et al. 1984; Ivanhoe 1995; Jurmain 2001; Nelson 1991; Schulz 1981; Tenney 1986). Mortality profiles from Central Valley sites also indicate that population increased steadily from the late Middle Archaic through the Emergent Periods (Bouey 1995:353; Doran 1980).

To directly measure prehistoric population growth over the past 4,000 years, White (2003b) studied ethnographic River Patwin and Valley Konkow territory, where the distinctive demographic, social, and economic extremes of the Central Valley had reached their apex (Baumhoff 1963; Kroeber 1922, 1936, 1939). Ethnographic and historical sources were consulted for information about village and population size, and records of all known surveys, sites, and excavations were examined. There were 29 excavated village sites with 39 separate occupation components which were assigned an age based on time-marker artifacts and radiocarbon dates. White (2003b) estimated population at around 625 persons by the end of the Middle Archaic (2550 cal B.C.), doubling and redoubling to 3,424 persons near the end of the Upper Archaic (cal A.D. 750), and tripling again to 12,555 persons by the end of the Emergent (cal A.D. 1820; Figure 10.5), findings consistent with predictions from intensification theory.

Optimality and Resource Depression

Through the 1980s, the California intensification literature relied on simple claims of relative efficiency rather than actual measurement of food value. New research on optimality theory addresses this shortcoming. Optimality theory assumes that human adaptations were conditioned by the fundamental goal of energetic efficiency, and thus diet tended to be composed of the most profitable resources involving the highest gain for the least expenditure. Of particular interest to intensification theory are the implications about demographic forcing. For example, optimality models predict that hunter-gatherers will often overharvest favored prey species like deer and elk, which are easy to diminish because they take a long time to reach reproductive maturity, gestate slowly, and have few offspring. Thus human demographic forcing is likely to result in local depletion of these species, with ensuing resource depression leading to diet and technological change.

Broughton (1988) introduced these concepts to Central Valley archaeology with a study of prehistoric Sacramento River fisheries. He created a diet-breadth model for the Sacramento Valley and predicted that early diets should concentrate on large game (tule elk, deer, pronghorn antelope), with ensuing resource depression resulting in a shift to small game (rabbits, squirrels, waterfowl), and then to fish (salmon, perch, minnows). He examined a number of Sacramento Valley archaeological assemblages and found that Upper Archaic Period diets were characterized by a low ratio of fish to terrestrial game, while Emergent Period diets had a high ratio of fish to terrestrial game, indicating a decline in foraging efficiency over time, consistent with predictions from intensification theory. Broughton (1994a) also conducted a more general study based on examination of faunal assemblages ranging in age from the Middle Archaic to the Terminal Prehistoric Period. He found that over time, anadromous and

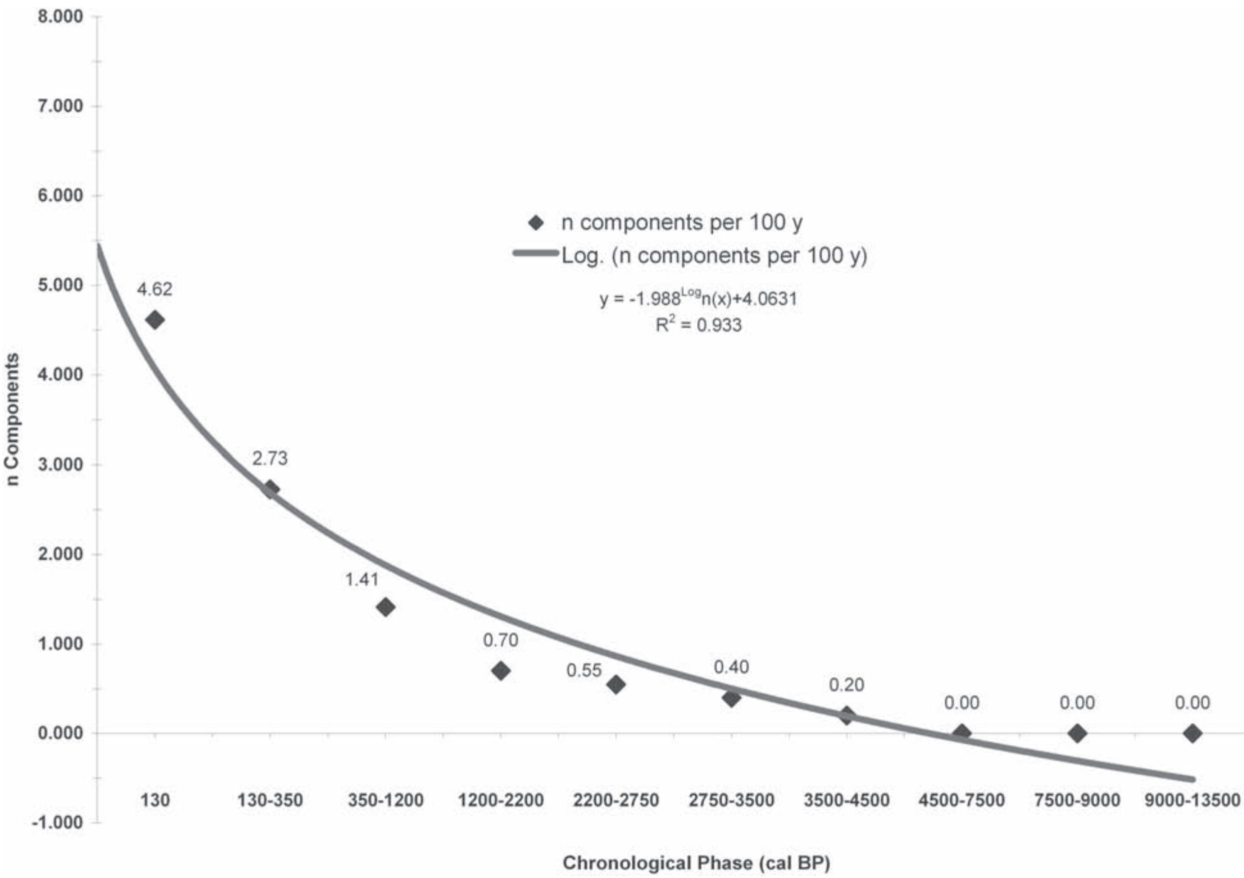

Figure 10.5. Lower Sacramento Valley population curve.

resident fish made up a progressively larger part of the diet relative to mammals. These studies implied that increasing reliance on local fisheries in part facilitated late prehistoric human population growth.

The Trouble with Acorns

Despite the early success of optimality theory, recent evidence pertaining to acorn exploitation provides a striking example of counterintuitive results. Based on changes in the types of stone grinding tools, Basgall (1987) argued that California's distinctive acorn economy developed relatively late in time—just 2,500 years ago in the Central Valley and substantially later in perimeter territories. Like Cohen (1981), Basgall (1987) concluded that the acorn was a high-cost vegetal food forced by late prehistoric population/resource imbalances. Wohlgemuth (1996) studied plant macrofossil assemblages recovered by flotation from a series of sites in Central California spanning the Middle Archaic through Emergent Periods (5500 cal B.C. to historic), and found a pattern of increasing density and diversity of seeds, and a greater proportion of large nut crops (especially acorn) during the Upper Archaic, consistent with Basgall's (1987) intensification argument. In addition, however, his research has also found widespread evidence for extensive use of acorns at a much earlier time depth and the increasing importance of small seeds relative to acorns during the Emergent Period, the latter especially acute in areas with the highest population densities (Wohlgemuth 2004).

With a new appreciation for the antiquity of acorn use, White (2003b) argues that either demographic thresholds were reached at an earlier time depth than previously predicted, or the food was more profitable than currently credited and therefore diet breadth models need to be recast. White suggests that we dispense with the assumption that acorns always required multistage processing, or that the end product was necessarily a fine, leached flour. Alternative products and processing probably characterized the Lower and Middle Archaic, involving methods that minimized handling costs. Whole or mulled acorns may have been treated with clay (White et al. 2002:536; White 2003b:26), a strategy that can reduce tannic acid content by more than 75 percent without the need for high-cost leaching (see Johns and Duquette 1991).

The Trouble with Small and Large Game

While Broughton's (1988, 1994a) analysis of Central Valley faunal assemblages focused on sites dating almost entirely to the Upper Archaic, most researchers took his model to unequivocally predict a prevailing pattern of large game harvest during the Archaic, replaced by small game harvest in the Emergent. In sharp contrast to this expectation, recent investigations at sites throughout the Central Valley have consistently found evidence for a high ratio of small to large game for over 7,000 years, between 7850 and 550 cal B.C. (Hartzell 1992; Meyer and Rosenthal 1997; Taite 1999; White 2003a), and a rise in the rate of large game harvest late in the prehistoric record (Furlong 2004; Taite 1999; Valente 1998a; White 2003a, 2003b). This is a phenomenon that has come to be identified by many researchers as the "artiodactyl spike."

These latter analyses show a substantial increase in the proportion of large game relative to small game, especially after 550 cal B.C., when other parts of the archaeological record clearly indicate that the rate of culture change was on the rise, and intensification phenomena were increasingly pronounced. Several explanations have been advanced, including the notion that later in time, people harvested in previously untouched environmental and cultural buffer zones (Broughton 1999; Holanda 2000; Taite 1999), that populations increasingly practiced mass capture methods, like deer drives and fences (White et al. 2002), that males began to hunt for prestige and not solely caloric gain (Hildebrandt and McGuire 2002), or simply that deer populations rebounded with the onset of Late Holocene environmental conditions (Broughton and Bayham 2003). The debate is ongoing (Furlong 2004; White 2005).

The Problem of the Whole Diet

While it is tempting to regard shortcomings in predictions about acorns, small game, and large game as evidence of a weakness in intensification theory itself, we may be missing the big picture and will only understand the fluctuations evident in game harvest and plant use once they are compared to each other and to important technological factors. White (2003b) attempted to synthesize the economic data from the same zone where he studied population, with the ultimate goal of correlating population expansion with economic change. He found a sharp increase in the rate of plant food production and sharp decline in the rate of animal food production after cal A.D. 770.

Notably, fish bone assemblages showed that more and smaller fish were taken after cal A.D. 770. Further, there was a steady decrease in the quantity and diversity of stone tools in village sites throughout this span, suggesting that plant food production and fish harvest involved off-site fixtures or soft technologies, probably including weirs, dip nets, seines, textile seed beaters, winnowing trays, and cooking vessels, as well as wooden mortars and perhaps wooden pestles, all technologies that are difficult to find and track in the archaeological record, and whose absence may have biased earlier studies (White 2003b).

White's (2003b) results show that the real story in the Central Valley is not in plant foods on the one hand or animal foods on the other, but the relationship between them. Plotting plant food and fish harvest curves against the Sacramento River population curve (Figure 10.6) shows that population had a direct causal relationship with plant food intensification (see also Wohlgemuth 2004).

QUESTIONS FOR FUTURE RESEARCH

While these results give us a renewed appreciation for intensification theory, the precise relationship between population change and culture change is still at issue. Even though we currently lack a common currency to measure the relative value of plant and animal foods, it is plain that the overall efficiency of the diet must have plummeted dramatically during the Emergent Period. Further, we currently have no means of relating economic change to sociocultural developments. However, the issue is central to determining if intensification was the unembellished product of resource depression and population growth, as current models require. Social complexity and instability clearly increased over time in the Central Valley, but because there is little or no attention to this issue the potential causal relationships are not part of the current debate. While it is possible that environmental productivity increased in the Late Holocene, it is also likely that any increase in food density would have rapidly created more densely packed populations facing the same problems with the same adaptation—the same ratio of people to resources that existed before the change in productivity. Thus intensification could only be related to a diminished ratio of resources to people, with proximate causes that might include environmental degradation or resource depression resulting from inexorable population growth.

We are convinced that resource intensification in the Central Valley was also marked by changes in hu-

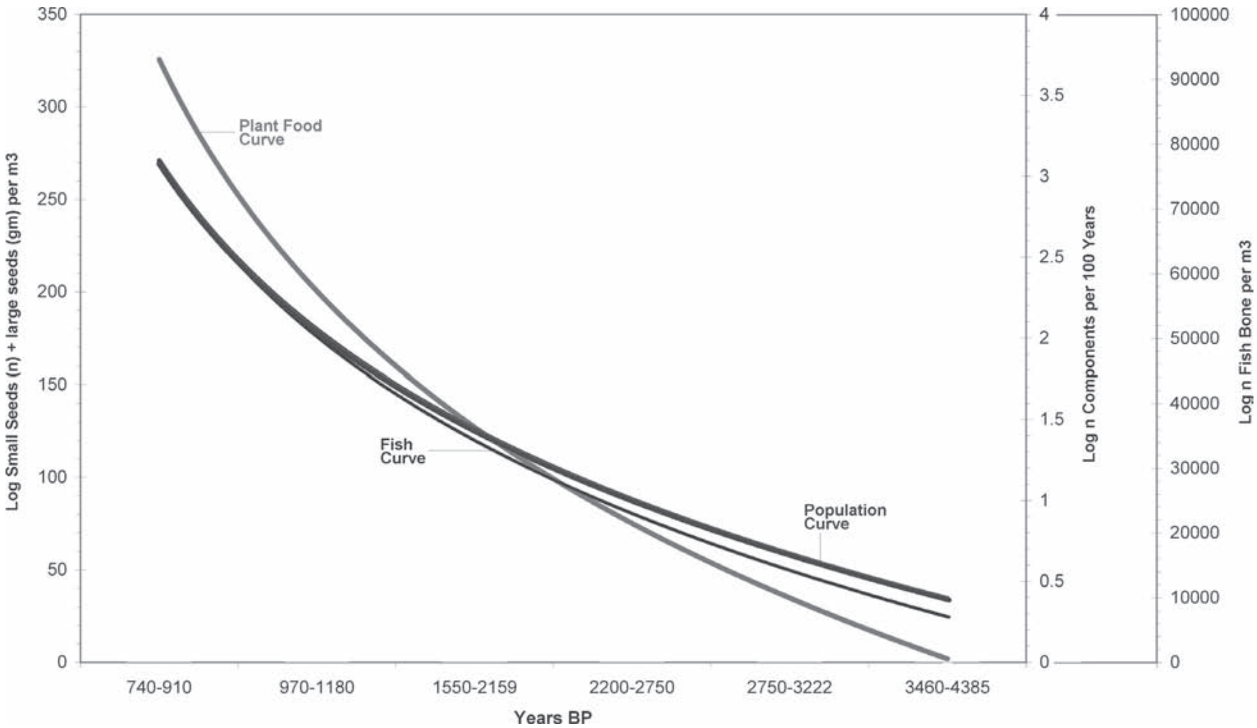

Figure 10.6. Lower Sacramento Valley plant, fish, and population curves, showing increases in plant and fish production closely linked to demographic change.

man organization in response to changes in resource density. Intensification was manifested in the development of an administrative elite able to plan and manage mass capture (White et al. 2002), and in changes in the labor investment of women toward provisioning and men toward prestige-seeking activity (Hildebrandt and McGuire 2002). In fact an important body of new research is beginning to address gender-based differences in sociopolitical roles (Atchley 1994), work habits (Cordero 2001), and health status (Hollimon 1995; Schulz 1981). These studies have found widespread evidence for differences over time between men and women in the organization of labor and access to subsistence resources and positions of authority.

Aside from the vital issues described above, two areas are poorly treated in current research. First, the problem of social change in relation to economic change is not well understood. Unfortunately, an extensive and valuable literature on the evolution of prehistoric Central Valley social structure (Fredrickson 1974b; T. King 1970, 1974a, 1978; Milliken and Bennyhoff 1993) and culture history (Bennyhoff and Fredrickson 1994) is underused if not commonly ignored. Renewed attention to these studies could contribute significantly to the present limited frame of reference. Second, the proper role of regional trade in intensification theory is now poorly understood and difficult to judge because intensification models focus on endogenous processes and seek triggering conditions in the dynamics of local population-resource relationships. Beaton's (1991c) model argues that intensification preceded extensification. However, new studies have shown that transregional trade appeared in the Central Valley during the Lower Archaic and was well established in the Middle Archaic, far in advance of the Emergent Period demographic thrust (Jackson et al. 1998; Rosenthal and Meyer 2004b; Vellanoweth 2001). A new theory incorporating exchange as a dimension of intensification is clearly in order.

The exciting thing about working in the field of Central Valley prehistory is that the basic terms of the argument are truly at issue with each shovel turned. We expect the next 20 years of research to supply a variety of new evidence pertinent to exploration of the causes and consequences of culture change in California's Great Valley.

NOTE

1. Unless otherwise noted, ^{14}C dates appearing here have been calibrated using CALIB v. 4.3 (Stuiver and Reimer 1993).