The Sierra Nevada: Archaeology in the Range of Light

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LOOKING EAST ACROSS THE FLOWERED PLAIN OF California's Central Valley in the late 1800s, conservationist John Muir beheld the Sierra Nevada in the distance and later described the range as "miles in height . . . and so gloriously colored, and so luminous, it seems to be not clothed with light but wholly composed of it, like the wall of some celestial city" (Muir 1894:2). For Muir, this "range of light" was a place of beauty, contentment, and introspection, drawing him to contemplate nature and the place of humankind within it. The Sierra Nevada continues to fascinate archaeologists, in part because this was one of the last regions in the state to witness systematic archaeological research. Much remains to be learned about prehistoric use of the area, and the nature of the archaeological record poses many challenges to interpretation.

Our modern sensibilities may find this area less hospitable than the temperate coast and plains of California and therefore an unexpected place for native occupation. Despite the fact that the mountains encompass often rugged terrain between the rich wetlands of California's Central Valley and the high desert of the Great Basin, the archaeological record of the Sierra Nevada documents use for thousands of years and has connections to the cultural history of both the east and the west. After more than 50 years of archaeological investigation, however, many questions remain regarding basic research issues such as cultural chronology and the subsistence strategies of the native inhabitants. The past 25 years of research have also witnessed significant synthetic studies and the development of regional research designs that have provided focus for ongoing investigations. Such guidance, as well as the innovative thinking of researchers, has resulted in exemplary studies of technology, exchange, gender relations, and population movements, with the promise of future contributions to understanding the past in this region and the role of Sierra people in shaping California's cultural landscape.

THE ENVIRONMENT AND THE PEOPLE OF THE SIERRA NEVADA

The Sierra Nevada Range in eastern California is 640 kilometers (400 miles) long and approximately 80 kilometers (50 miles) wide. It abuts the southern end of the Cascade Range on the north and adjoins the central Transverse Ranges of southern California in the south. The crest of the Sierra attains a maximum of elevation of approximately 2,740 meters (9,000 feet) in the north, but gradually increases in elevation to the south. The highest peaks and passes rise to more than 3,960 meters (13,000 feet) in elevation and include Mount Whitney, the highest point in the contiguous 48 states at 4,418 meters (14,496 feet). The slope of the Sierra Nevada also varies from west to east, as the western slope rises gradually over the width of the range. In contrast, the eastern slope exhibits an often dramatic, relatively steep escarpment, particularly in the southern half of the range.

The topographic relief of the Sierra Nevada reflects its unique geologic history. The mountains are composed primarily of a large batholith of granitic rock that has been subject to uplift for millions of years and has undergone more recent glaciation. Uplift of the eastern side has been dominant, resulting in the westward tilt of the range and the steeper slopes characteristic of the eastern side. Likewise, uplift has been greater in the south than in the north. As a result, somewhat older prebatholithic metamorphic rocks occur as roof pendants on the highest peaks of the southern range, but are more abundant and continuous in lower elevations of the western front of the northern range. These older formations include metavolcanic rocks, as well as metasediments such as quartzite, marble, slate, and schist. Younger volcanic rocks including basalt are also found in the Sierra north of Lake Tahoe, evidently related to volcanism of the adjoining Cascade Range (Schoenherr 1992). For the native people of the Sierra Nevada, the distribution of these various rock types had direct bearing on stone procurement and production technology, while the presence of gold-bearing deposits in the foothills of the northern and central Sierra also had a significant impact on native people and culture after 1849 as a result of the Gold Rush.

Several major river watersheds—from the Feather River in the north to the Kern River in the south—

occur along the western slope of the Sierra Nevada (Figure 12.1). These rivers originate as streams in the snowmelt and proglacial lake basins of the Sierra crest, and drain into the Central Valley. Conversely, the Truckee River originates at Lake Tahoe in the northern Sierra and flows east into the Great Basin. Multiple tributaries of the Carson and Walker Rivers also originate on the east slope south of Lake Tahoe and flow into the Great Basin. Smaller streams that drain the remainder of the steep east slope primarily contribute to the Owens River watershed. As discussed below, the watersheds of the west slope in particular served to define traditional territories of native people in the area, and the often deep and rugged canyons formed by the rivers hampered north-south travel by native occupants of the region, with the intervening ridges instead facilitating travel east and west.

The snowpack of the high Sierra that feeds this hydrological system is due to the prevailing west to east movement of storms from the Pacific Ocean, which contributes substantial precipitation in the form of rain and snow during the winter months, as moisture is lost as the storms rise over the mountains. The amount of rain and snow varies with elevation, and the snowline also varies from year to year between 900 and 1,500 meters (3,000 and 5,000 feet) in elevation. There is an approximate 0.55°C (1°F) decrease in temperature for each 90-meter (300-foot) increase in elevation (Schoenherr 1992:71; Storer et al. 2004:12), with a concomitant increase in annual precipitation of 5 to 10 centimeters (2 to 4 inches) for this same interval. Snowfall accounts for more than 85 percent of the total precipitation in the higher elevations of the Sierra (Storer et al. 2004:15) and would have made much of the high Sierra inhospitable for winter use in the past.

Since precipitation and growing season vary with elevation, these factors, as well as slope and latitude, result in diverse biotic communities in the mountains. Schoenherr (1992; see also Munz and Keck 1959:14–18) identifies six major vegetation communities along the western slope of the Sierra Nevada today (although numerous vegetation series and diverse habitats occur within these broad communities) (Sawyer and Keeler-Wolf 1995), which include, from lowest to highest, chaparral, foothill woodland, yellow pine forest, lodgepole–red fir forest, subalpine forest, and the alpine zone. The latter four communities also occur on the east slope, although in generally higher and narrower elevation zones. The east side also supports pinyon-juniper woodland in the mid elevations, while small, relict groves of Big Trees *(Sequoia gigantea)* are also present midslope on the western side as far north as the Stanislaus River. These groves are most abundant, however, in the Kings and Kaweah River watersheds of the southern Sierra.

As temperatures rise and snow melts during the spring and summer, different vegetal resources become available to people and other animals within each biotic community, prompting upslope movement in the spring and return to lower elevation zones in the late fall in most areas of the range. The current structure of modern vegetation communities, however, is due at least in part to fire suppression activities, historic mining, logging, and cattle grazing, as well as global warming that began sometime between A.D. 1850 and 1900 (Sierra Nevada Ecosystem Project 1996). Human action also shaped past vegetation communities in many areas of the Sierra Nevada, with cultural modification of the landscape by native inhabitants through use of fire and other means (Anderson 2005; Anderson and Carpenter 1991; Anderson and Moratto 1996; Reynolds 1959).

In addition to the elevation-related biotic variation apparent today, significant climatic shifts and concomitant vegetation change occurred in the Sierra Nevada during the Holocene (Spaulding 1999; Woolfenden 1996). Pollen stratigraphic records indicate that the current pattern of climate and the primary constituents of vegetation communities were apparently in place by the Middle Holocene (ca. 1000 cal B.C.). Plant species frequency within various biotic communities and habitats, however, has continued to change since that time on scales of decades or centuries. Other paleoenvironmental data also suggest that severe droughts affected the Sierra Nevada at ca. A.D. 892 to 1112 and A.D. 1210 to 1350 (Lindström 1990; Stine 1994), while earlier periods of drought or drier conditions are also evident in the northern Sierra (Lindström 2000). Reflecting persistent low precipitation during these periods, evidence for these droughts comes in the form of tree stumps currently submerged in high-country lakes and rivers of the eastern Sierra, including Lake Tahoe, Fallen Leaf Lake, Donner Lake, Independence Lake, the Walker River, Mono Lake, and Tenaya Lake. Radiocarbon dates on the outer growth ring of these stumps document commencement of vegetation growth in former lake and stream beds following dramatic decreases in water levels during these arid periods.

Given the geographic position of the Sierra Nevada within California, the culture and history of the native people of the region are connected to that of both California and the Great Basin. Ethnographic data indicate that these people were traditionally organized in

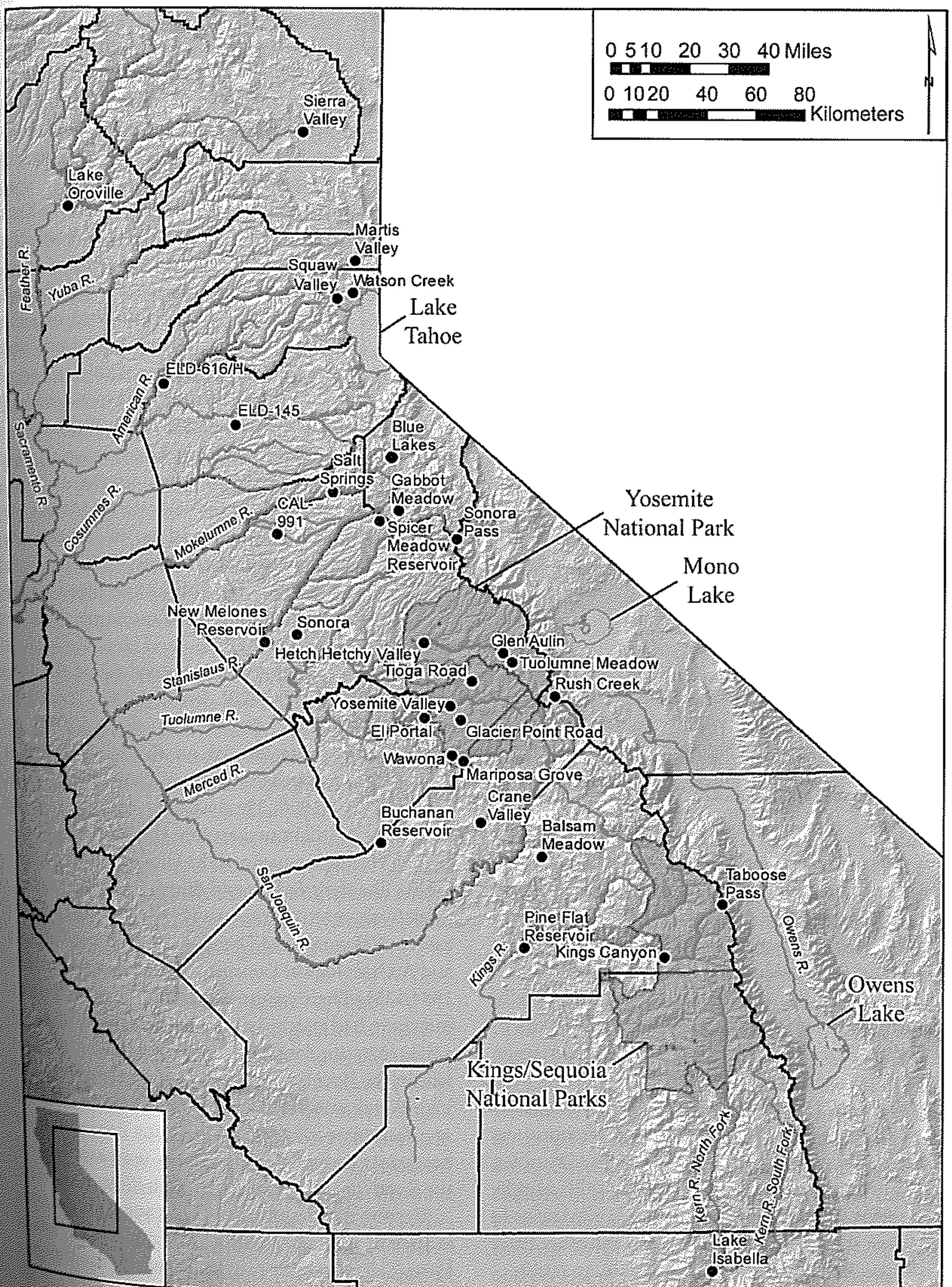

Figure 12.1. Archaeological sites and locations of the Sierra Nevada.

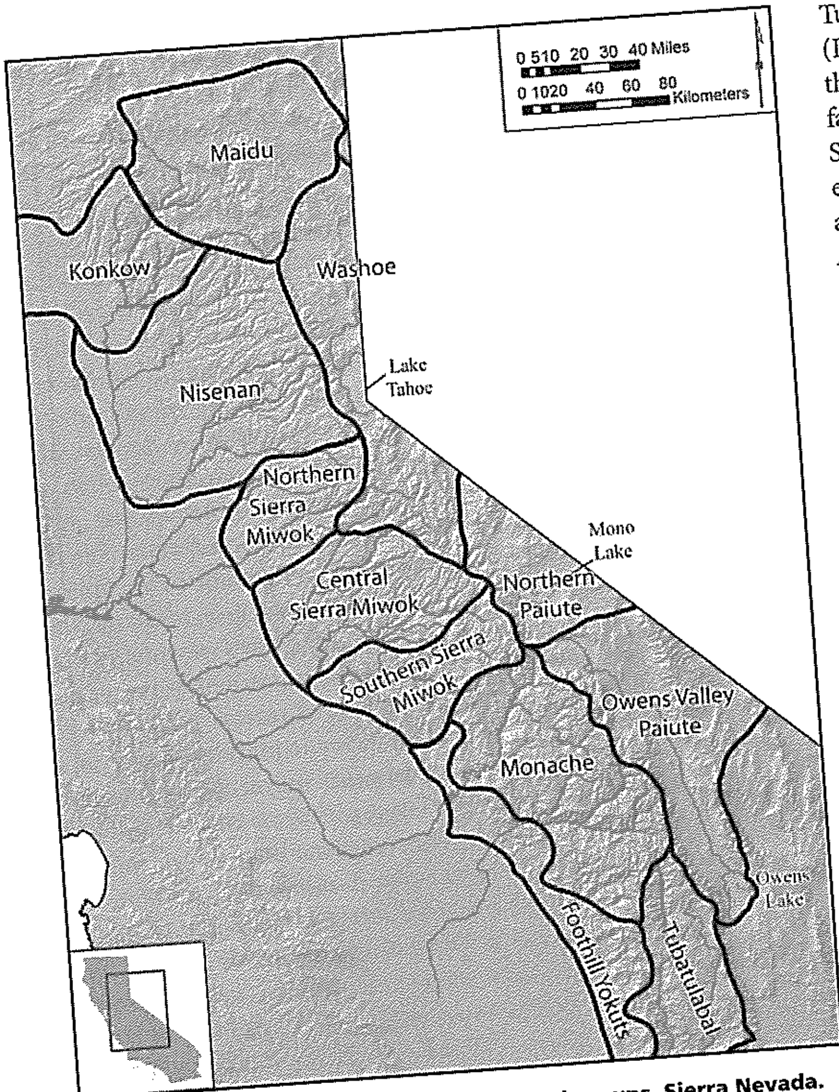

Figure 12.2. Approximate location of tribal groups, Sierra Nevada.

small village tribelets rather than the large, politically unified tribes common in many other areas of North America. Therefore, consideration of native cultural groups within the Sierra, as elsewhere in California, is facilitated by considering ethnolinguistic affiliation (Figure 12.2). At historic contact, the native people of the northern Sierra included the Maidu and Konkow of the Feather River drainage (Riddell 1978), the Nisenan of the Yuba and American River watersheds (Wilson and Towne 1978), and the Washoe of the Lake Tahoe region (d'Azevedo 1986). The Washoe territory was permeable, however, as d'Azevedo (1986:467) notes, allowing negotiated joint use of much of this area by neighboring peoples. The Washoe speak a language in the Hokan stock (Jacobsen 1986), and the other three groups speak Maidu dialects of the Penutian family.

The northern, central, and southern Miwok (or Me'wuk) inhabited the west slope of central Sierra Nevada, including the Cosumnes, Mokelumne, Stanislaus, Tuolumne, and Merced River drainages (Levy 1978b). The languages of these three groups also belong to the Penutian family. East of the crest in the central Sierra was the territory of the Northern Paiute (Fowler and Liljeblad 1986), a Numic-speaking people in the Uto-Aztecan language family. While maps of ethnolinguistic "territories" (Kroeber 1925) tend to depict the Sierra crest as a boundary between the Paiute and their western neighbors, people who wintered in lower elevations of either the eastern or western slopes both likely used the high country within and south of Washoe territory on a seasonal basis (Steward 1933:325, 329). There was no "boundary" in any fixed sense.

Finally, in the southern Sierra, the Monache (Western Mono) occupied the midslope of the San Joaquin, Kings, and Kaweah Rivers (Spier 1978b). Foothill Yokuts lived on the lower slopes of these same drainages (Spier 1978a), and the Tubatulabal inhabited the watershed of the Kern River (C. R. Smith 1978). The Owens Valley Paiute and Western Shoshone were located on the east side of the southern Sierra (Liljeblad and Fowler 1986; Thomas et al. 1986). Linguistic data suggest that the Monache, speakers of a Numic language of the Uto-Aztecan linguistic family like their Paiute and Shoshone neighbors, are a relatively recent arrival to the west slope from the east ca. 500 years ago (Theodoratus Cultural Research and Archaeological Consulting and Research Services 1984:135). Their seasonal use of the area, however, may have had much deeper roots. Tubatulabal is also a Uto-Aztecan language, but Yokuts languages are within the Penutian linguistic family. Once again, the high Sierra was likely an area of joint use by western and eastern peoples; for example, the Paiute and other occupants east of the mountains used areas west of the Sierra crest, including the Kern Plateau.

Despite this linguistic diversity, some general similarities in material culture and cultural practices of these Sierra people can be drawn from ethnography. Such similarities largely reflect adaptation to the mountainous environment and its biotic zonation. For example, all western slope groups spent the winter in larger villages at lower elevations at or below the snowline. During the summer and fall families dispersed to higher elevation zones, following the seasonal migration of game and the appearance of greens, bulbs, fruits, and nuts. With the exception of the Washoe, people of the eastern slope also used the area only on a seasonal basis, although the steeper slope of the eastern Sierra provided access to diverse biotic zones without requiring relocation of residential sites for extended periods. High Sierra environments and resources such as pinyon nuts were within a day's walk of the base of the mountains. Dwellings at seasonal camps in the high country were likely ephemeral brush shelters, while more substantial structures of bark slabs were constructed for use in the fall and winter.

Deer and acorns were particularly important subsistence resources to the people of the Sierra Nevada, although the mountains would have afforded a great diversity of game and plant foods given the multiple biotic zones. Processing of vegetal resources such as acorns was facilitated by the large granite or basalt outcrops present. Mortars were created in these outcrops for pounding foodstuffs such as acorns, manzanita berries, and small game; abundant water-worn cobbles served as expedient pestles. Sierra people traded with neighboring groups to the east and west for resources not locally available, including foodstuffs and stone for the manufacture of tools. Arguably one of the most important items acquired through trade in the central and southern Sierra was obsidian, since local granite is unsuitable for flaked stone tool manufacture. Baskets served for cooking and storage (Figure 12.3), and granaries were often built to store acorns over winter. The construction of such granaries, however, varied among the different ethnolinguistic groups.

ARCHAEOLOGICAL STUDY PRIOR TO 1980

Excellent summaries of archaeological investigations in the Sierra Nevada prior to 1980 are provided by Chartkoff and Chartkoff (1984) and Moratto (1984). Therefore, only a brief review will be provided here, and the reader is directed to the bibliography of the latter book for citations for the investigations discussed. Systematic archaeological survey and excavation in the Sierra Nevada was initiated by University of California–Berkeley, faculty and students in late 1940s and early 1950s. These investigations included work in the Lake Tahoe basin, Yosemite National Park, Kings Canyon, and various reservoirs in the southern Sierra Nevada (see Figure 12.1). Investigations primarily by

Figure 12.3. Yosemite Indians, Yosemite Valley, ca. 1865. (Courtesy of the J. Paul Getty Museum, Los Angeles; John P. Soule [photographer] about 1865, albumen silver.)

those affiliated with or trained at the University of California continued during the early 1960s, but there was a substantial increase (and perhaps equally important, sustained work by a diverse cadre of researchers) with the rise of cultural resource management projects beginning in the early 1970s. Notable among these projects were archaeological investigations for reservoir developments in the lower foothills at Lake Oroville on the Feather River, New Melones reservoir on the Stanislaus River, Buchanan reservoir on the Chowchilla River, and Lake Isabella on the Kern River. In addition, work continued in the Lake Tahoe region, and investigations for hydroelectric projects in the middle San Joaquin drainage and portions of the Pacific Crest Trail in the southern Sierra were undertaken at this time.

Most studies during the first two decades of work focused on sites and areas along major rivers, often in low- to middle-elevation settings. Work at Lake Tahoe was a notable exception, as it provided data for a higher-elevation zone. In addition, as was common for archaeological research of this era (particularly in an area subject to relatively little investigation), these efforts focused on providing a general picture of changes in material culture through time. Numerous local chronological sequences based primarily on projectile points, milling tools, ground stone ornaments, and the use of specific lithic materials were proposed. Absolute dating of suggested temporal complexes or phases was problematic, however, given the poor preservation of radiocarbon-datable features. Many of these sequences relied instead on temporal information from the Central Valley or western Great Basin to infer the time of phase transitions, and the initial time of occupation remained largely undetermined.

In general, these sequences documented initial use of large stemmed or corner-notched dart points and portable millingstones prior to about cal A.D. 500. Basalt served as the dominant lithic material in the northern Sierra, where such stone was locally available. Use of obsidian imported from east of the Sierra was prevalent in most other areas except in the low elevation zones of the west, where use of chert was common. Dart technology gave way to the bow and arrow after about cal A.D. 500, as indicated by use of smaller corner-notched points. Introduction of bedrock mortars also occurred sometime between cal A.D. 500 and 1250, with this technology taking advantage of the large rock outcrops common in the mountains. Occupants of the northern Sierra discontinued their reliance on basalt, but both chert and (to a lesser extent) obsidian found favor in this area after ca. A.D. 500. In the central and southern Sierra, use of obsidian continued, and geochemical studies by Jackson (1974) documented a geographic pattern of reliance on the nearest high-quality material. Bodie Hills obsidian was commonly used in the north-central Sierra, Casa Diablo obsidian was prevalent in the central and south-central Sierra, and glass from the Coso volcanic field was common in the southernmost areas (see Chapter 17). After ca. cal A.D. 1250, use of small side-notched or (in the northern Sierra) contracting stem arrow points, ground stone ornaments, and bedrock mortar technology was dominant.

As of 1980, then, a general outline of the culture history of the Sierra Nevada had emerged and the primary constituents of the archaeological record had been recognized. Assemblages were dominated by flaked and, to a lesser extent, ground stone artifacts. The former included projectile points, other bifacial tools such as drills, expedient flake scrapers, and debitage, while the latter included both portable and stationary milling implements. Stationary milling features with mortars were common throughout the range, but other features such as house floors and hearths were relatively rare due to bioturbation of deposits or ephemeral use in upper elevation zones, or both. Organic materials including faunal bone, botanical remains, and shell beads were also infrequent, likely due to the coarse, acidic soils typical of the region. Preservation of such remains was enhanced, however, if deposits were in rock shelters, which were rare but present in various areas of the Sierra.

A BRIEF HISTORY AND MAJOR PROJECTS SINCE 1980

Since 1980, cultural resource management investigations have contributed significantly to our knowledge of Sierra Nevada archaeology. These efforts include the completed reports for the New Melones project (Moratto et al. 1988), excavation at Early Holocene sites in the central Sierra foothills and northern uplands, and increased work in mid- to upper-elevation areas. For example, important studies for cultural resource compliance have been undertaken in the northeastern area at Sierra Valley (Waechter and Andolina 2005), the Tahoe-Truckee region (Ataman et al. 1999; Bloomer et al. 1997; Elston et al. 1994; Lindström 1982), the American River watershed (Jackson and Ballard 1999; Rosenthal and Waechter 2002), the Mokelumne River drainage (Wirth Environmental Services 1985), the headwaters of the Stanislaus River (Peak and Neuenschwander 1991), Yosemite National Park (Hull and Moratto 1999), the Rush Creek watershed of the east-central Sierra (Jackson and Morgan 1999), and Crane Valley (Goldberg and Skinner 1990; Goldberg et al. 1986) and Balsam Meadow (Jackson and Dietz 1984; Goldberg and Moratto 1984) of the San Joaquin River watershed. In addition, some graduate student research projects have been undertaken in various areas, including studies of fishing in the Truckee River region (Lindström 1992), Early Holocene occupation at Lake Tahoe (Martin 1998), contact-era culture change in the central Sierra (Hull 2002; Van Bueren 1983), and alpine land use in the southern Sierra (Roper-Wickstrom 1992; Stevens 2005).

Examination of archaeological contributions since 1980 benefits from several important synthetic studies of Sierra Nevada archaeology completed in the past two decades. The *Cultural Resources Overview of the Southern Sierra Nevada* (Theodoratus Cultural Research and Archaeological Consulting and Research Services 1984) considered the archaeology of portions of the San Joaquin, Kings, Kaweah, and Kern River watersheds, and Kowta's (1988) model of native land use in the Feather River area provided an overview for the northernmost area of the Sierra Nevada. The *Framework for Archaeological Research and Management for North-central Sierra Nevada* (Jackson et al. 1994), also known as FARM, encompassed the area from the American to the Tuolumne River on the west slope, as well as the Lake Tahoe basin. Finally, the *Archaeological Synthesis and Research Design, Yosemite National Park, California* (Hull and Moratto 1999) summarized data for the central Sierra and updated the previous research design for this region (Moratto 1981). This volume fit the Merced and upper Tuolumne River watersheds into the chain of synthetic work for the Sierra Nevada, effectively completing coverage of the entire range.

As these documents indicate, issues of chronology have continued to occupy an important place in Sierra Nevada archaeology. New sequences have been proposed for previously unstudied areas such as the Mokelumne River drainage (Cleland 1988), and researchers have continued to refine existing temporal sequences (Figure 12.4). In particular, this latter work has witnessed the incorporation of subsistence-settlement adaptive strategies into temporal schemes for the Tahoe-Truckee area (Elston et al. 1994) and lower Stanislaus River (Moratto et al. 1988). Such interpretations often rely on ethnographic data and postulated population movements based on linguistic data, however, rather than unequivocal archaeological evidence, casting some doubt on their applicability to more ancient time periods. Conversely, the routine use of obsidian hydration dating has significantly improved the prospects for independent dating of assemblages, decreasing the reliance on temporal data from the east or west. Obsidian hydration studies have not necessarily realized this full potential, however, as data have often been tied to projectile point sequences of the Great Basin, in particular, rather than radiocarbon dates specific to Sierra archaeological sites (see Rosenthal 2002; Theodoratus Cultural Research and Archaeological Consulting and Research Services 1984). Likewise, many radiocarbon dates derive from nonfeature contexts, undermining confidence in the finer details of nearly all existing chronological sequences. As noted in recent syntheses (Jackson et al. 1994; Moratto 1999), this methodological issue is crucial in light of ongoing attempts to understand adaptive shifts and the proximate cause(s) of apparent culture change.

While generally affirming earlier observations, studies since 1980 have incrementally advanced our understanding of changes in material culture through time, particularly with respect to lithic procurement and technology. Poor preservation of organic materials in mid- to high-elevation zones remains a significant problem, however, and hampers full understanding of subsistence and related settlement shifts. Likewise, the evident reoccupation of sites over hundreds or thousands of years has been amply demonstrated by obsidian hydration studies and, coupled with factors undermining depositional integrity, continues to challenge archaeologists working in this region. Dwelling, storage, and processing features other than the ubiquitous bedrock mortar continue to be rare, especially in mid-elevation zones. New types of features have been recognized, however, including stone granary bases in the low-elevation areas of the southern Sierra, rock ring dwellings and possible stone game drive features in the alpine zone of the central and southern Sierra Nevada (Roper-Wickstrom 1992; Stevens 2005), and stone-lined vegetable processing features in the northern Sierra (Bloomer et al. 2002; Waechter and Andolina 2005).

SIGNIFICANT DEVELOPMENTS SINCE 1980

Both the FARM and the *Yosemite Synthesis* identify broad research themes that structure the discussion of significant archaeological interpretations since 1980. These documents also note the contribution of Sierra studies to paleoenvironmental research over the past two decades, particularly with respect to documenting prolonged droughts (Lindström 1990, 2000; Stine 1994), considering the potential effect of Inyo-Mono volcanic activity on the occupants of the west slope (Jackson and Morgan 1999; Spaulding 1999), and the use of fire as a vegetation management tool (Anderson and Moratto 1996). Since Woolfenden (1996; Spaulding 1999) provides a detailed review of such research, the current summary will focus on the remaining research domains of chronology, economy, settlement, social organization, and demography. Only a few issues and case studies in each of these domains can be considered in the limited space here.

Chronology

Two important contributions have been made within the realm of chronology in the Sierra Nevada—one related to knowledge of past peoples and land use, and the other methodological. In the first case, archaeological investigations since 1980 have added significantly to our appreciation for Early Holocene use in the Sierra Nevada and California more generally. Although still largely confined to isolated projectile points or modest assemblages in the higher elevation zones, work in the Stanislaus River watershed and elsewhere in the northeastern Sierra has documented earlier initial use of both lower and upper elevation settings than previously known (Martin 1998; Peak and Neuenschwander 1991). Extending the record of human use into the more distant past (ca. 8000 cal B.C.), these finds often reveal the use of large stemmed points similar to those associated with this time period in the Great Basin or, less frequently, possible fluted

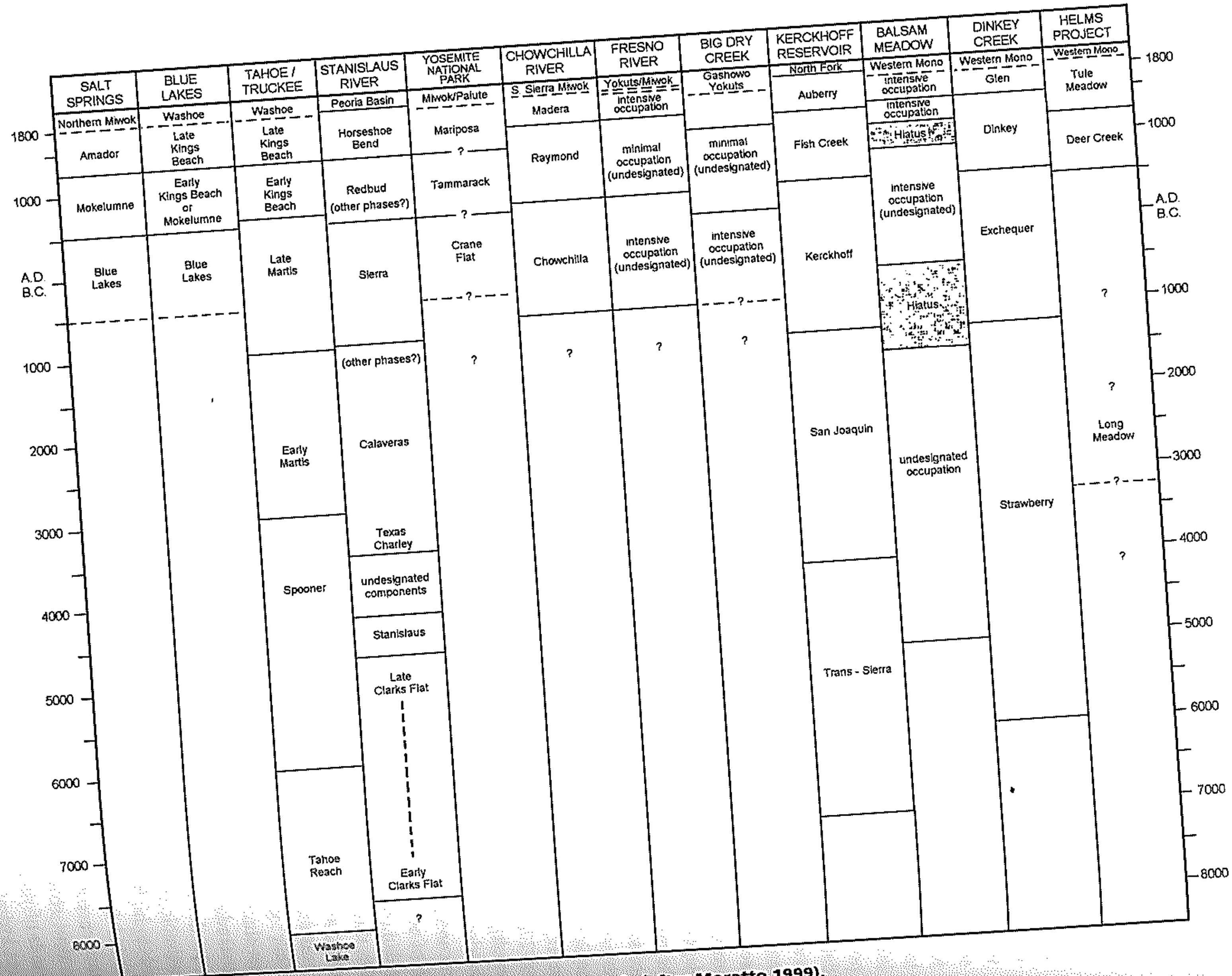

Figure 12.4. Chronological sequences of the Sierra Nevada (after Moratto 1999).

points like those in related Late Pleistocene and Early Holocene occupation in areas to the east and west. Reviewing the evidence amassed thus far, Moratto (1999) suggests that such early use may be recognized elsewhere in the Sierra as well, and he stresses that future studies must consider geomorphic context to ensure that such early use is not overlooked.

With respect to methods, the routine use of obsidian hydration analysis since the mid-1980s has provided for both relative dating of deposits and studies of site formation, as well as new approaches to absolute dating with hydration results. Recent research has sought to establish temperature-dependent obsidian hydration rates for major obsidian sources used by Sierra peoples through the application of mathematical models of the hydration process (Hull 2001, 2002; Stevens 2002, 2005). While such models continue to be refined in laboratory research of obsidian from elsewhere in the world (Anovitz et al. 1999, 2004) and these studies may necessitate further refinement of hydration applications in the Sierra, such absolute dating methods may ultimately provide for assessment of culture change disentangled from the "total packages" of phase constructs common to more traditional cultural chronology in the Sierra and elsewhere in California. Instead, individual traits can be examined independently, as is necessary for analyses seeking cause and effect. Recognizing the potential of this approach may require a reevaluation of obsidian hydration sampling methods, however, including a move away from the common practice of simple column sampling based on an arbitrary number of flakes from every or alternate 10 centimeter excavation levels. Such a strategy may tell us more about rates of sediment deposition or geomorphic processes than intensity of cultural activity, contrary to the assumptions that often underlie such sampling.

Economy

FLAKED STONE TECHNOLOGY As highlighted above, the northern Sierra and lower western flank differ from the remainder of the Sierra in the local availability of toolstone, which may contribute to differences in lithic technology between these areas. In regions of both local and distant material acquisition, however, Sierra archaeologists have traditionally focused on bifacial reduction. This perspective was fostered in part by the predominant mode of production at major obsidian quarries of eastern California investigated by Ericson (1981, 1982) and others (Jackson 1984) in the late 1970s and early 1980s. Ongoing archaeological research on the western slope since the mid-1980s, however, has shifted the focus of reduction technology studies to direct assessment of west slope lithic assemblages rather than consideration of only quarry production. Although evidence of biface production and even biface caches in the northern portion of Yosemite National Park (Humphreys 1994) consistent with the traditional model of lithic material acquisition is common in the Sierra, a more diverse picture of obsidian acquisition has begun to emerge.

For example, Jackson's (1988) report of a large core on the western slope in the San Joaqµin River drainage suggests transport of some material in relatively unworked form. West slope technological analysis in recent years highlights evidence of scavenging as a means of material acquisition. Rather than acquisition of obsidian via trans-Sierra travel or trade, Goldberg and Skinner (1990) documented bipolar reduction of scavenged Sierra concave base projectile points late in time to produce flakes of sufficient size for production of arrow points at Crane Valley. This production strategy was confirmed here and in subsequent studies elsewhere through the use of multiple obsidian hydration samples from a single artifact. As both the bipolar fracture and the original worked surface were sampled, hydration data indicated that bipolar reduction occurred significantly later than original manufacture of the large concave base point.

Such rethinking of obsidian procurement and use in the western Sierra has led to even greater focus on technology, highlighting a research area in which Sierra archaeology has played a particularly significant role in California archaeology rather than representing an inordinate fixation on technology for its own sake. Lithic tools and debris are the one constant (and common) element of the archaeological record of this region, while the prevalence of obsidian in central and southern Sierra assemblages provides for obsidian hydration dating that can identify temporal trends. Investigation of bipolar reduction, final projectile point manufacture in the form of notching, regularized biface production indicated by transverse parallel pressure flakes, and examination of scavenging through hydration sampling of bulb removal flakes, among other technological traits, all promise to provide a fuller understanding of resource acquisition through time in light of factors such as territoriality or seasonally restricted access. The results of these analyses may ultimately enhance interpretation elsewhere in California where direct temporal data are lacking but similar technological trends have been observed.

GROUND STONE TECHNOLOGY Understanding of ground stone technology in the Sierra has also witnessed significant change in the past 20 years, due to an influential functional study of bedrock mortars (McCarthy, Blount, and Hicks 1985). Working from information provided by native consultants and existing ethnography, this research suggested that the depth of mortars was related to function rather than duration of use, as previously supposed. That is, mortars were actually carved, pecked, and shaped to specific depths for particular purposes. Based on ethnographic research among the Monache, who focused on the processing of black oak acorns, three functional types were identified. Shallow starter mortars were used for initial acorn processing, somewhat deeper finishing mortars were used for final acorn processing, and deep seed mortars were used to process seeds.

This model was subsequently applied to archaeological data from various areas in the central and southern Sierra, including Crane Valley (McCarthy, Blount, and Hicks 1985) and Yosemite National Park (Hull et al. 1999). In Crane Valley, the archaeological data indicated that these functional types were recognized in prehistory as well, since the relative representation of mortars within the three classes was consistent with that identified in the ethnographic sample. However, the researchers warned that the model might only apply to the Monache and the processing of black oak acorns.

In Yosemite, stationary milling feature data were considered in light of this model and another based on Miwok ethnography, with data in some areas very similar to those observed in Crane Valley. Comparison of milling technologies in mid-elevation valleys in the watersheds of the Tuolumne and main Merced Rivers (e.g., El Portal, Glacier Point Road, Tioga Road, Yosemite Valley) with those at sites in drainage of the south fork of the Merced River (e.g., Mariposa Grove, Wawona), however, seemed to demonstrate distinct geographic preferences in vegetal processing (Hull et al. 1999). Although starter and finishing mortar cups occur in roughly equal proportions in both areas (Table 12.1), deeper seed cups tend to be more common in the south than in the north. In the latter area, milling slicks are more common, suggesting two alternate means of processing smaller seeds in these two regions. Jackson et al. (1994) cautioned against ascribing ethnicity based on milling technologies, as factors such as local resource exploitation may affect processing decisions made by people in the past. The differences in stationary milling feature assemblages between the main and south forks of the Merced River, however, cannot be attributed to environmental characteristics. Therefore these data may suggest the potential to explore regional (if not ethnic) preferences in processing technologies.

One of the most difficult problems still facing Sierra Nevada archaeologists with respect to ground stone tools is determining when the shift from millingstones to mortars occurred in this region. Here, as elsewhere in California, such a shift has generally been taken to represent an increasing emphasis on acorns in the diet, although ethnographic data from throughout California document the use of mortars to process a variety of vegetal and animal products, as well as minerals (Rucks 1995; Schroth 1996). If mortars were primarily used to process acorns, however, the shift from millingstones (i.e., small seed processing) to mortars would represent a significant subsistence shift. Viewed within optimal foraging models, acorn processing requires a substantial time investment. This subsistence intensification would not occur unless necessitated by an imbalance between subsistence resources and population. As discussed by Basgall (1987), such an imbalance could have occurred due to increasing population size and

Table 12.1. Relative Representation of Mortars and Milling Slicks in Various Areas of the Central Sierra Nevada

Region	*Starter Mortars (%)*	*Finishing Mortars (%)*	*Seed Mortars (%)*	*Milling Slicks (%)*
Crane Valley	52.3	18.9	28.9	
Mariposa Grove	59	13	28	
Wawona	37	15	44	
El Portal	50	15	26	10
Glacier Point Road	57	13	22	8
Yosemite Valley	75	10	8	7
Hetch Hetchy Reservoir	86	7	6	1
Lower Tioga Road	69	17	13	1
Upper Tioga Road	83	7	3	7

Source: After Hull et al. 1999.

concomitant territorial circumscription preventing expansion into other areas. Thus, determining when this technology was adopted in the Sierra is crucial to inferring subsistence intensification, particularly since other sources of data on these issues are unlikely to be developed given poor preservation of organic materials. In addition, the shift to bedrock mortars could have further implications with respect to the role of women's work, gender relations, concepts of ownership, and attachment to place (see below).

Timing of the introduction of bedrock mortars has been difficult to establish because these features cannot be directly dated. Rather, dates must derive from associated cultural deposits, and obsidian hydration dating of artifacts from such sites often reveals multiple components spanning hundreds or thousands of years. Stevens (2002) made an initial attempt to address this issue through an innovative study that brought together data from a large area of the southern Sierra Nevada. He argued that a regional approach can overcome potential idiosyncrasies of individual site dates and provide the broad picture of mortar use through time. Relying on temperature-corrected obsidian hydration dates from associated deposits, this study suggests that mortars may have been introduced more than 2,500 years ago, with use peaking in low and mid-elevation zones after cal A.D. 500. In contrast, use of mortars in higher elevation zones did not become prevalent until after cal A.D. 1000 and is especially indicated in the past 500 years. These results suggest possible increased use of more marginal high Sierra locales late in time, perhaps related to population growth, the migration of Monache to the west slope of the Sierra, or both.

EXCHANGE As noted previously, the general geographic distributions of obsidian quarry source materials in western Sierra archaeological sites were established in the 1970s. Continuing work provides more detail, however, particularly with respect to recognizing intrasource patterns and use of lesser quarry sources such as Fish Springs and Mono Craters by Sierra people. In addition, as noted previously, technological studies have significantly altered our view of how lithic material was acquired, with potential implications for how archaeological sites should be sampled to recognize possible source-specific patterns of material use.

Identification of intersource geochemical variability at Casa Diablo and the Coso volcanic field by Hughes (1989, 1994b) has provided for finer distinctions in defining regional obsidian use, with initial results from Sierra archaeological studies suggesting acquisition of material from the nearest available flow. With respect to lesser quarry sources, ongoing research suggests that use of Mono Craters obsidian became more common after the formation of Panum Dome ca. cal A.D. 1350, and this material may have supplanted Casa Diablo obsidian as the predominant material in the areas closest to this new source (see Hull 2002). Likewise, work in Sequoia National Park indicates likely direct acquisition of Fish Springs glass and the significance of this material in proximate areas of the high Sierra such as Taboose Pass (Roper-Wickstrom 1992; Stevens 2005). Farther north, work in the Feather, American, and Yuba River watersheds has documented use of northern rather than eastern California obsidian source materials, including Tuscan, Kelly Mountain, East Medicine Lake, and South Warners.

Understanding the source of basaltic materials for tools in the northern Sierra and potential geographic patterns of use has been a more difficult problem until recently. Particularly significant advances have been made in the past 15 years, with the initiation of basalt and vitric tuff geochemical source studies (Bloomer et al. 1997; Jackson et al. 1994; Lindström and Bloomer 1994; Northrup et al. 1999). Such studies distinguish more than a dozen quarry source materials, including major sources at Alder Hill and Watson Creek in the Tahoe-Truckee region and the Gold Lake group to the northwest in Sierra County. McGuire and Bloomer (1997; see also Northrup et al. 1999) document both local use and east-to-west transport of Sierra basalt in the Yuba and American River watersheds. These patterns mirror east-west transport or exchange of obsidian observed in the central and southern Sierra, and underscore the dearth of north-south exchange or transport in this rugged terrain.

Settlement

As elsewhere in California, Binford's (1980) model of forager and collector subsistence-settlement strategies has become the dominant means by which regional researchers consider settlement in the Sierra Nevada. Again, making broad characterizations for the Sierra as a whole, it appears that initial sustained occupation of the Sierra after ca. 3000 cal B.C. represents relatively large residential sites occupied (or reoccupied) for substantial periods of time. Such a pattern is consistent with the collector mode of organization, and some researchers suggest that this use represents a primary hunting focus in many mid- to high-elevation areas. This conclusion is based primarily on artifact assemblages, however, rather than faunal or floral remains. After ca. cal A.D. 500, the settlement pattern clearly shifts, with residential sites both smaller in size and more ephemeral in terms of quantity of cultural debris. Rather than sustained occupation, this use seems more consistent with short-term residential bases and possible limited subsistence resource acquisition of foragers rather than collectors. In the northeastern Sierra, Elston and his colleagues (Intermountain Research 1995:17) suggested that this may reflect an accommodation to the arrival of pinyon to the area, while on the west slope there is some speculation that this change may be related to the incorporation of acorn into the diet. After ca. cal A.D. 1250, there is a return to large, substantial residential sites and concomitant subsistence resource diversification. In the alpine areas of the southern Sierra (Stevens 2005), such use is even represented by sites with rock-based dwellings, evidently reflecting occupation by people spending winter months on the eastern rather than western slope of the Sierra. This late use represents a return to a collector strategy.

Social Organization

Social organization remains a relatively enigmatic archaeological research domain in the Sierra because the types of data often considered in such studies—including burials and ornamental objects—are rare in all but the lowest elevation zones. One exception is Jackson's (1991) study of bedrock mortars in the southern Sierra, in which he argued for the importance of female activities in dictating habitation location. Prior to the introduction of bedrock mortar technology to the Sierra, all technology associated with hunting and gathering was portable. Jackson therefore concluded that decisions about where to establish camps or villages were based on factors such as availability of and access to subsistence resources, particularly game. With the increasing importance of acorn and the stationary milling technology associated with it, however, the location of camps and villages became dictated in part by the availability of suitable rock outcrops, as well as oaks. Jackson suggested that this shift—presumably associated with women's work—meant that the influence of women in residential location decisions may have increased, representing a potential shift in power and gender relations within households or groups.

Although several assumptions regarding decision making and subsistence resource distributions necessarily underlie this argument, this research challenges Sierra archaeologists—and California archaeologists in general—to consider issues of gender and social organization from data other than burials or similar sources traditionally invoked in such research. Recent ethnographic research among the Washoe (Rucks 1995) also highlights the significance of portable and stationary milling implements to concepts of property, sharing, social relations, and worldview. Such observations have potential application to future archaeological research on milling artifacts (and perhaps other tools) in the Sierra Nevada, pushing archaeological research of material culture beyond technology.

Demography

Apparent shifts in population size through time were recognized in the archaeological record of the Sierra and adjoining foothills more than three decades ago. This was demonstrated most dramatically at Buchanan reservoir (Moratto 1972), and subsequent studies throughout the range (Goldberg et al. 1986; Hull and Moratto 1999; Stevens 2002; Wirth Environmental Services 1985) have suggested that populations may have suffered significant declines between ca. cal A.D. 500 and 1200 or, alternately, may have adopted a settlement system that resulted in more dispersed and ephemeral occupation sites that can be mistaken for regional population decline. Assessing the validity of one or the other of these perspectives is difficult, as this topic requires a regional (rather than site-specific) approach to analysis. In addition, random sampling and the collection of data with the specific intent of demographic reconstruction is necessary. These requirements have not been met in most demographic analyses, although recent research in Yosemite Valley based on more than 2,200 obsidian hydration dates was so structured (Hull 2002). Significantly, this study also documented significant population decline—likely unattributable simply to settlement reorganization—between approximately cal A.D. 500 and 1350.

As indicated by recent work in the Rush Meadow area (Jackson and Morgan 1999), any interpretation of population size and movements in the Sierra will likely require a detailed and holistic approach. In this region, for example, it appears that there were local responses to periodic volcanic activity in the Inyo-Mono chain, including possible local abandonments on the order of 100 to 300 years. The potential for local events of either natural or cultural origin to influence regional demography argues for careful assessment of the variety of possible factors contributing to patterns we observe in the archaeological record of the Sierra Nevada and elsewhere in California.

CONCLUSION

In general, the emerging picture for the Sierra Nevada is one of initial use or occupation in the Tahoe-Truckee region and lower western foothill areas by small, relatively mobile groups by at least 7500 cal B.C. Significant occupation of the Sierra foothills, and especially use of mid- to upper-elevation areas of the central and southern Sierra, did not become prevalent until after ca. 3000 cal B.C. There may have been a hunting focus at this time in upper-elevation areas, but the presence of portable milling equipment argues for a more diverse subsistence base in low- to mid-elevation occupation sites, at least. Between ca. cal A.D. 500 and 1250, a significant shift in human use of the Sierra Nevada is evident. Substantial changes occurred with respect to technology, trade, subsistence, settlement, and population. The potential interplay of these factors and concomitant environmental change in the form of long-term climatic trends and shorter-term natural events such as prolonged droughts and volcanic activity in the Inyo-Mono region hamper attempts to reach definitive conclusions regarding proximate, or even ultimate, cause.

At a minimum, it appears that there was a substantial population decline along the entire length of the western slope of the Sierra at this time. Such decline is indicated throughout the northern Sierra, the lower elevation zones of the central and southern Sierra, and in mid-elevation zones of Yosemite National Park. Population decline may also have occurred elsewhere. This phenomenon may in part represent a shift in settlement to other areas; for example, some researchers have suggested that there may have been more activity in Sierra Valley (Waechter and Andolina 2005). Other similarly affected areas of the northeastern Sierra include the Blue Lakes region on the Mokelumne River (Wirth Environmental Services 1985) and mid-elevation locales in the central and southern Sierra such as Crane Valley (Goldberg et al. 1986) and Balsam Meadow (Jackson and Dietz 1984). The recent data from Yosemite Valley (Hull 2002), however, do not support the posited upslope shift of population for the central and southern Sierra as a whole, and data from the Mokelumne drainage (Wirth Environmental Services 1985) may be too limited to argue unequivocally for population dispersal (as opposed to decline) at this time. In other words, the Yosemite Valley study suggests that apparent population decline is not simply a function of more dispersed land use on the western slope of the Sierra related to adoption of the bedrock mortar and acorn intensification.

The record of latest use of the Sierra after ca. cal A.D. 1250 to 1500 reflects a return to a more densely settled region, with more intensive use of vegetal foods such as acorns (in the west) and pinyon nuts (in the east). Although distinctions between the northern and central/southern Sierra are evident throughout the sequence in terms of lithic material use and perhaps flaked stone tool assemblages, this latest occupation marks an even greater delineation. There is a clear affinity in the northwestern zone to areas farther north and west in terms of lithic materials and projectile point types, while the central and southern Sierra continue a "blended" pattern of traits common to both the east and west.

Avoiding the question of ethnicity or interpretations based on linguistic data for any of these broad periods of use after 3000 cal B.C., at a minimum the archaeological record of the Sierra Nevada appears to document significant population movements or dispersal coincident with or beginning somewhat prior to a period of environmental stress between cal A.D. 500 and 1250 (Waechter and Andolina 2005). Providing well-reasoned interpretations and defensible arguments regarding the cause of this or other patterns, however, will necessarily depend on placing the Sierra data in the larger context of archaeology to both the west and east. Initial steps have already been taken in this direction, including Kowta's (1988) model for the northern Sierra, work in the Truckee River area (Elston et al. 1994), and investigations in Tuolumne Meadows (Hull et al. 1995) and the alpine southern Sierra Nevada (Stevens 2005).

FUTURE DIRECTIONS

As with archaeology anywhere, researchers in the Sierra Nevada must cope with the limitations and embrace the strengths of the regional record. Two major limitations overshadow Sierra archaeology. The first is the complexity of site formation due to evident reoccupation and bioturbation. The second is poor preservation of features and organic remains. In the former case, new micromorphology techniques recently employed in Yosemite National Park (Hicks et al. 2006) may hold promise, or at least thoroughly and critically document the obstacles researchers face when attempting to base interpretations on stratigraphy. With respect to the issue of preservation, advancements in recovery and analysis of organic residues or soil chemistry may ultimately provide a better view of that part of the archaeological record underrepresented in the Sierra Nevada. Currently, however, it appears that we will never be able to make the quantitative—as opposed to qualitative—statements relevant to subsistence and other related research domains that are possible in areas to the east and west. The one exception, as highlighted by Hull and Moratto (1999), is rock shelter deposits that foster better preservation, although recent research has suggested that these sites may have witnessed significant use only in the past 300 years (Hull 2002; White 1988).

The archaeological record of the Sierra Nevada also has some significant strengths, primarily the capacity to date artifacts via obsidian hydration dating, which can offset some of the problems created by site formation issues. With this tool, central and southern Sierra archaeologists have the capacity to break free of the dependency on the Great Basin chronology. They can also begin to move away from a reliance on categories such as phases and periods to absolute dating, which is critical to assessing potential cause and effect in short- and long-term culture change in the region. Issues such as the timing of the introduction of bedrock mortars and the bow and arrow, the decline in trans-Sierra exchange (Bennyhoff and Hughes 1987), and possible population decline can be explored. Answers to these questions, in turn, are significant to a host of other issues, such as subsistence intensification and potential changes in social organization.

Sierra Nevada archaeology benefits from the fact that much of this area is federal land that continues to be the focus of ongoing archaeological survey and is less developed than many other areas of the state. As the above review highlights, these characteristics facilitate a broad regional approach to a variety of issues and suggest that the archaeological record of the Sierra has significant contributions to make to California archaeology. A regional perspective and site preservation enhance understanding settlement patterns in light of foraging models, although the lack of direct subsistence data tempers enthusiasm somewhat in the Sierra. In all but the lowest elevation zones of this region, subsistence and its relevance to settlement must be inferred instead from artifact assemblages and features. Likewise, while changes in human population size and movements made possible by a regional perspective may be of particular interest to Sierra archaeologists, the patterns and possible causes for such shifts have potential significance to areas to the west, as well, and may be related to long-term climatic trends observed throughout western North America (Jones et al. 1999; Woolfenden 1996). Ongoing studies of flaked and ground stone tool technology in the Sierra may provide interesting case studies of use to researchers elsewhere in California and the Great Basin, while also providing a fuller understanding of regional trends of embedded versus logistic procurement, exchange, and ethnic identity. Geochemical studies of basaltic materials in the north, intersource differences in eastern California obsidians, and perhaps similar advancements with respect to cryptocrystalline silicates will also contribute important information to these research topics. The archaeological record of the Sierra also documents the effects of Euro-American incursion on native peoples at some distance from nonnative settlements on the coast, and provides a view of short- and long-term culture change in such contexts that can contribute to our understanding of contact-era culture change in both California and North America as a whole.

Finally, the continued integration of ethnography and the traditional knowledge of Indian people of the Sierra into archaeological research holds great promise. Thus far, such work has primarily focused on milling technology (McCarthy et al. 1985; Rucks 1995) and land-use practices (Anderson 2005; Anderson and Moratto 1996). These topics and others, including documentation of past events in native oral tradition and myth (Hull 2002) and the influence of nonnative incursion on traditional lifeways (Davis-King 1998; Rucks 1995), are prospects for future research. In addition, archaeologists and native people who have collaborated on projects in this region have found that this experience enriches their sense of participation and the connection of past and present, while also expanding the relevance of archaeological investigations.

Whatever avenues of future research are taken in the Sierra, we must bear in mind that the record can only be understood in terms of the processes and events that were taking place to both the east and west. The archaeological record of this region—rather than representing a marginal area in either the past or present—has relevance to not only Sierra archaeologists but also to those working throughout California and the Great Basin. The "light" of Sierra Nevada archaeology is the contribution it can make to a wide array of theoretical, methodological, and anthropological issues both within the Sierra and beyond.