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Geologic Setting and Prehistoric Settlement Patterning in the Central Sierra Nevada, California

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ARCHAEOLOGICAL studies of prehistoric settlement patterns have contributed to our understanding of cultural-ecological relationships that underlie successful human adaptations in many environments. One outcome of this research has been the development of models that attempt to predict the locations of archaeological sites, and their densities and cultural characteristics (e.g., Jochim 1976).

Among examples of archaeological predictive settlement pattern investigations in California, Pilgram (1987; Pilgram and Thor 1981) developed a model for estimating prehistoric site densities based on commonly mapped environmental variables (topography, water resources, vegetation, and geology) in the central Sierra Nevada. Jackson (1984) completed a study of relationships between site types, environmental setting, and the geometry of site spacing in the southern Sierra Nevada. In addition, Crist (1981) investigated the relationship between archaeological site types and environmental factors including landform type, biotic community, distance to water source, water source type, and topographic slope and aspect. (See also Hull and Mundy [1985] for similar research in Yosemite National Park.)

All these predictive models agree that there is a significant positive correlation between site location and availability of a reliable potable water source. However, the effectiveness of predictive settlement models is limited in this regard because although the close spatial association between archae-

ological sites and water sources is recognized, the models cannot actually predict where adequate water sources exist apart from perennial streams and springs depicted on topographic maps. This is especially troublesome for efforts aimed at predicting the geographical distribution of so-called midslope sites which often are not situated adjacent to mapped streams or springs.

This paper reports a study of geologic/hydrologic environmental association in the central Sierra Nevada and corresponding implications for prehistoric settlement patterning. Archaeological data suggest that native American populations in parts of the central Sierra Nevada situated most settlements along perennial streams and at midslope localities along the exposed contact between two superimposed geologic units: Pliocene volcanics resting atop Mesozoic granitic rocks of the Sierra Nevada batholith. Groundwater emerges as springs and stream flow along, or just downslope from, the contact. Above this geological nonconformity groundwater is not reliable year round. Thus, knowledge of the approximate location of the geological nonconformity effectively alerts the archaeologist to an environmental zone in which water sources (and sites) are likely to occur.

Archaeological sites found at elevations above the contact zone are typically small, limited-task facilities, some hypothetically occupied only seasonally (spring to early summer). Below the contact zone water in smaller stream courses tends to be insuffi-

cient to maintain a perennial surface flow over the entire stream length. More substantial sites are found at midslope settings along the short, intermediate stream sections where water flow is maintained during the drought period of summer and fall.

Due to the summer-through-fall drought characteristic of the regional climate, many surface water sources dry up before the onset of winter precipitation. Deprivation of groundwater sources occurs at a critical time in the native subsistence procurement cycle because acorns, a major staple food crop of later prehistoric and historic native American populations, ripen in the fall. Not only is water necessary for basic human survival, processing acorns requires large amounts of water to remove tannic acid and render them palatable.

Site survey data from three timber harvest compartments in the Stanislaus National Forest are described. These survey results illustrate a relationship between geology, hydrology, and prehistoric settlement patterning in this part of the central Sierra Nevada.

CULTURAL AND ENVIRONMENTAL SETTING

The study area is located in the Stanislaus National Forest, in the central Sierra Nevada of California (Fig. 1). Historically, the upland areas of this portion of the Sierra Nevada were claimed by Central Sierra Miwok groups, although seasonal use of the region by Washo is also documented (Kroeber 1925; Downs 1966). Native subsistence activities in this region focused on the collection of vegetable resources and hunting.

Topography in the study area is steep, highly dissected, mountainous terrain forested in a series of vegetation communities varying in species composition with elevation, which ranges from ca. 360 to 3,000 meters. Portions of the study area ad-

dressed in this paper are situated in what has been termed the "Yellow Pine Belt" (Storer and Usinger 1963), or "Upper Montane Forest" (Küchler 1977).

Historic regional climate is characterized by precipitation concentrated in the months between December and May, with summer drought eased by occasional summer thunderstorms. Winter precipitation occurs primarily as snow above 1,000 meters, and as rain at lower elevations. Surface water, principally as stream flow, is most abundant with the onset of snowmelt. Surface water availability is significantly diminished by late fall and early winter, preceding heavy precipitation periods.

The Sierra Nevada batholith is composed primarily of granitic rocks including granite, quartz monzonite, granodiorite, and quartz diorite. The relationship between these plutonic rocks and overlying Cenozoic volcanics is of principal interest for this study. Andesitic volcanic flows and other volcanoclastics of Pliocene age are abundant in the central Sierra Nevada. These rocks were laid down in a series of events after a long period of erosion of the granitic rocks. Some of these older rocks are capped by Pleistocene glacial deposits. Volcanic and glacial deposits have eroded away in many areas of the central Sierra Nevada, once again exposing the Mesozoic rocks (Hill 1975; Norris and Webb 1976).

Because the volcanoclastics were deposited on a highly eroded granitic landscape, the nonconformity between the two units can be quite irregular and the depth of volcanoclastic deposits varies. Erosion of the volcanic rocks has resulted in an alluvial mantle of volcanic debris that may extend some distance downslope from the original contact. This alluvial material is quite shallow, and it is not uncommon to find granite outcrops (as opposed to glacial erratics) exposed in a field of superficial

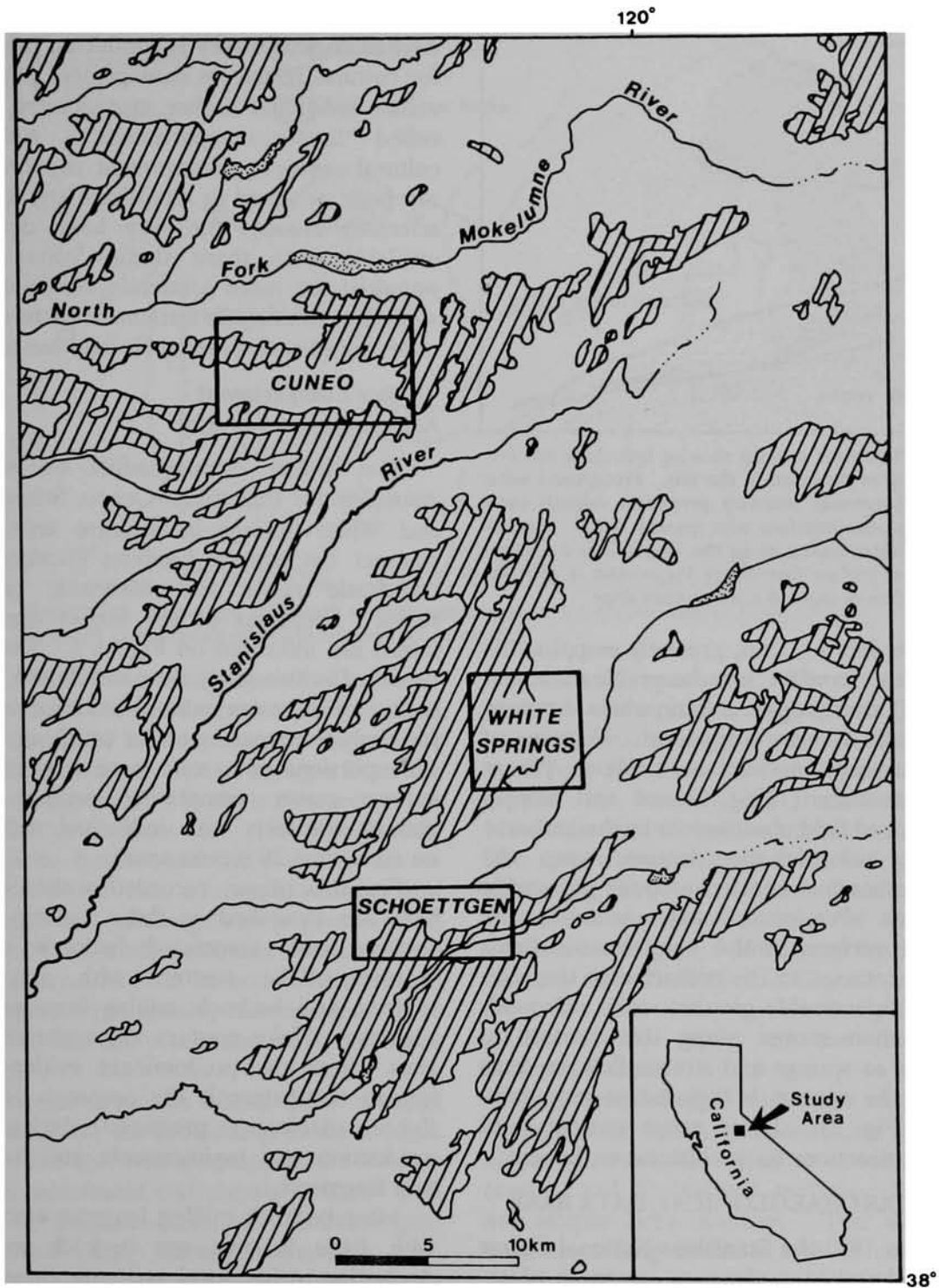


Fig. 1. Location of study area and three timber compartments in the Stanislaus National Forest. Hatched areas are Pliocene andesitic volcanics.

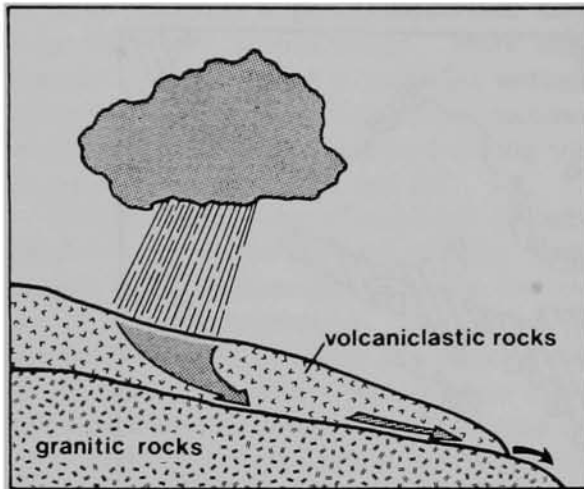


Fig. 2. Schematic drawing showing hydrologic relationships discussed in the text. Precipitated water penetrates relatively permeable volcanic rocks to the interface with granitic rocks. Groundwater moves along the interface and emerges as surface flow where the contact is near-surface or exposed in a mountain slope.

volcanic debris. Thus, precisely mapping the geological "contact" can be problematic, but general stratigraphic relationships between rock units are more apparent. Mapping of geologic units reported here follows Turner and Ransome (1898), Strand and Koenig (1965), and field observations by the author.

The volcaniclastic deposits atop the granitic basement rocks are quite permeable to water. Precipitated water infiltrates the ground surface in the volcaniclastic fields and penetrates to the contact with the relatively impermeable granitic rocks. Groundwater then moves along this contact to emerge as springs and stream flow in areas where the contact is exposed in mountainsides (Fig. 2). These water sources were prime attractions for prehistoric settlement.

THE ARCHAEOLOGICAL DATA BASE

Since 1973 the Stanislaus National Forest has undertaken a vigorous campaign of archaeological site survey with the goal of completing an inventory of all archaeological

resources within the 4,420-sq. km. forest. Archaeological survey is conducted primarily for cultural resources management purposes within individual timber management tracts called "timber compartments." Although cultural resource management surveys have not been designed to investigate any specific scientific inquiry, the very large database available from these studies offers great potential for more academic archaeological studies of prehistoric settlement patterns and other broad-scale prehistoric land-use topics.

Timber Compartment Archaeological Surveys¹

The timber compartments selected as examples for this study--Cuneo, Schoettgen, and White Springs--incorporate areas that transect the contact between Pliocene volcaniclastic rocks and Mesozoic granitic rocks. Locations of the timber compartments are indicated on Figure 1. The data reported in this study were developed in the course of intensive cultural resource surveys for timber compartments in which all accessible portions of a tract were examined by survey crews completing on-foot line-abreast transects with individual surveyors no more than 20 meters apart.

For this paper, recorded archaeological sites are described as flake scatters, flake scatters with associated bedrock milling features, flake scatters with associated midden and bedrock milling features, and quarries. Flake scatters are archaeological sites where the predominant evidence for human occupation is the presence of lithic flakes (debitage) produced during tool production and maintenance, and tools or tool fragments.

Most bedrock milling features associated with flake scatters are bedrock mortars. According to historical accounts, these were used by Miwok primarily for milling acorns and seeds (Gifford 1932; Barrett and Gifford

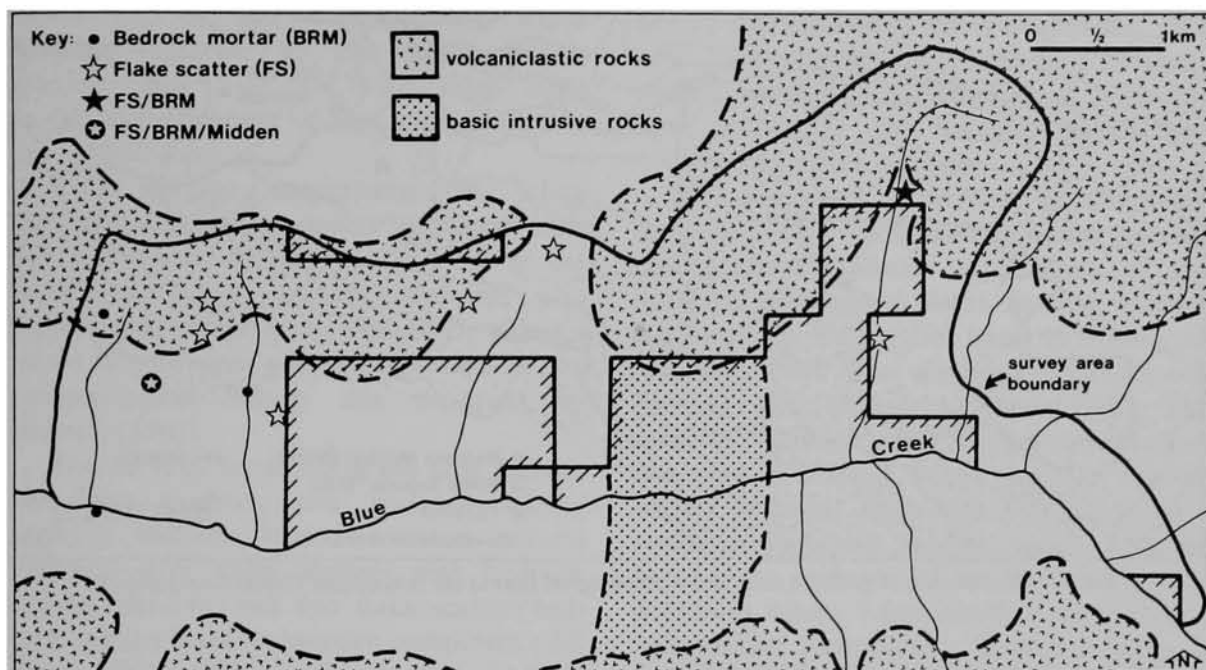


Fig. 3. Distribution of geologic units and archaeological sites in the Cuneo Timber Compartment. Hatched boundary lines indicate private in-holdings not surveyed.

1933). The Washo also prepared other foods (e.g., meat) in bedrock mortars (Downs 1966). The number of bedrock mortars on any one boulder or bedrock exposure ranges from one to 42 among the sites in the survey areas.

"Midden" refers to soils significantly altered by human activity, primarily by incorporation of ash, charcoal, artifacts and debitage, and, although rarely preserved in the acidic soils of the Sierra Nevada, other organic remains such as bone. Midden soil development presumably reflects repeated or intensive human occupation at a particular locality.

Quarries are sites where lithic material was mined for the production of stone tools. A rhyolitic tuff was quarried in the Schoetgen compartment and elsewhere in the area (e.g., at Summit Lake; cf. Archaeological Consulting and Research Services, Inc. [ACRS] 1980) but only a few tools of this material have been found at sites away from the quarries.

Cuneo Compartment. The Cuneo compartment incorporates approximately 1,295 ha. at elevations ranging from 1,525 to 2,100 m. Upper elevations of the compartment are capped by volcaniclastic rocks overlying Mesozoic granitic and basic intrusive rocks. The area is on the steep south-facing slopes of deeply entrenched Blue Creek, which forms the southern boundary of the compartment. Figure 3 illustrates the archaeological site distribution and geologic units. Data for this discussion are based on the ACRS (1979) report to the Stanislaus National Forest.

Ten archaeological sites were discovered in the Cuneo timber compartment. One is a large, complex site with a midden, flake scatter, and 52 bedrock mortars. Six sites are simple flake scatters. Two sites are bedrock milling facilities without associated flake scatters or culturally-altered soils. One site is a flake scatter/bedrock milling facility.

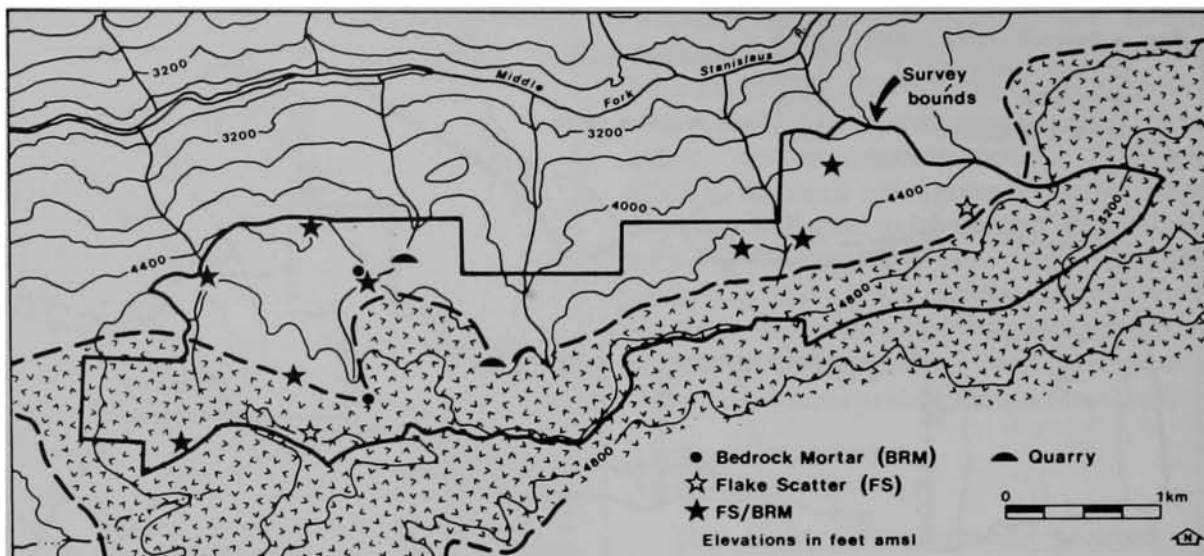


Fig. 4. Distribution of geologic units and archaeological sites in the Schoettgen Timber Compartment.

All but three of the sites in the Cuneo compartment are situated below the geological nonconformity and occur near either springs or stream water sources. Two of the sites located above the nonconformity are very sparse flake scatters. Neither site has an identifiable water source within 400 meters.² The third site is an andesite boulder with a single probable bedrock mortar and without any other associated cultural material.

Schoettgen Compartment. The Schoettgen compartment covers 1,154 ha. in an area between the Middle and South forks of the Stanislaus River. The survey area is on north-facing slopes overlooking the Middle Fork. Site survey data for the compartment are reported by Jackson and Lönnerberg (1981). Figure 4 illustrates the distribution of prehistoric archaeological sites and geological units.

The archaeological site inventory for the Schoettgen compartment includes eight sites with flake scatters and associated bedrock milling facilities, two flake scatters, two sites with bedrock milling features exclusive-

ly, and two rhyolitic tuff quarries. At neither quarry is there evidence of actual habitation. These quarry sites are irrelevant to the current model because their location is determined by the availability of a specific lithic material.

Two of the recorded sites are in settings above the geological nonconformity. At the time these sites were recorded (November 1979) no viable water source was found. A spring adjacent to one site was dry; no evidence of any potential water source was found closer than 150 meters to the other, and this stream drainage also was dry. This may imply occupation in an earlier season.

Field observations at several sites along stream courses indicate that water emerges in these channels only in the immediate area of the contact between the volcanoclastic and granitic rocks. Stream flow is typically maintained only over a very short distance (30 meters or less) before the water disappears into the stream bottom sediments.

It was also noted during the Schoettgen survey that an area of reasonably level terrain often results from the differential

weathering of the comparatively softer volcanics relative to the much harder granitic rocks (Fig. 2). This "bench" adds to the attractiveness of the environment in the contact zone.

White Springs Compartment. The White Springs compartment covers 990 ha. of land north and west of the Middle Fork of the Stanislaus River, with Compoodle and Smoothwire creeks being the major streams in the survey area (Fig. 5). Results of the archaeological survey are reported by Jackson (1980).

The 15 sites recorded in the area include six flake scatters, two bedrock milling facilities without other associated cultural material, four flake scatters with bedrock milling features, and two flake scatter/bedrock milling features/midden complexes. All but one site are either close to the geologic contact or along the two perennial streams. No sites were found in the area covered with volcanoclastic rocks (Fig. 5). A few isolated obsidian flakes and flake tools found widely dispersed across the volcanoclastic field are the only material evidence that the upland environment was used.

DISCUSSION

In pointing out the apparent relationship between geological setting, hydrology, and archaeological site distribution, I am not inferring a deterministic model. It is certain that many cultural and other environmental factors were important in the selection of a specific site location. These probably include insolation, slope, vegetation mosaic, topographic aspect, prevailing wind, aesthetics, territoriality, engendered activities, production technology, procurement strategies, and others. Many of these other attractive environmental attributes are characteristic of the ecotone setting along the geologic contact. Fundamentally, however, prolonged human occupation of an area can-

not be divorced from water availability. We now have a better understanding of water source distribution on the Sierran landscape and can relate this to site survey and settlement pattern analysis.

The described relationship between plutonic basement rocks and Pliocene volcanoclastic rocks is found over much of the northern and central Sierra Nevada, extending from the Yuba River basin to the northern Tuolumne River drainage (Burnett and Jennings 1962; Strand and Koenig 1965). The specific hydrologic relationship probably does not exist in settings where massive, consolidated andesitic flows cap Sierran granitic rocks or Paleozoic marine rocks. Nor is there clear evidence of the hydrologic phenomenon where volcanoclastics cover Paleozoic marine formations. In such settings it is possible that the hydrologic relationship is manifest where glacial deposits rest directly on granitic foundations; this merits further examination (cf. ACRS 1980).

In-field archaeological survey strategies that attempt to apply this model should focus less on finding any actual "exposure" of the nonconformity between the geological units and emphasize coverage of an area extending perhaps 200 meters on either side of a more generalized stratigraphic perception of the positions of the volcanoclastic and granitic rock units. An adequate understanding of one's position relative to the two units is achieved for archaeologists by observing the relative proportions of exposed granitic outcrops versus volcanoclastic debris. Very close attention should be paid to locating ephemeral water sources such as very small springs and very limited stream flow over short sections of stream channels.

With regard to the distribution of archaeological site "types," the maintenance of relatively larger populations on the landscape requires increased demands vis-a-vis the water supply. Consequently it is not sur-

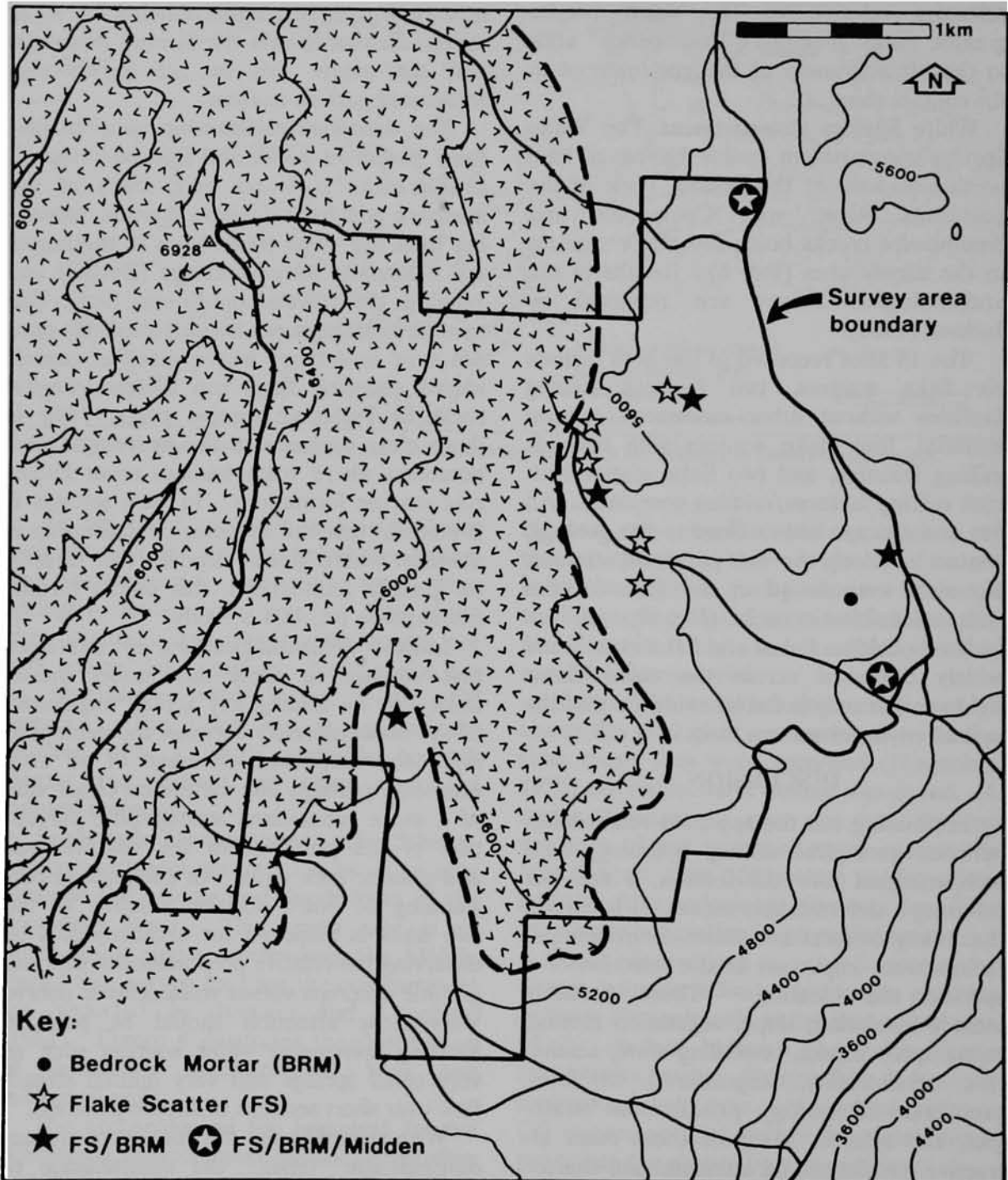


Fig. 5. Distribution of geologic units and archaeological sites in the White Springs Timber Compartment.

prising that the most complex sites (those with flake scatters, midden, and bedrock milling features) are situated near the most dependable water sources. On the other hand, it is not contradictory to expect that relatively small, task-oriented human groups are less demanding of water volume, and smaller, less complex sites are less closely associated with major water sources.

An understanding of the relationship between geology and hydrology in the central Sierra also helps explain the difference in Sierran prehistoric settlement patterns versus those of the mountainous interior North Coast Ranges. In the latter area, relatively intensive use of ridge tops for settlement and transportation routes has been documented (e.g., Jackson 1976; Hildebrandt and Hayes 1984). Although other geographical factors are apparent, ridges in the North Coast Ranges tend to be relatively well watered, with springs on or very near the ridge summits. This is not generally the case in the central Sierra.

CONCLUSION

A study of the spatial distribution of recorded archaeological sites in California's central Sierra Nevada suggests a critical positive correlation between archaeological site location and the hydrologic association between Pliocene volcanoclastic and underlying granitic rocks. Groundwater penetrates the permeable volcanoclastic rocks and emerges as springs and stream flow near the interface with underlying impermeable granitic rocks. Surface water is available below the nonconformity during summer drought and it is in the vicinity of these water sources that settlements were situated. This ecological setting offers other attractive features conducive to human settlement, including relatively level terrain, and associated faunal and floral communities important to native American subsistence.

It seems likely that specific locations of springs and intermediate stream course flows have varied with climatic fluctuations throughout the Holocene, and as the result of historic human-induced environmental alterations. Nevertheless, knowledge of the general location of the contact between volcanoclastic and granitic units allows archaeologists to make more effective predictions about the location and nature of archaeological sites in unsurveyed areas of the central Sierra Nevada.

NOTES

1. Archaeological survey was conducted for the U.S.D.A., Stanislaus National Forest, by Archaeological Consulting and Research Services, Inc., pursuant to contract numbers 53-91S8-8-6067 (Cuneo) and 53-91S8-9-6278 (Schoettgen and White Springs).

2. The historic distribution of springs in the survey area has been altered by logging, road construction, livestock grazing, and lack of spring maintenance. Some springs available prehistorically probably have disappeared. This affects recording of "nearest water" to archaeological sites as required on most site survey record forms.

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