Quantifying Prehistoric Site Densities using Geographic Information Systems: A Test for the Middle and Lower American River Region, California

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Introduction-Basis of model/How used in study

Analytical models are well-suited to applications in land management. For our interests they can be used to identify patterns in spatial relationships between archeological sites and their physical locations and thus indicate potential relationships between the natural or social environment and the locations of past human activities. A causal relationship is posited: environmental factors influence where human activities occur (Kincaid 1988:550). Most importantly for land planning, models can predict site densities determined from a given independent variable or set of independent variables (Judge and Sebastian 1988).

The quantity as well as the quality of analysis necessary to develop such models require automated spatial analysis of the data through the use of geographic information system (GIS). The GIS system used in this analysis is Arc/Info.

The basis of the site density model used in this analysis assumes that prehistoric occupants of the region had a strong relationship with their environment. Because of this relationship, it is further assumed that these prehistoric hunters and gatherers distributed themselves over the region in a non-random pattern in order to exploit subsistence and other resources and to use areas for other specific or general activities. The independent variables used in this analysis are considered the landscape: soils/landforms, slope, potential natural vegetation, and distance to watercourses. Site location is the dependent variable. The goal of the model will be two fold: (1) to examine the relative relationship of known sites to the various independent variables, and (2) to develop estimates of site densities sorted by the independent variables or sets of independent variables.

Naturally, as with any human system, since humans do not behave mechanistically, no one variable, or even set of independent variables will completely explain site location, such variables still may account for the significant variance present in the site data set. Further, since each human group can interact with their natural and social environment in complex and in different ways (many non-lineal), the relationships between the independent and dependent variables can vary widely from cultural system to cultural system. For example, the abandonment of village with the death of a headmen and the move to a camp site or another abandoned village is a variable not controlled. The complexity of determining the relationship of the independent variables with the archeological record is increased by changes in the landscape, by a depositional record that is both incomplete and sometimes complex, and the temporal and spatial variation of archeological cultural patterns for a given region.

While we recognize that the selected independent variables are dynamic, each responding to changes in climate, time, tectonic, and bio-geographic factors, for the purposes of this preliminary model the independent variables are held constant. On a general level the landscape over the last couple of millennia, prior to the historic period, is assumed to be relatively static, that is, no major changes have occurred in landforms/soils, slope, exposure, location of water courses, potential flora or fauna. For this reason the model will be most representative of the late prehistoric period, or approximately the last 2000 years. This assumption does not ignore that natural and cultural change did occur during this time period, since they did, but the amount of change is assumed, based on the data at hand, to be within the range of the model's resolution and relatively minor when compared to earlier archeological cultures and environments.

Study Area

The study area covers the middle and lower reaches of the American River thence southward following the lower margins of the foothills and eastern margins of the Sacramento-San Joaquin Delta to the Stanislaus River (Figure ___). Ideally, for studies such as this the entire watershed would be included, however the selected area was determined by a water needs analysis that the Bureau of Reclamation was requested to undertake by a number of water agencies. Future work will be devoted to include the entire watershed.

Population Estimates and Site Density

For an examination of the model's output at the synchronic level an estimate of late prehistoric population levels for the study area is required. That is, do the predicted number of sites exceed, meet, or fall short of the number estimated from population approximations. If the predicted number of sites do not meet the number determined from population approximations, then the predictive site density model is too conservative and can be rejected.

For the most part regional population estimates are based on a very sketchy and incomplete ethnographic record[1] or upon resource based models (environmental determinants). In the region several areas have been examined and estimates derived for the late prehistoric/proto-historic Southern Maidu (Nisenan), Northern Valley Yokut, and Miwok. Wilson and Towne (1978:388) report for the Nisenan that village or community groups that controlled a certain territory ranged from extended families of 15 to 25 people to large villages of several families numbering over 500. Total population for the Maidu, inclusive of the Nisenan, was approximately 9,000 in 1770, but may have been as low as 4,000 (Kroeber 1929). According to Riddell (1978:386) only one third of the 9,000 estimate were Nisenan. Sutter in 1846 employeed Gatten to make a census for the region, who submitted a tally of 22,353 Indians in the general vicinity of his colony, Nueva Helvetia (Heizer and Hester 1970). Gatten proceeded down the Mokelumne, where he recorded two villages, up the Cosumnes, where he recorded seven villages, down the American and up the Feather. The total population is broken down by males and females for six "tame" tribelets and 28 "wild" tribelets. Bennyhoff (1977:35) determined that the "tame" groups included three Plains Miwok and three Yokut groups; the "wild" tribelets included only nine Plains Miwok groups while the remainder represented Foothill and Valley Nisenan, and Valley Maidu. Gatten's post-mission period census was affected by the malaria and mission de-population that occurred at the lowland sites.

For the eastern Miwok Levy (1978:402) estimates a population of 19,500 at a date of 1805, prior to their decimation. The Miwok sub-unit, the Plains Miwok probably numbered about 11,000 (Cook 1955b). About A.D. 1800 they were divided into about 28 tribelets, the main villages of which were distributed along the banks of the Sacramento, Cosumnes, and Mokelumne rivers (Bennyhoff 1977) and averaged about 400 individuals (Levy 1978:402). Available evidence suggests that from one to three smaller villages were inhabited contemporaneously with the tribelet center, depending on both the season and size of the tribelet (Bennyhoff ibid:147). Estimates for Northern Sierra Miwok are about 2,000 individuals, Central Sierra Miwok at 2,100 and Southern Sierra Miwok at 2,700 (Levy 1978:402). Baumhoff (1963:Table 15) gives estimates of 14,350 for the Plains Miwok, 4,410 for the Central Sierra Miwok and 5,766 for the Southern Miwok at 1800. In contrast, a 1990 census identified a total Miwok (including Coast and Lake Miwok) population of 3,381 (Bates 1994).

The population figures for the Northern Valley Yokuts are not reliable (Baumhoff 1963). Cook (1955) estimated 25,100 for the entire Northern Valley Yokut territory which extended along a broad swath of land on both sides of the San Joaquin River beginning in the southern delta area to Friant. The Yokut population in the study area was probably on the order of 5,000. From these data we conclude that the reconstructed ethnographic population estimate for the entire study area must have been >20,000.

Baumhoff (1963) using a game-fish-acorn resource based model estimated that the Plains Miwok population density in and adjacent to the Sacramento-San Joaquin Delta was one of the highest for aboriginal California, averaging over 10 persons per square mile. His other population estimates inclusive of the study area are 2-3 persons per square mile for the higher alluvial plains to 5-7 persons per square mile for the foothill zone. The alluvial plains would consist of grassland crossed by strips of riparian vegetation whereas the foothill zone would consist of blue oak/digger pine woodland and mixed conifers.

The GIS soils/landform areas and Baumhoff's mapped categories are not congruent but when the GIS categories are compressed they conform enough to be useful for comparison. The study area covers approximately 3,300 square miles: 1900 square miles of Nisenan land, 910 square miles of Miwok land and 490 square miles of Northern Valley Yokut territory. Of this, 607 square miles consist of flood plains, basin and basin rims and organic soils on deltas low alluvial plains (= Delta/Riparian), 980 square miles of low stream terraces and low fans, high stream terraces and fans, and low terraces and floodplains with dunes (= Alluvial plains), and 1109 square miles of high terraces and hills, low and middle foothills, and uplands with serpentine rocks (= Foothill zone). Using Baumhoff's population density estimates gives a population estimate of approximately 16,800 individuals. This crude estimate does not include the "Uplands-mountains with granitic and volcanic soils" areas. Including these areas into the estimate would probably provide a figure similar to that derived from the ethnographic reconstructions noted above.

How far back in time such population estimates can be extended is open to question. Archeological studies in the central Sierra Nevada foothills have suggested that diachronic population numbers have varied significantly (Moratto 1984). Co-occurring with the population changes have been changes in subsistence and settlement patterns, as well as, in some instances, cultural and biological change. Again the amount of change is considered to be within resolution of the model.

Population/Number of Sites

For converting population estimates into site numbers requires some further speculation on the number of individuals per site at a given time. With this synchronic approach it is recognized that: (1) not all sites were occupied, (2) population varied by site type, and (3) some sites were re-used, abandoned, or destroyed by natural processes. According to Dixon (1905) the Northern Maidu moved their villages every five or six years to another location about one eighth to one-quarter of a mile away to prevent illness and vacate houses that were full of vermin. It is likely, at least to some degree, that a similar practice occurred within the study area. The late prehistoric settlement pattern consists of one or more major tribelet villages with a number of satellite secondary villages, camps, quarries, etc. associated with one or more watersheds[2].

The exception to this pattern appears to be the Cosumnes River which has a very high recorded site density of 2.4 sites/square mile for the middle and lower reaches. Bennyhoff (1977:95) concluded that prior to the 1833 plague it was probable that 12 villages were distributed between the mouth of the Cosumnes River and Sloughhouse, representative of two contemporaneous villages per tribelet, and one tribelet center every 3.7 miles. The mission records and Sutter documents suggest that eight Plains Miwok tribelets occupied the Cosumnes River, Deer Creek, and Laguna Creek in aboriginal times (Bennyhoff ibid.). Where noted, most of the Cosumnes sites are recorded on the site forms as habitation or village sites. However, since the region is one of the earliest to be examined in California, with very different goals and standards than today, site classification may need revision. Further, some of the sites on the Cosumnes have been recorded more than once for different locations (M. Russo personnel communication 1995). Conversely, if the settlement pattern and density is at least partially real, and it would appear reasonable to assume that all the variability seen for this drainage cannot be accounted for by re-recordation of the same sites, such a cluster of sites may have some highly related characteristics that are not representative of the region as a whole. For a number of reasons, unlike the American River, the area was never extensively placer mined and never densely settled during the early historic period and for these same reasons sites were not as likely to have been destroyed. The Cosumnes also had, and still has in places, a relatively wide riparian forest that contained a large percentage of oaks and other resources that could support high population densities. While the Cosumnes area needs to be field checked and re-mapped, complete verification is impossible since a

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number of recorded sites are known to have been destroyed in the last 40 years primarily from farm related land leveling.

For the Nisenan the numbers of individuals per site reportedly varied from 15 to >500 (Kroeber 1925:831). Levy (1978) suggests an average of 400 per tribelet village for the Plains Miwok. The data for the Northern Valley Yokuts is even more equivocal. Cook (1955) estimates 900 individuals for three villages in the Sacramento-San Joaquin Delta, but this has been questioned by Bennyhoff (1977:133). For the whole study area major villages probably averaged around 300 to 400 individuals, a number that seasonally fluctuated to adjust to subsistence needs. Each major village probably had several smaller satellite villages and seasonally occupied camps containing 5 to 50 persons. Such a constellation would reflect the settlement pattern of a tribelet or among the Yokuts a segment of a tribe. Thus, based on the ethnographic/ecological determinant population estimates there should be about 50 to 60 major villages in the study area, roughly about twice the number of known ethnographic villages. Each village probably had 10 to 20 satellite villages, camps, workshops, quarries, etc., giving a total number of active sites being in the range of 500 to 1200, with the upper range approximating the number of sites known for the study area. Considering that most of the habitation sites and BRMs in the data base date to, or have a component dating to the last two millennia and that some sites were abandoned and/or destroyed by natural processes and new sites established, the total number of sites using this approach must be considerably higher, possibly 3000 or more.

Resolution of the data.

Sources of Data: Information Center, SHPO data base. USBR data base (Auburn)

The quality of the data base is uneven and individual site records vary greatly in the data they contain. Many older site records, for example, lack all but the most basic locational information. While a majority of sites have been placed into the SHPO database, particularly prehistoric sites, many sites have not yet been included or have not even been assigned trinomials. Of the latter, only those sites identified during the inventory of the proposed Auburn Reservoir were included in the GIS data base.

The SHPO database site types are generic and assigning sites to specific categories is not rigorous. Categories are not exclusive. Particularly vexing was the category that included bedrock mortars with milling features. For some sites, specifically those on the flood plain, this problem became readily apparent when plotted with soils/landforms.

The chronologic division of most sites in the study area is not well defined and is primarily based on limited observation or is unknown. Assignment of the majority of the habitation and bedrock mortar (BRM) sites to the late prehistoric period is probably within reason and acceptable for this level of analysis. Some chronologic data provided by regional researchers (W. Olsen, personnel communication 1995) supports this assumption. Of note, is that a number of sites or localities appear to have been utilized for many thousands of years suggesting a continuity through time (eg. Stream terraces and alluvial toe slopes of hills on which Creviscreek soils occur (Payen 1973)). However, known flake scatters and quarries, for the most part, have no time constraints and could be representative of any cultural period.

Site mapping.

To assess the sensitivity and predictive density of cultural resources in the study area information was obtained from the State Historic Preservation Office and Bureau of Reclamation records. A delimited file containing locational and site content data from the California Archeological Site Inventory was clipped to restrict the geographic coverage to correspond with the study area. This data was downloaded into Reclamation's Geographical Information System (GIS) with Arc/Info 7.0.3 as the primary software. Programming was accomplished through ArcMacro Language. Site locations were plotted on U.S.G.S. 7.5 minute quadrangle sheet overlays using Universal Transverse Mercator coordinates and compared to hard copy locations obtained from individual Information Centers of the California Historical Resources Information System (Information Center) for accuracy. For all records where locational errors were discovered they were corrected. If there was insufficient data to make the correction they were rejected. This three tiered approach worked well for correcting site locations that were based on UTMs.

Independent variables.

Soils/landforms indicate the relative, and in some instances the absolute, genetic age of the surface, and the geomorphic type (floodplains, low terrace, high terrace, uplands, etc.). The approach here parallels the descriptions provided in *Soil Survey of Sacramento County, California* (Tugel 1993). Since soil classification is multi-factorial some vegetation information is embedded in the soils/landform variable. For example, areas of riparian forest vegetation correspond to areas of Columbia soils along the American and Cosumnes Rivers and Mokelumne soils, which are in freshwater marshes, formed in thick deposits of decomposing tules and reeds that formerly grew near sea level. Slope is the steepness and exposure of the landform. Information on slope also is embedded in the soils/landform variable but has been examined as an independent variable for this analysis. Potential natural vegetation is based on Küchler's vegetation map of California (1977). Each of the plant associations have specific resources that could be exploited on a seasonal basis (Schulz 1981). Water resources were and are, of course, critical for any human group. Water courses are mapped at levels (hierarchical branches starting from the Sacramento River) assumed to have water, discontinuously along their beds for part of the year. Levels 1-7 were examined. Measured distance to water is based on two approaches: cost-function and shortest distance. The former method incorporates the physiography in determining distance to the nearest water source. To further define this variable water course miles per landform unit was calculated for use as a measure of stream density.

The independent variables were derived from STASCO (General Soil Map for the State of California) for soils/landforms, Küchler (1977) for the potential vegetation, EPA River Reach file for stream classification, and for slope a processed 1:250,000 scale digital elevation model. The scale (1:1,000,000) and hence, the resolution of Küchler's vegetation mapping limits this variable's usefulness since it ignores the narrower bands of riparian vegetation and the boundaries of the marshlands are poorly developed. Future efforts will be made to refine the potential vegetation for the area.

Sample and Standardizing

Only a relatively small percentage (approximately 3%) of the study area has been systematically surveyed and coverage ranges from more than 7% to less than 0.1% for the various landforms. Accurate estimates of coverage are difficult to derive since many sites that have been assigned trinomials were recorded years ago and prior to any standards for survey and coverage was not defined. Further, as noted, not all the sites recorded in these surveys have been assigned trinomials and many have not been included in our data base.

Of those lands systematically surveyed, various standards have been met. The surveys range from sampling to complete coverage of specific areas. Earlier surveys generally did not specify methods, survey area, and did not record historic sites, or only recorded prominent ones. We have made the assumption, perhaps incorrectly, that the methods of surveys made since the mid-1980's have been fairly uniform and most types of cultural resources have been given equal consideration.

Classification for sites has been standardized to the categories on the State Historic Preservation Officer's *Archeological Data Encoding Sheet* although some categories were compressed into others. This less than ideal situation was necessary since many of the categories overlap and classification has not been consistent.

Results

Known Distribution

The known distribution of prehistoric and historic sites is presented on maps and files maintained at the Bureau of Reclamation. Some 933 prehistoric sites are included in Reclamation's data base for recorded sites. As illustrated in Figure __ and Table 1, known prehistoric sites show a strong locational relationship to the selected independent variable (soils/landforms). Almost one site per square mile are known for the flood plains and low alluvial fans (riparian zones) (Known density results have not been standardized.) and most sites are less than 1 km from levels 1-7 waterways (Table 2). The known site density (0.01 to 0.34/square mile) are low for the low stream terraces and fans, high terraces and hills, areas of organic soils on deltas and basins, and low terraces and floodplains with dunes. Known sites per square mile increase to 0.5 in the uplands- lower and middle foothills with Blue oak/Digger pine woodland. One site (SJo-225, Potato Slough Mound) is recorded for "Organic soils on deltas and basins," however, on closer inspection the site is on a mound composed of sandy silt which is surrounded by organics.

Landform	Total Area (Sq Miles)	Recorded Sites	Inventory Area	Percent Survey	Sites in Inventory	Site Density[1]	Sites Predicted
Flood Plains	208.5	195	3.1	1.47	12	3.9	807
Basins	304.0	31	0.0	0.00	0	-	-
Low Stream Terraces	693.9	72	5.6	0.80	1	0.16	124
High Stream Terraces	160.3	40	7.1	4.42	18	2.5	401
Organic Soils	92.3	1[2]	0.0	0.04	0	-	-
Low Terraces/Flood	126.2	2	0.0	0.00	0	-	-
High Terraces/Hills	503.9	169	38.6	7.65	58	1.5	756
Uplands: Foothills	555.5	333	24.0	4.31	84	3.5	1946
Uplands: Serpentine	49.3	11	0.1	0.21	0	-	-
Uplands: Granite	469.4	57	3.2	0.67	9	2.8	1314
Uplands: Volcanics	119.0	22	0.0	0.00	0	-	-
(Reservoir Areas[3])	21.6		2.6	12.25	54	20.4	441
Totals	3303.9	933	84.3	2.55	236	2.8	5789

Table 1. Landforms within the study area: Total area, total number of site, areas subject to archeological inventory, percent of each landform inventoried, sites within inventory areas, site density, and total projected sites within each landform. Note: 1) Sites per square mile; 2) Site is located on a sandy-silt mound surrounded by organics; 3) Areas of water currently within reservoirs.

Prehistoric site type	Average Dist (M)	Standard Deviation	Minimum Dist (M)	Maximum Dist (M)
1 Habitation debris	377	591	0	5331
2 BRM/Milling with lithic scatter	344	348	0	1393
3 BRM or Milling site only	271	419	0	4120
4 Lithic scatter	412	329	8	1102
5 Petroglyph	353	330	12	720

6 Quarry	378	280	114	767
9 Unknown	510	648	6	2383

Table 2. Statistics on the distance to water courses for sites types from the study area. Figures include all water courses except for manmade.

Soils/Landforms

Site density and type varies with soils/landforms (Tables 1 and 5). All sites noted for the flood plains and low alluvial fans are habitation sites and a few unknown. Flake scatters and bedrock mortar sites increase dramatically with elevation related to landform change. Bedrock mortars are, of course, dependent upon rock outcrops and also are related to soils that support oak growth. Flake scatters are probably more visible with elevation since there is less deposition and more erosion in upland areas. Undoubtedly, cultural patterns and resource availability are also being reflected in the distribution of flake scatters.

Distance to water

Several approaches were used to examine the distance of known sites to water courses. These included: distance to water by site, average distance to all water courses by site type, distance to all reaches except manmade by site, type, and distances to all water courses except manmade and intermittent by site. Results are presented all natural courses and all natural courses except intermittent in Tables 2 and 3. For most site types average distance is less than one kilometer from water courses. When one excludes intermittent water courses the average distance is greater but still less than a kilometer for the overall majority of sites and in particular for lithic scatters, bed rock mortars, and habitation sites. The skewed distribution for lithic scatters may be a function of erosion, particularly in the reservoir areas.

Prehistoric site type	Average Dist (M)	Standard Deviation	Minimum Dist (M)	Maximum Dist (M)
1 Habitation debris	737	1062	2	7345
2 BRM/Milling with lithic scatter	902	1151	9	5118
3 BRM or Milling site only	1215	1406	4	7851
4 Lithic scatter	999	1111	8	6888
5 Petroglyph	2578	1317	720	3550
6 Quarry	1816	1059	674	3083
9 Unknown	802	959	61	3620

Table 3. Statistics on the distance to water courses for sites types from the study area. Figures include all water courses except for manmade and intermittent streams.

Slope

Percent slope was determined for each site and sorted by landform and site type. The results are presented in table 5. Not surprising the average slope for sites is less than 4.5 percent with the largest number of them found on slopes of less than 2 percent. Slope, therefore explains some of the variability of site distribution.

Prehistoric site type	Percent	Raw Count	Avg % Slope
1 Habitation debris	54	507	1.99
2 Bedrock mortars/Mill with lithic scatter	11	98	4.05
3 Bedrock Mortars or Mill site only	23	212	4.44
4 Lithic scatter	9	87	3.09
5 Petroglyph	0.4	4	3.13
6 Quarry	0.4	4	2.05
9 Unknown	2	20	2.84

Table: 4. Known sites sorted by Percent, Raw counts, and Average percent slope.

Vegetation

The density and types of sites undoubtedly is influenced by vegetation, particularly by the distribution of oak woodland and the riparian forest. For example, the study area contains over 800,000 acres that could have supported oaks. However, the distribution of oaks is not uniform and a figure of 500,000 acres is probably closer to the mark. An acre of oak woodland can yield at least a ton of acorns during a good year (Koenig and Knops 1995:7). Acorn production is highly variable, species specific, and good years are far fewer than average and poor years. Cultural factors also are significant in regards to acorn utilization since Native Californians have very strong species preferences (Baumhoff 1963:163). Thus, while acorn production is highly variable, even in a poor year with acorn production at 10 percent or less of a good year's production, and considering cultural preferences, loss to insects and animals, with carry over storage the potential for significant populations based on acorn subsistence (approximately 0.25 tons/person) is still greater than the ethnographic population estimates discussed above.

A preliminary look at the low resolution vegetation mapping that we used suggests that some of the site density variance is related to vegetation and that a higher resolution analysis is warranted. The possible relationship, not surprisingly, is particularly suggestive for the distribution of bed rock mortars and oaks.

Predicted Site Density

Sampling/Biases/Qualifications

To develop a predictive model a sample had to be selected. The sample was selected on the following criteria:

> Areas that were delineated as surveyed on the information center maps and had an associated report describing some type of systematic coverage.

Sample size is highly variable ranging from 0 to 7.65 percent of the various soils/landforms, and only 6 out of the 11 are represented. Of the 6 used for prediction two had a sample survey coverage of less than 1 percent. As noted above, the Cosumnes River area may have a high site density that is due to a number of factors that need further clarification and evaluation; therefore, it was not included as part of the representative sample.

Random distribution

A random distribution was generated for the study area for comparative purposes. The area was divided into 1 km squares and a random distribution of 10 percent was selected since this sample approximated the number of known sites. When the results were visually compared to the known site distribution the difference was obvious suggesting that known site distribution is not random. Additional future analysis with more stringent controls will be required to define the amount of variance.

Predicted Results

Results are presented in Tables 1 and 5. Sufficient data was available for site density prediction for six soil/landform types and existing reservoir areas (water: which covers primarily two landform types- High terraces/hills and Uplands/lower and middle foothills). The model predicts a total of almost 6000 sites for the study area.[3] Comparison of known site locations to predicted site density is different by about a factor of 4 to 10. Determined site density ranged from 0.16/square mile for low stream terraces and fans to 3.9/square mile for flood plains and low alluvial fans. However, only 1.47 percent of the flood plains and 0.8 percent of the low stream terraces surveyed have been used as the basis for the model, thus predictive confidence levels will be large. Excluding the flood plains and low alluvial fans site density increased with elevation for upland areas with oaks (2.8 to 3.5/square mile). Reservoir areas had very high values (corrected) of approximately 20 sites per square mile. On closer inspection a large number of these sites were found to be flake scatters that had been exposed by reservoir erosion that otherwise would have been invisible. Such buried sites may be earlier and therefore temporally incompatible.

Landforms	Inventory: Site Types						Projected Site Types					
	L	M	LM	H	O	U	L	M	LM	H	O	U
Flood Plains				12						807		
Basins												
Low Stream Ter.				1						124		
High Stream Ter.	1	4	5	7		1	23	90	113	158		23
Organic Soils												
Low Ter./Dunes												
High Ter./Hills	2	25	5	20	6		26	326	65	261	78	
Up: Foothills	4	48	6	25	1		93	1111	139	579	23	
Up: Serpentine												
Up: Granite		6	1	2				880	147	293		
Up: Volcanics												
Water (Reservoir)1	25	3	14	11		1	208	25	116	91		8
	32	86	31	78	7	2	350	2432	580	2313	101	31

Table 5. Distribution of site types by land form and the project total of sites for the study area. Note: L: Lithic scatter; M: Bedrock Mortar or other

milling site; LM: Combination of lithic scatter and milling artifacts; H: Habitation site; O: Other site type includes petroglyphs, stone features, or quarry; and U: Unknown site contents. (1- primarily High terraces/hills and Uplands/lower and middle foothills)

Discussion

Known site location for the study area indicates that a large number of prehistoric sites are present (>1,000). The number of known sites is based on limited coverage of the area, probably totaling no more than about 5 percent or less. The coverage mostly is restricted to areas that have been selected for development and in many instances are the same areas that were favored by prehistoric populations for some of the same reasons, such as drainage and topography. Survey coverage undoubtedly is also related to the various counties' application of environmental law and regulation in the planning process.

Even at the crude level of analysis presented here it is possible to provide site density predictions for areas that have not been surveyed. The predicted number of sites is roughly six times greater than the known sites. For examination, when the predictive model was tested against surveyed areas not included in the predictive sample the results demonstrated that the approach is promising (Figure _____).

While the known site location data give no surprise results, the predictive results give rise to a number of questions. The number of sites predicted by the density model is far greater than the number of known sites or the number estimated from the population/ethnographic and ecological determinants for the study area. What might this indicate? Are the population estimates too low, or is the number of individuals per site or site constellation too high, or were site constellation numbers greater than posited, or combinations of all or some of these factors? In particular many lithic scatters are ephemeral and an adjustment to the site constellation numbers is warranted. Are the chronological assignments used too encompassing? To a degree this would appear to be the case, particularly for some catagories of sites, such as quarries and flake scatters. Nevertheless, we predict that with further analysis that the majority of sites will either date to the late prehistoric or will have a late prehistoric component. Does the concept of site need to be redefined? At a minimum site categories and attributes need further definition or reclassification. It is obvious that the site density model is not too conservative but are the model's predictions too high because of inadequate sample sizes for some soils/landforms? Even if they are too high, since predictions for only six of the soils/landforms could be made, the eventual inclusion of the predictions of the remaining soils/landforms categories will undoubtedly support the estimate for the total area. In sum, it would appear that there were lots of folks doing lots of things over study area for the last 2,000 years.

While all the questions noted cannot be directly resolved with the data at hand, it is possible to test the model through additional survey of selected areas and develop greater precision on the region's population estimates and the resolution of the independent variables. Structured surveys that address site density and chronology can be used to confirm or correct the results presented here. It is here that the real value of GIS based density models abide, that is they are cumulative, testable and can be refined. Since many sites have been destroyed and the land surface modified by developments beginning before the Gold Rush it may be impossible to achieve adequate samples for all areas. Nonetheless the model may help to fill these data gaps. To expand the analysis of settlement patterns it will be necessary to more clearly define site types and their attributes and transfer the revisions to the data base. In the interim, the model will suffice to provide a preliminary estimate of sites per unit area that can be used with caution for preliminary studies in specific areas.

END NOTES

(1) The Yokuts, Nisenan, and Plains Miwok people were greatly affected by incursions of Europeans into California. Initially Spanish explorers and later mission expansion affected their cultures. Coastal California Indians fled their new lives at the Missions and were often pursued by military patrols. Some of the Plains Miwok were recruited and added to Mission rolls. The Plains Miwok also began a program of raiding coastal Missions and other settlements. Horse meat became a part of the aboriginal diet. Retreat to refuge sites located in the upper foothills occurred.

Other forces adversely affected California Indians. A plague, identified as malaria, may have killed as much as 75% of the native population and destroyed many Central Valley villages (Cook 1955a, 1976). The gold rush brought thousands of men into traditional Miwok, Nisenan, and Yokut territory. Indians were first exploited as laborers for gold mining, but soon this invasion led to widespread killing, destruction of villages and their ecosystem. This period "quickly destroyed (the Nisenan) as a viable culture" (Wilson and Towne 1978:396) and what is known of the Yokuts is assembled "piecemeal from the writings of explorers, military men, missionaries, and other early travelers" (Wallace 1978:462).

(2) The territory for the Plains Miwok and the Nisenan was divided into tribelets which contained several villages located on the flats or ridges parallel to river drainages. The Yokuts settled adjacent to river banks or upon low mounds and built small, lightly built structures, covered with woven tule stalks (Wallace 1978).

For the Plains Miwok Bennyhoff (1977:147) concluded:

> "Permanent villages were confined to natural levees and knolls along the banks of the major watercourses and adjacent lakes. Tribelet centers were occupied more or less continuously for generations, so the bulk of the population must be considered sedentary. Segments of the tribelet population established seasonal camps along intermittent creeks during the spring, and temporary hunting and harvesting camps probably were set up wherever the need arose. No midden accumulations are found on the dry plains and uplands away from watercourses; though unoccupied by a resident population, this hinterland was extensively exploited by hunters and collectors of both food and raw materials. Abandoned villages retained their names and served as camp sites of temporary abodes for villages which had to move upon the death of village headmen."

This settlement pattern also is probably applicable to the Nisenan and Northern Valley Yokuts.

(3) The number of sites will increase when Forest Service data for the five other landform types is integrated into the data base.

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