Applying GIS to Archaeological Site Prediction on Camp Pendleton, Southern California

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Abstract

Recent archaeological investigations on Camp Pendleton have applied geographic information systems (GIS) to project design. This article presents the preliminary results of predictive modeling for Late Holocene adaptation in two distinct areas in relationship to hydrography, topography, vegetation, and resource exploitation. Site prediction using these variables was modeled to aid the Marine Corps Base in cultural resource management. The two models provided a sensitivity indicator for areas with potential cultural remains.

Modeling Inland and Coastal Areas for Site Potential

Archaeologists have used GIS fairly extensively for predictive modeling of site location and of landscapes (e.g., Allen et al. 1990; Maschner 1996). A predictive model for site location as constructed here is a statistical representation of particular environmental characteristics that may have been selected by prehistoric peoples for locating their camps and villages. The goal of the locational models constructed for Camp Pendleton is to determine the probability of locating archaeological sites in unsurveyed or inadequately surveyed areas. A sensitivity map produced by the model allows us to focus our efforts on areas with the highest potential for archaeological resources.

A theoretical limitation of locational modeling is its prejudice toward environmental determinism since cultural factors are not incorporated into the models (Leusen 1996). Cultural factors are not excluded intentionally, rather they are largely unknown or too difficult to model. Cultural factors including social, political, economic, religious, and ideological are critical elements to consider when modeling settlement patterns. However, their definition and the ability to map them is highly elusive. Therefore, to limit environmental deterministic critique, the locational model should focus on addressing environmental parameters that the prehistoric decision-makers chose for site location rather than determining what environmental variables influenced site location (Leusen 1996), the assumption being that social parameters are not as easily measurable as environmental factors. Thus, locational choice factors are based on our understanding of the settlement locational factors of the prehistoric population, and the aim is to increase our understanding of these factors as we construct the predictive model. We attempt to limit environmental determinism in our models by using ethnohistoric information to select the location choice factors. In southern California, we have a rich ethnohistoric record which is a rarity in most parts of the world. When available, such an ethnohistoric account is invaluable to archaeologists to aid in the interpretation and understanding of past ways of life and adaptations. Modeling past human adaptations using ethnohistoric information is an efficient way to understand prehistoric human behavior and cultural systems. However, it is imperative that direct analogies not be made between the ethnohistoric and prehistoric systems. Assumptions about prehistoric human adaptations, behavior, and socio-cultural systems can be made after discerning a "fit." Such modeling avoids the pitfalls of direct analogy and uniformatarianism. This is particularly appropriate for the Camp Pendleton area given that ethnohistoric accounts are primarily normative, generalized summaries of elderly informant accounts. They are not first-hand ethnographic observations with a diachronic perspective, nor do they discuss regional variation.

Camp Pendleton straddles the boundary between the ethnohistoric Native American Luiseño and Juaneño cultural groups (Kroeber 1925:636). Both of these groups are Shoshonean speaking populations that have inhabited what is now northern San Diego, southern Orange and southeastern Riverside counties through the ethnohistoric period into the twentieth century. They represent the descendants of local Late Prehistoric populations. We know from the ethnohistoric records that seasonality and scheduling of resource exploitation were critical elements of settlement patterns (Bean and Shipek 1978; Sparkman 1908; White 1963). Plant and animal resources used as human food were not available everywhere year round, instead they were available in specific seasons in particular areas within the general Camp Pendleton region. There was also considerable long-term planning of resource exploitation associated with, for example, the seasonal availability of acorns, yucca, grasses, and shellfish, in conjunction with small animal hunting. Some accounts indicate that coastal communities exploited local shellfish in the winter, and, during times of stress, the interior Luiseño traveled to the coast to obtain fish, shellfish, and even some land mammals. All accounts emphasize that populations were concentrated in the highlands for the acorn harvest during the months of October and November.

The settlement patterns and subsistence systems of the Luiseño and the Juaneño were tailored to exploit the seasonal fluctuations of resources. Their settlement pattern involved annual movements of populations from the mountains and highlands to valley floors and the coast. The duration and location of settlement camps was dependent on the availability of plant and animal resources. Given the general ethnohistory of the Luiseño and Juaneño, groups residing in the Camp Pendleton region could have utilized several ecological niches varying by altitude. During early and mid-summer, subsistence activities could have focused on staple seed-bearing plants. Grasses would have been available on the coastal terraces, large inland valleys, and open upland settings. Then settlements may have moved to the higher elevations with aggregation of families into larger groups for acorn harvests. Animal exploitation may have been most extensive during the months when plant resources were meager. Supplementary plant foods including yucca and cactus were also exploited as needed. Any coastal settlements could have supplemented these resources with shellfish and marine fish exploitation. The availability of these resources varied during the year, notably for fish, and from year to year for *Donax gouldii* (Beanclam).

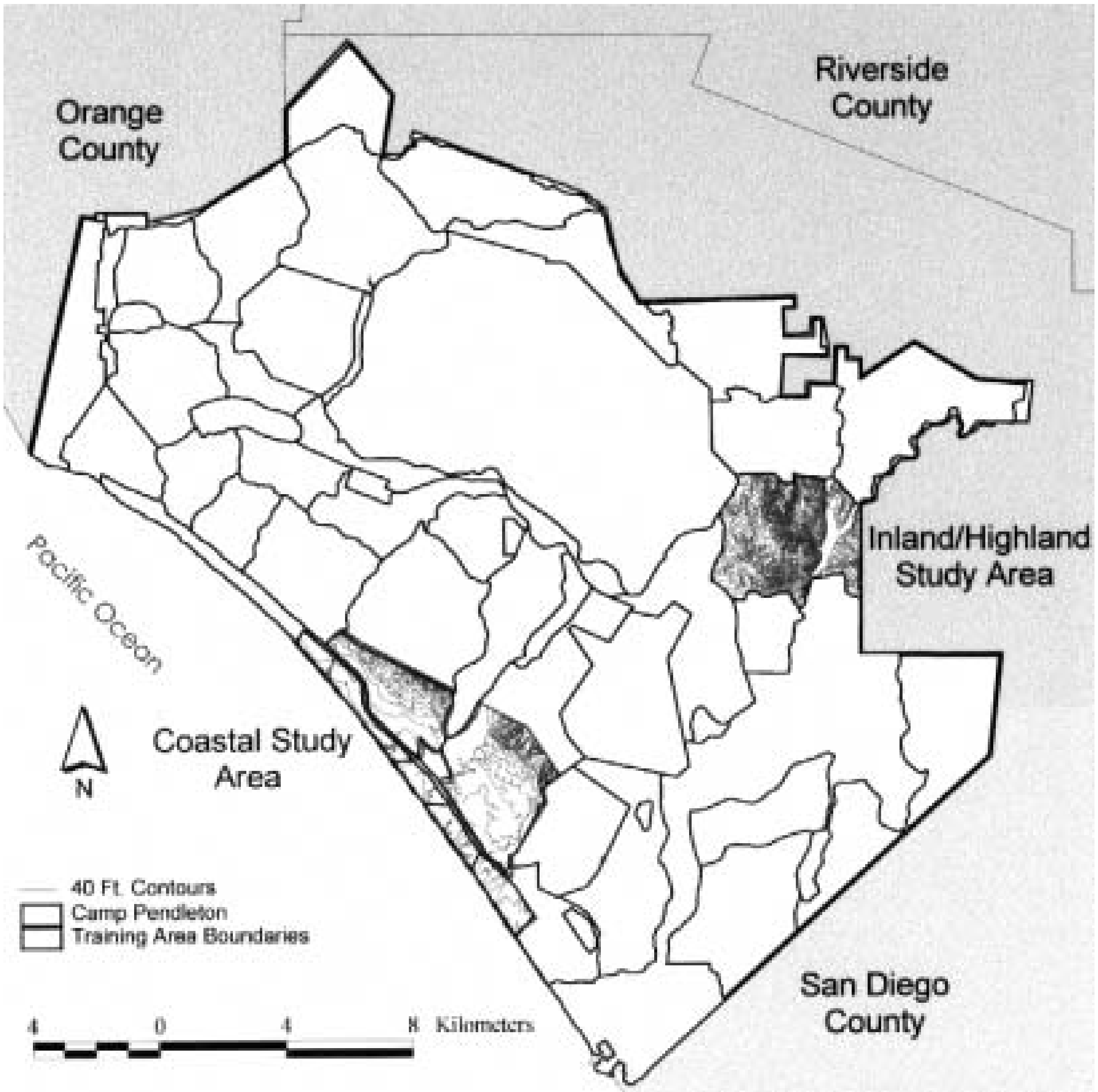

Fig. 1. Areas in Camp Pendleton for which predictive models have been constructed.

Constructing the Models

Based on the ethnohistoric context and information on settlement patterns and subsistence systems (Bean and Shipek 1978; White 1963), we constructed two different predictive models: one for the coast and one for the inland highlands (Fig. 1). The coastal model had two locational choice parameters: distance to fresh water and slope; while the inland model had three parameters: distance to fresh water, slope, and vegetation type. The location choice parameters included in the two models fulfill both environmental factors and cultural choices.

For the coastal model, an area along southwestern Camp Pendleton was considered which included the immediate coastline and the adjacent area up to two miles inland (see Fig. 1). The locational choice factors for this area include distance to fresh water and slope. Vegetation type was not used as a variable for the coastal model because it is relatively homogenous, comprised primarily of coastal sage and grasses. In ARC/INFO (a GIS software package) the topography coverage was clipped to the size of the study area, and the hydrology coverage was clipped to an area slightly larger than the study area. In ArcView, with the Spatial Analyst extension, slope was derived from the clipped topography coverage. A 100 m^2 grid cell size was used throughout the project. The slope grid was reclassified into three categories: 0 - 10 degrees was coded to 3, 10 - 30 degrees was coded to 2, and greater than 30 degrees was coded to 1. A score of 1 refers to areas that are unlikely to contain archaeological sites, a score of 2 a moderate chance, and 3 a high potential. Using the clipped hydrology coverage, a grid representing distance from fresh water was created. The grid was reclassified into three categories: 0 - 100 meters was coded to 3, 100 - 300 meters was coded to 2, and greater than 300 meters was coded to 1. The two reclassified or weighted grids were combined and divided by 2 to produce a site probability map ranked from 1 to 3; 3 representing the highest potential, 2 moderate potential, and 1 low potential. Increments of 100 meters were used to rank resource utilization because it was the most conservative measure of least distance within foraging range.

The inland/highland model was constructed for an area on Camp Pendleton which predominantly consists of moderate sloping hills with several drainage systems (see Fig. 1). The location choice parameters include distance to fresh water, slope, and vegetation communities with documented Native American use. The inland/highland model was constructed in the same manner as the coastal model, but vegetation was included. We made the assumption that the vegetation present today broadly represents the vegetation present in Late Holocene times (Anderson 1996). Within the study area, the following vegetation types are present: freshwater marsh, Engelmann oak, non-native grassland, southern coast live oak riparian, southern willow scrub, valley needle grass, willow riparian forest, various types of coastal sage scrub/ chaparral and Diegan coastal sage scrub. All vegetation classes except the coastal sage and chaparral classes are considered to be food sources for Native American populations. Based on this preface, the vegetation types were then categorized as non-food and food source. It was assumed that the non-native grasslands were populated with native grasses prior to European settlement. In ArcView, vegetation classes that are considered food sources were selected within the study area, and a grid calculating the distance from the selected classes was produced. The grid was reclassified into three categories: 0 - 100 meters was coded to 3, 100 - 300 meters was coded to 2, and greater than 300 meters was coded to 1. The three reclassified or weighted grids were combined and divided by 3 to produce a site probability map ranked from 1 to 3; 3 representing the highest potential, 2 moderate potential, and 1 low potential. In other words, areas with vegetation classes that are considered food sources were ranked as having the highest potential for cultural resources. Areas within 100-300 meters of

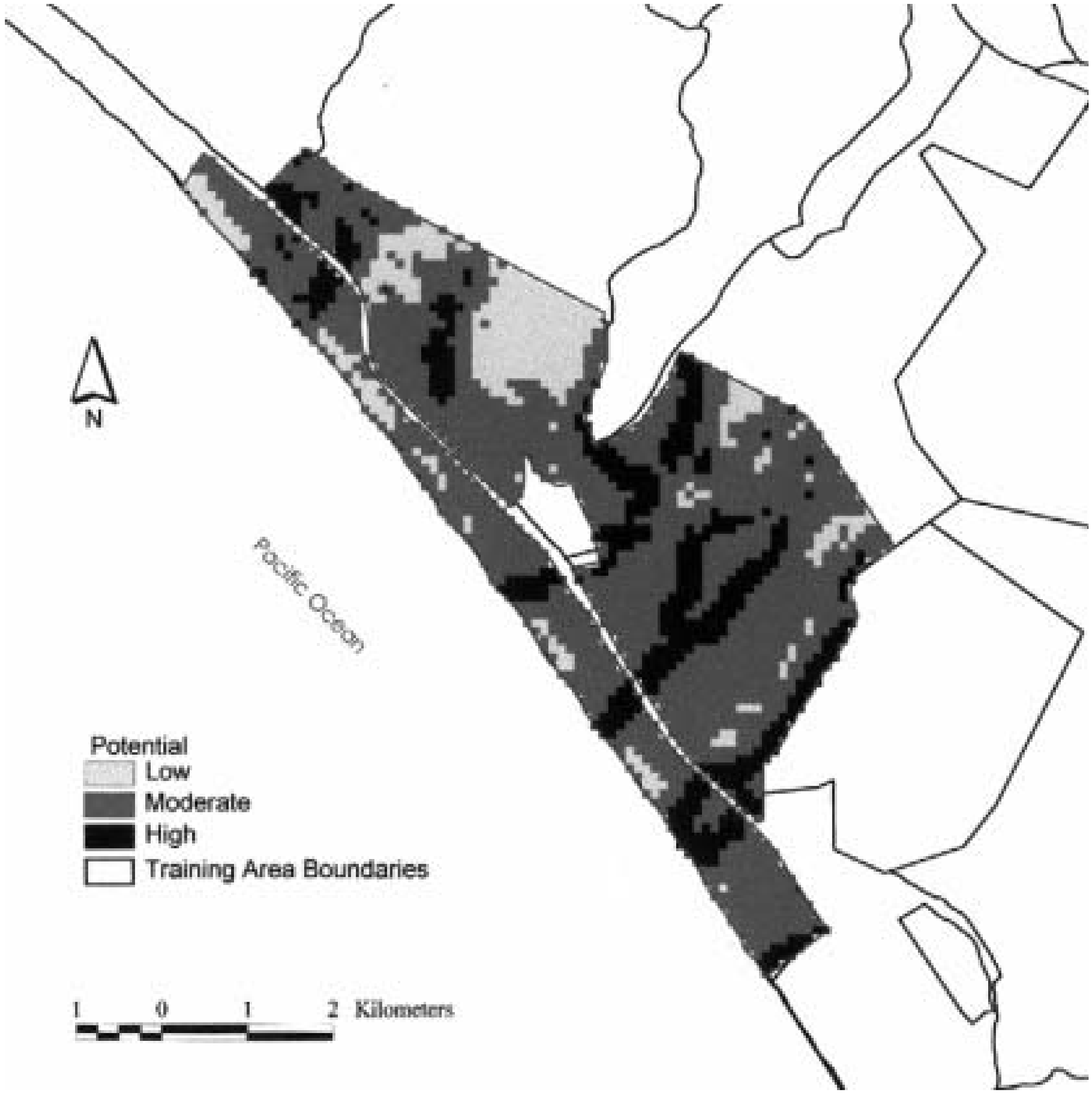

Figure 2. Coastal Model.

the vegetation classes considered to be food sources were ranked as having moderate potential, and areas greater than 300 meters were ranked as having low potential.

Application of the Model to Archaeological Data

Archaeological survey results from Reddy (1998a, 1998b) were used to test these models. In these surveys, an archaeological site was defined as three or more artifacts and ecofacts within a 25 meter square area. If artifact clusters were separated by more than 50 meters they were considered two distinct sites. If a site was located in two site potential categories areas, the

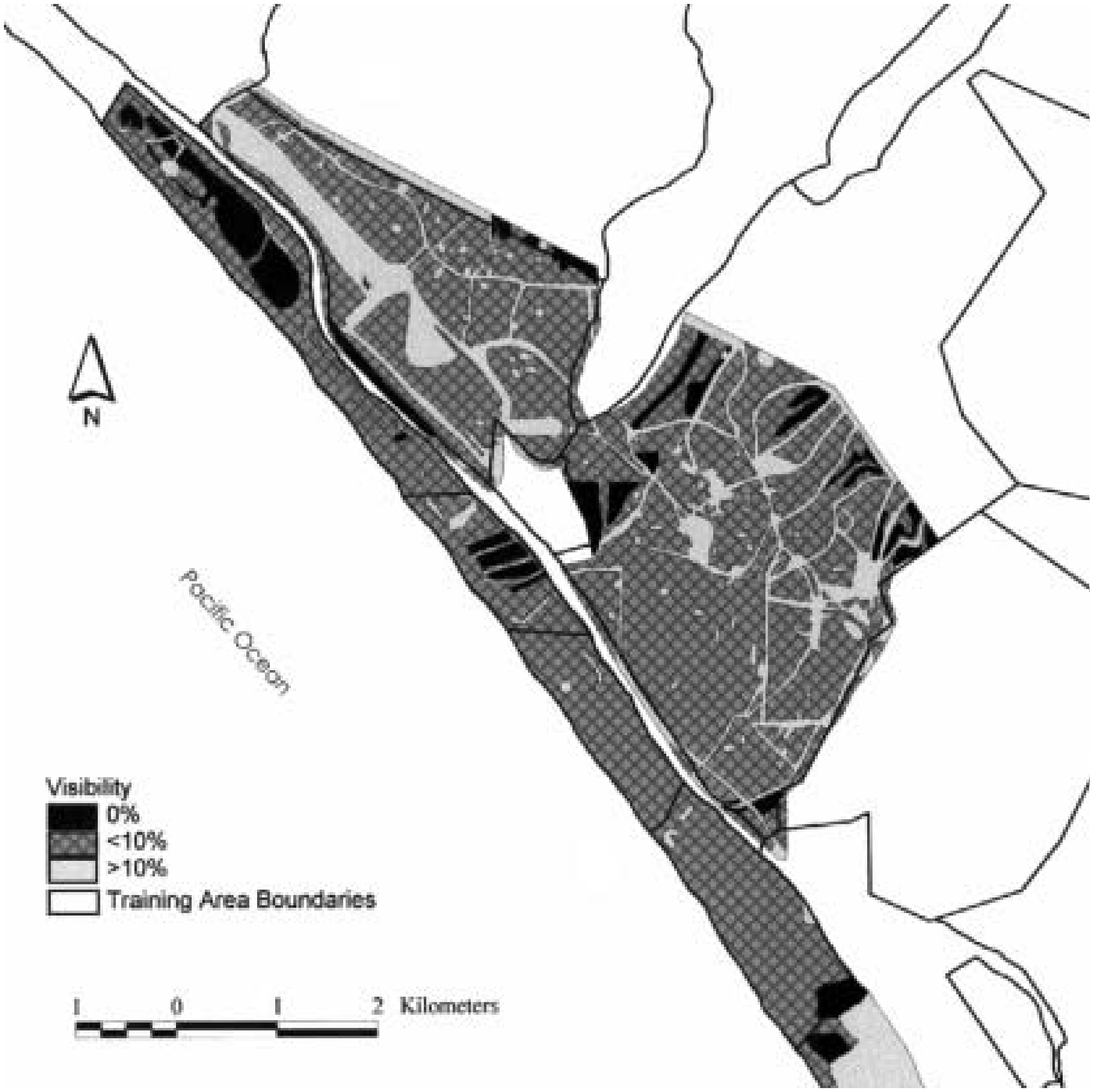

Fig. 3. Coastal Ground Cover Visibility.

site was assigned to the category containing the largest portion of the site. If a site was located equally into two categories, the site was assigned to the higher ranked category.

Coastal Model

For the coastal model (Fig. 2), the majority of the sites are located in the high and moderate area, specifically along the drainages of Las Flores Creek, Aliso Canyon, Horno Canyon and several unnamed ephemeral drainages. Additionally, all the largest sites and all the sites recommended for the *National Register of Historic Places* are located in the high potential areas.

Table 1. Summary of Coastal Model and Site Occurrences.

Potential	Area (m^2)	Per cent of total area	Number of Sites	Site Density (per 10,000 m^2)
Low	37000	14	1	0.27
Moderate	130600	40	18 *	1.38
High	121000	46	28 **	2.30

*includes two sites located through ground cover clearance
**includes seven sites located through ground cover clearance

A limiting factor during the pedestrian archaeological survey was poor ground visibility (Fig. 3). Ground visibility is a limiting ecological factor for archaeological survey along the coast of southern California since dense vegetation hinders detection of archaeological sites. After the pedestrian survey of the study area, it was decided that an enhanced survey was necessary to address the problem of limited ground visibility. Methods chosen to address the problem include shovel scrapes, shovel test pits, and raking. The predictive model was used in assessing the intensity of the ground cover clearance (GCC) program, the assumption being that the high and moderate potential areas need more intensive ground cover clearance methods as compared to the low potential areas. The results of the GCC program indicate that of the nine sites recorded through GCC, seven were in the high and only two were in the moderate.

Table 1 summarizes the archaeological sites within the coastal study area. Approximately 46 per cent of the coastal study area is comprised of areas of high potential for archaeological sites, 40 percent of moderate potential areas and only 14 per cent of low potential areas. The high and moderate potential areas account for 86 per cent of the study area, and these areas have 98 per cent of the archaeological sites, with the high potential areas containing 60 per cent of the sites. The low potential areas have only one archaeological site (2 per cent). Since the moderate and high potential areas both have comparable and adequately large areas in square meters, we consider it unlikely that survey area sample size plays any significant role in determining the site density. However, given that the low potential area is very small in size, it is possible that this small sample fraction is partially contributing to the dramatically low site density documented. Nonetheless, it is clear that the site density results demonstrate a close fit between the archaeological survey results and the expectations of the coastal site location model.

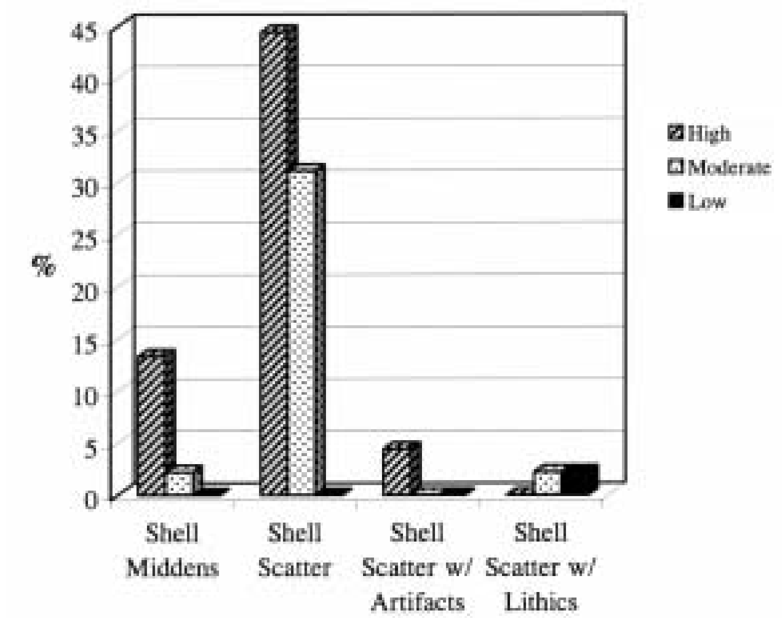

Fig. 4. Distribution of Coastal Site Types.

As assumed by the predictive model, there is a correlation between the locational choices made by prehistoric populations in this coastal area and distance to fresh water and slope. The distribution of site types between the three sensitivity areas indicates an interesting pattern (Fig. 4). Four main site types are identified including shell middens, shell scatters, shell scatter with artifacts, and shell scatters with lithics. Shell middens predominantly occur in the high potential areas, while the shell scatters are well distributed between the high and moderate potential areas. Shell scatters with lithics are divided between low and moderate potential sites, while shell scatters with artifacts were located only in high potential areas. Shell middens and artifact scatters represent possible residential sites, and their location in the high potential areas suggests that the socio-cultural choice for residential camps was primarily riverine flood plain adjacent to marine terraces. Low density scatters with shell and lithics are divided between low and moderate potential areas while scatters with a more diverse range of artifacts along with shell are located only in high potential areas. Low density scatters with shell and lithics are typically locales of minimal habitation and specialized activities. Their location in only the low and moderate potential areas is indicative of short term use of the landscape possibly related to exploitation of terrestrial and marine fauna. The implications of these spatial patterns along this coastal area are explored further by Byrd and Reddy (this issue). We also plan on investigating these intriguing relationships further to assess what additional locational choices are involved in determining distribution of site types between these two sensitivity areas.

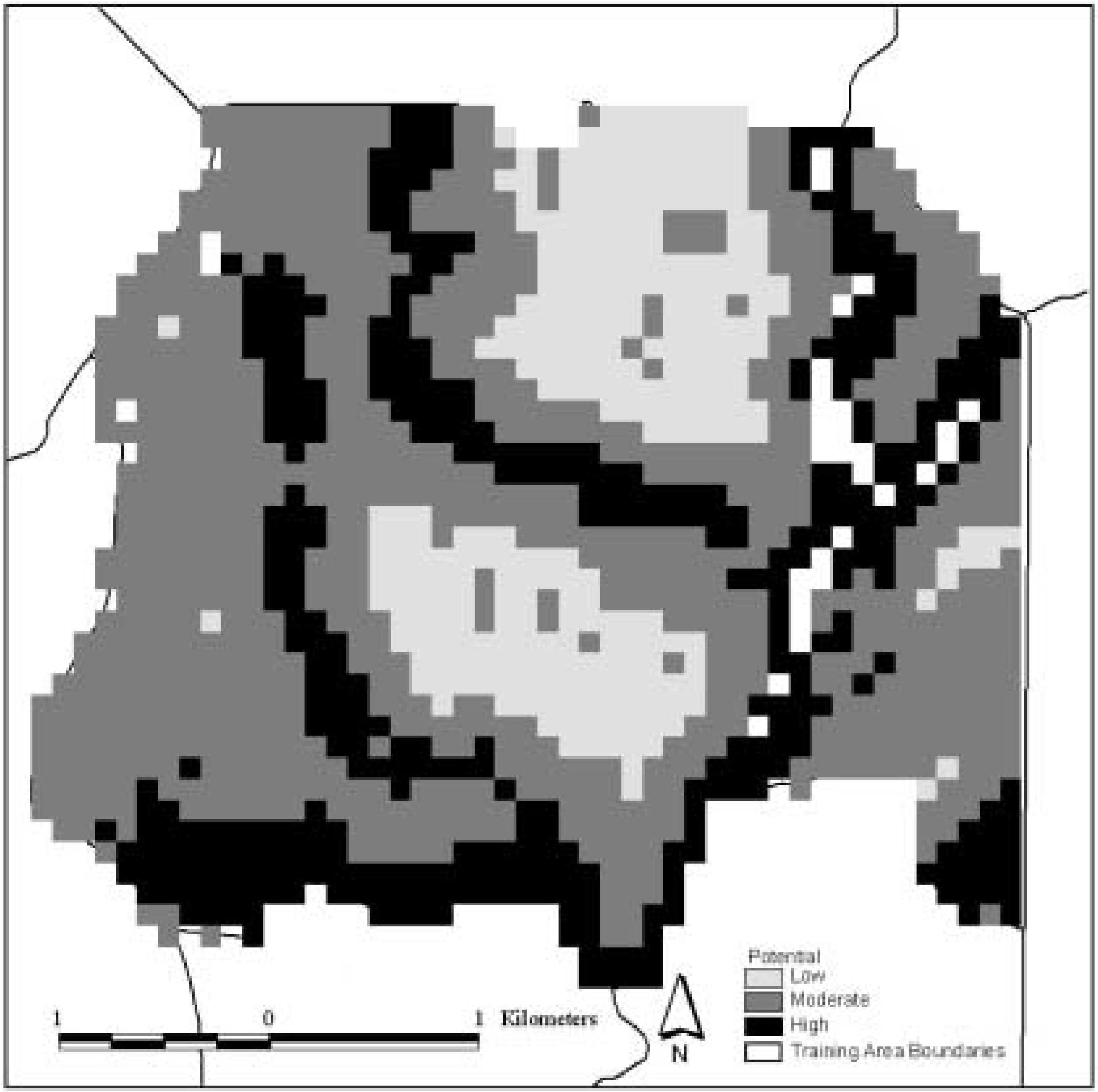

Fig. 5. Inland/Highland Model.

A summary of the archaeological sites is presented in Table 2. The high and moderate potential areas for archaeological sites account for 94 per cent of the area and all the archaeological sites. Almost 79 per cent of the sites are located in the high potential areas. There appears to be no distinction in site size between the high and moderate potential areas. There is an interesting pattern observed in the site types between the high and moderate sensitivity areas (Fig. 5). Of the total sites, the high potential areas have sites with milling features (36 per cent), lithic scatters (12 per cent), and artifact scatters (12 per cent). In contrast, the moderate potential areas have relatively few sites with milling (3 per cent) and rock ring sites (3 per

Table 2. Summary of Highland/Inland Model and Site occurrences.

Potential	Area (m^2)	Per cent of total area	Number of Sites	Site Density (per 10,000 m^2)
Low	8,700	6	0	0
Moderate	77,500	50	7	0.90
High	68,000	44	26	3.82

cent), while lithic scatters and artifact scatters account for 24 per cent and 9 per cent respectively.

Of the total sites, the two site types that dominate the high and moderate potential landscapes are milling sites and lithic scatters (see Fig. 6). The high potential areas are primarily dominated by milling sites, with lithic scatters and artifact scatters occurring less frequently. In contrast, the moderate potential areas have a very low occurrence of milling sites, but a higher percentage of lithic scatters, with artifact scatters and rock ring sites occurring infrequently. Therefore, we suggest that the two sensitivity areas present different aspects of settlement; the high potential areas are more attractive for milling activities, while the moderate potential areas were locales of lithic reduction and related tasks and general non-milling related activities. As expected for the model of this area, the correlation between vegetation, settlement density, and site type is very pronounced.

Since the archaeological survey was conducted only in the western portion of the area, the eastern portions can be surveyed based on the results from this area. The focus of survey coverage can be placed on the high and moderate, with minimal effort in the low potential areas. Although the inland/highland model needs to be tested more rigorously, we are particularly impressed by its higher predictability as compared to the coastal model. We plan on exploring this pattern further and particularly investigating whether there could be other locational choices on the coast that could increase the predictability of the model. For example, specific micro-environmental variables that may further increase the goodness of fit.

Conclusion

In conclusion, our preliminary models for the coast and the inland areas have used the basic tenors of human behavior in the form of locational choice factors of distance to water, slope

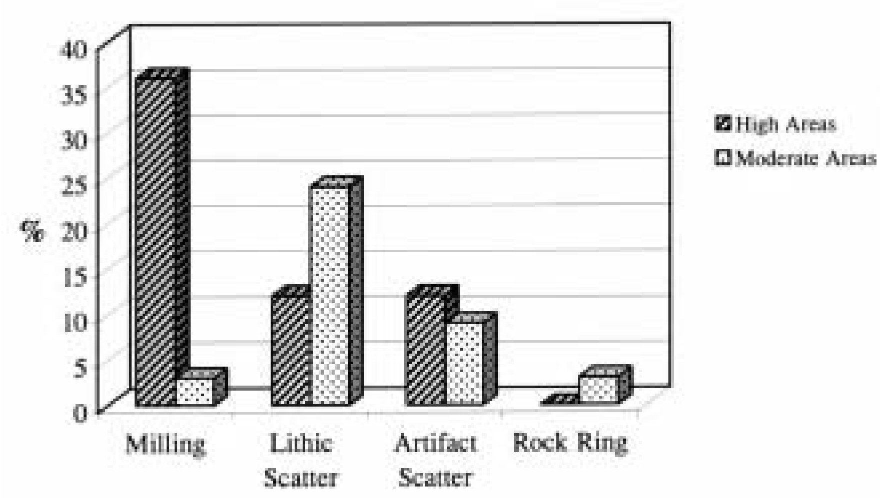

Fig. 6. Distribution of Inland Site Types.

and vegetation type in an attempt to understand the past landscape in two distinct areas on Camp Pendleton. Our study and application of GIS predictive locational modeling, although preliminary and still in the planning stage, has the potential for contributing significantly to understanding prehistoric settlement patterns and for the management of cultural resources within Camp Pendleton. Locational modeling has already been used on Camp Pendleton in assessing the intensity of survey coverage and ground cover clearance methods (Reddy 1998a). We maintain that the low potential areas should not be denoted as archaeologically unimportant within Camp Pendleton without archaeological survey. Instead, the locational modeling has been used primarily to assess the intensity of survey coverage and the survey spacing interval.

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