CHUMASH SOCIAL GEOGRAPHY:

A QUANTITATIVE ANALYSIS[1]

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ABSTRACT

Mission registers provide an important source of information about marriage patterns in aboriginal California. A total of 804 intervillage marriages were tabulated for the Santa Barbara region to reconstruct social networks existing during the early Colonial Period. Cluster analysis and regression were used to study Chumash social interaction by considering locational, demographic, environmental, and political variables. Intermarrying clusters of villages defined settlement groups that were linked together economically and politically. The social network patterns observed in ethnohistoric data will assist in interpreting archaeological evidence of intervillage economic exchange.

INTRODUCTION

Various researchers have offered hypotheses to explain how Chumash social networks were related to intercommunity economic interaction (e.g., C. King 1981a, 1981b; L. King 1982; Spanne 1975; Tainter 1971, 1975). To test such hypotheses, there has been a need for new sources of relevant data (cf. Glassow 1979). For the Chumash region, it is possible to gather ethnohistoric information regarding social networks by reconstructing marriage patterns during the early Colonial Period (Horne 1981; Johnson 1988a; C. King 1984). Mission registers are virtually the only sources for such information (Brown 1967; Johnson 1988b).

The Chumash are well known for their extensive involvement in an exchange system that linked together settlements in different resource areas. Particular villages specialized in procuring various raw materials, foodstuffs, and manufactured items that were traded with other villages (Arnold 1987; C. King 1976). Shell bead money served as the principal medium of exchange in this system (C. King 1978, 1981a, 1981b). Chester King has proposed that trading systems like those which arose among the Chumash were the result of neighboring groups adapted to resources with different seasonal patterns of differing degrees of reliability, and the greater these differences were, the greater the intensity of economic interaction would be (C. King 1976:289-290). Linda King suggested that marriages between coastal and inland Chumash villages served as the basis for alliances to increase access to trade goods (L. King 1982:135).

Chumash villages appear to have been federated together in groups or "provinces" under the limited authority of a paramount

chief (Harrington 1942:33; Hudson and Underhay 1978:27-31; Johnson 1988a:116-121, 291-292; L. King 1969:41; Landberg 1965:131-132). Villages that were allied politically supported each other in conflicts with villages in other federations (Johnson 1988a:121-127; L. King 1982:Chap. 7). A previous study of marriages in a small portion of Chumash territory indicated that far fewer marriages than expected occurred between a settlement cluster in the Goleta valley and the two large villages known as "Dos Pueblos," presumably because of warfare between these two population centers (Johnson, Warren, and Warren 1982:40-42).

Based on the preceding information, our expectations are that marriage patterns should reflect economic and political relations among village groups. Certainly too, there are more mundane geographic variables, such as locational propinquity and population density, that exert an influence on marriage mate selection. The following analyses attempt to determine which factors played an important role in influencing Chumash intervillage marriage patterns. The region under study includes villages along the Santa Barbara Channel mainland coast between Point Arguello and Rincon and the adjacent Santa Ynez Valley. The locations of these villages are shown in Figure 1, using Spanish spellings as commonly appear in mission documents.

CLUSTER ANALYSIS OF MARRIAGE PATTERNS

A total of 804 exogamous marriages were recorded among the forty Chumash villages in our study area (see Tables 1 - 3). The methods employed for collecting the marriage data have been described elsewhere (Johnson 1988a:Chap. 3). As we have proposed above, it is reasonable to suppose that villages which formed intermarrying groups would be more likely to be politically integrated into village federations. This assumption may be used to interpret a cluster analysis of the Chumash social network (see Figure 2).

The hierarchical clustering program used on the Chumash marriage matrix was UCLUS (MacEvoy and Freeman 1987:103-104), based on an algorithm developed by D'Andrade (1978). Intervillage marriages were treated as a "similarity" matrix where the number of marriages between villages served as an index of social closeness. Groups of villages that tended to intermarry among themselves were defined by their inclusion in hierarchical clusters. Village pairs sharing the greatest number of marriages were placed at node level 1. If pairwise comparisons indicated that each of the villages grouped at level 1 also shared a fairly large number of marriages with another village or pair of villages, then these were clustered at node level 2, and so forth.

At a higher level of inclusiveness, i.e., at node level 7, the cluster analysis of Chumash marriages produced groups that bore considerable resemblance to what we might expect regarding village federations that were unified politically and geographically (see Johnson 1988a:121-127). Non-spatial data thus provided information that could be translated into spatial patterns (see Figure 3). From marriage information alone, three

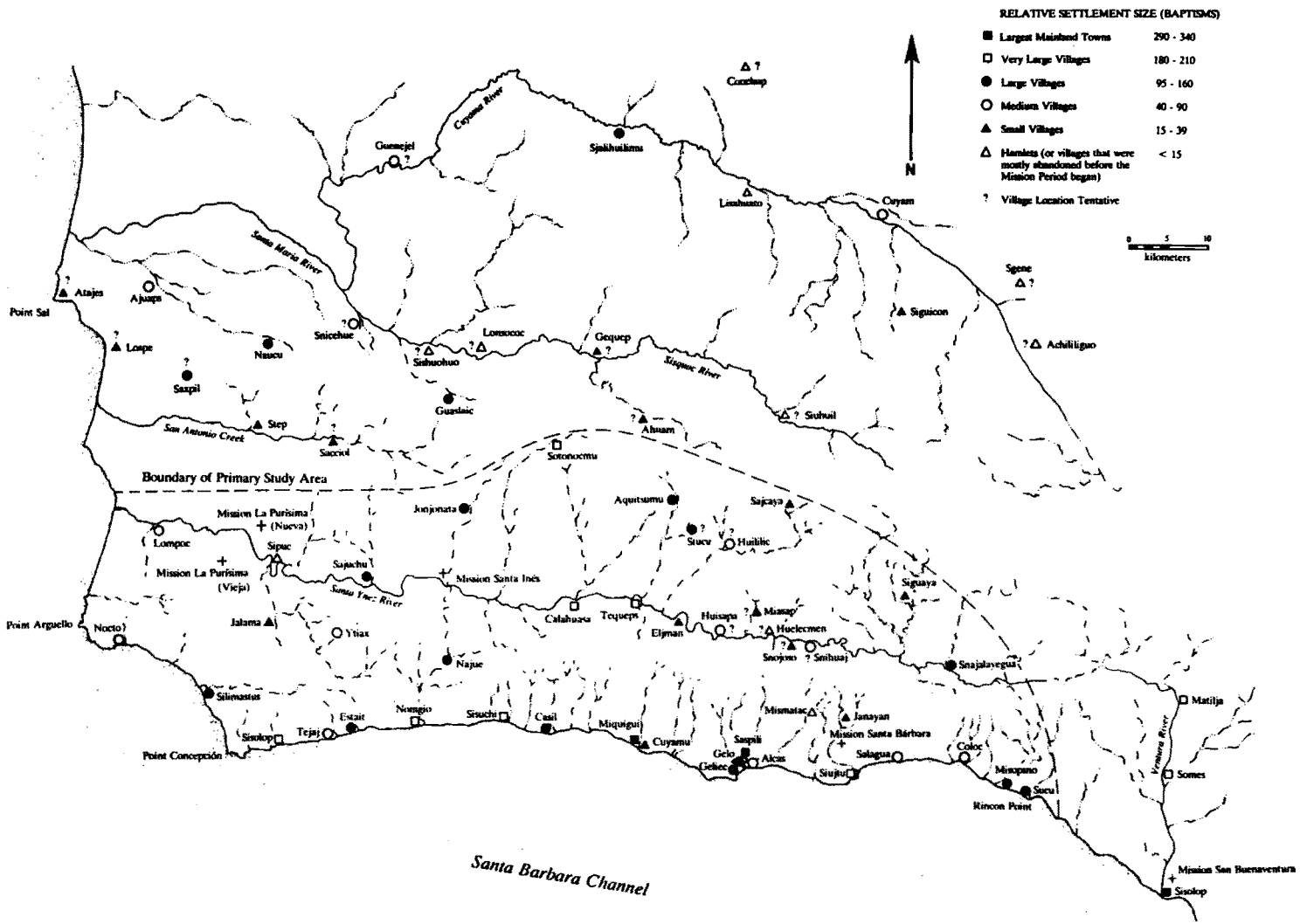

FIGURE 1. Chumash village locations

TABLE 1

MARRIAGES AMONG COASTAL VILLAGES[a]

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
1 Nocto																				
2 Silimastus	4																			
3 Sisolop	8	12																		
4 Tejaj	1	2	2																	
5 Estait	2	0	3	3																
6 Nomgio	1	1	5	4	8															
7 Sisuchi	0	0	5	1	5	5														
8 Casil	0	0	3	0	2	0	9													
9 Miquigui	0	1	2	0	3	3	8	4												
10 Cuyamu	0	0	1	0	0	0	1	2	4											
11 Geliec	0	0	0	0	0	0	0	0	1	0										
12 Gelo	0	0	0	0	0	0	0	0	5	1	5									
13 Saspili	0	0	0	0	1	0	1	0	4	0	3	8								
14 Alcas	0	0	0	0	0	0	1	0	1	0	4	6	4							
15 Janayan	0	0	0	0	0	0	0	1	1	0	4	0	1	0						
16 Slujtu	0	0	0	0	0	0	5	2	0	0	3	5	6	1	1					
17 Salagua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2				
18 Coloc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3			
19 Misopsno	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2	1		
20 Sucu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	7	
Totals	16	20	41	13	27	27	42	23	37	9	20	30	29	17	8	25	9	6	12	11

[a] The totals appearing at the bottom of the table represent a sum of row and column totals combined for each village.

TABLE 2

MARRIAGES AMONG INLAND VILLAGES[a]

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
21 Lompoc																					
22 Jalama	1																				
23 Sipuc	2	0																			
24 Sajuchu	3	1	1																		
25 Ytlax	4	1	1	5																	
26 Najue	0	1	1	4	0																
27 Jonjonata	0	0	0	3	0	3															
28 Sotonocmu	0	0	0	2	0	1	8														
29 Aquitsumu	0	0	0	0	0	0	0	8													
30 Calahuasa	0	0	0	1	0	2	6	1	3												
31 Tequeps	0	0	0	0	0	0	0	2	4	7											
32 Eljman	0	0	0	0	0	0	0	0	0	1	1										
33 Stucu	0	0	0	0	0	0	0	2	3	1	2	0									
34 Sajcaya	0	0	0	0	0	0	0	0	0	0	0	0	3								
35 Hullilic	0	0	0	0	0	0	0	0	0	1	3	0	3	2							
36 Hulsapa	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0						
37 Miasap	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1					
38 Snojoso	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
39 Snihuaj	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	2			
40 Snajalayegua	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	3		
41 Siguaya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	5	
Totals	10	4	5	20	11	12	20	24	21	25	20	3	15	5	11	5	4	4	10	12	9

[a] The totals appearing at the bottom of the table represent a sum of row and column totals combined for each village.

TABLE 3

MARRIAGES BETWEEN COASTAL AND INLAND VILLAGES[a]

Villages	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	*41*	*Totals*
1	3	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5
2	3	3	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
3	1	3	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6
4	1	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
5	2	0	0	1	1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8
6	0	0	0	1	2	4	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	10
7	0	0	0	2	0	0	2	0	0	2	4	0	0	0	0	0	0	0	0	0	0	10
8	0	0	0	0	0	0	0	0	0	9	1	1	0	0	0	0	0	0	0	0	0	11
9	0	0	0	0	0	0	0	0	1	1	6	3	0	0	0	0	0	2	0	1	0	14
10	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	3
11	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	5
12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	0	0	4
13	0	0	0	0	0	0	0	0	1	1	0	0	3	1	2	7	1	0	2	0	0	18
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	1	0	5
16	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	4
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	0	5
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	3
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Totals	10	7	0	7	7	11	3	0	2	18	15	4	5	1	2	12	1	4	8	14	1	132

[a] The numbers heading each row and column correspond to those designating villages in Tables 1 and 2.

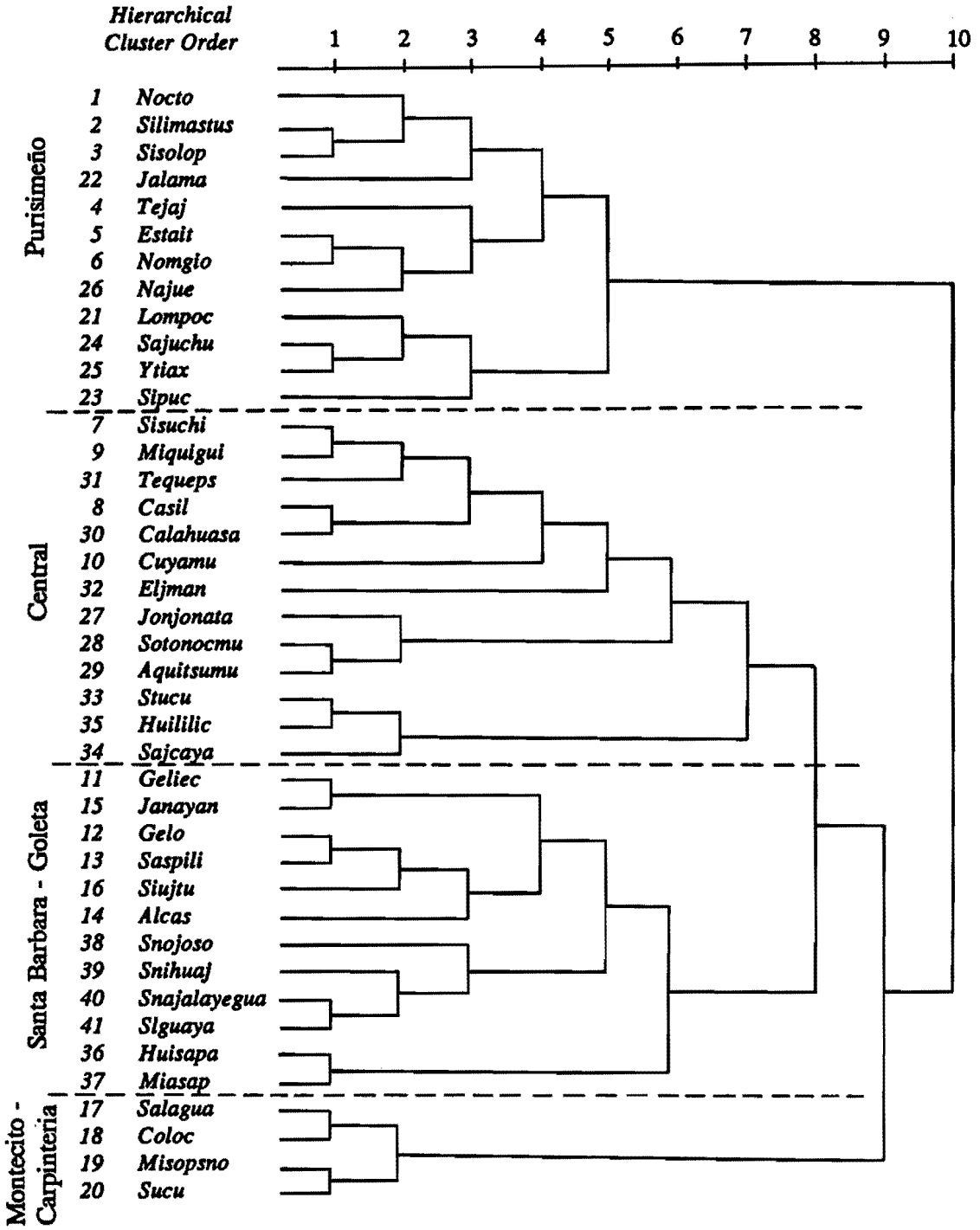

FIGURE 2. Cluster analysis of Chumash intervillage marriages.

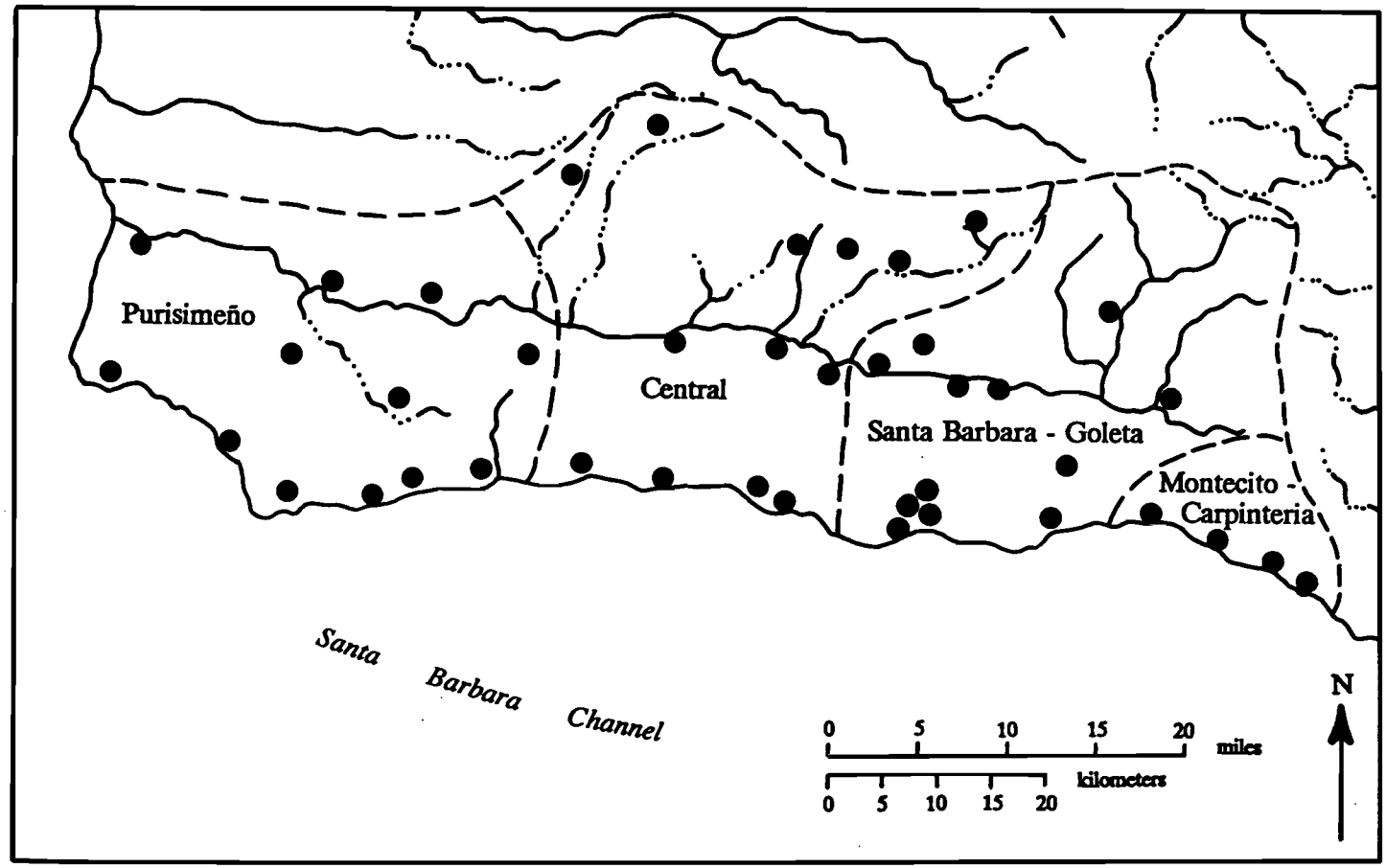

FIGURE 3. Groups of intermarrying villages based on cluster analysis

groups containing nearly an identical number of villages could be defined. These were a Purisimeño group, a Central group, and a Santa Barbara-Goleta group. A fourth, smaller cluster of four villages in the Montecito-Carpinteria Valley area may actually represent some degree of social integration into a larger group which lay mostly to the east and southeast of our study area. A number of marriages from these four villages occurred with people from the Ventureño area, especially from villages along the Ventura River.[2] The number of twelve to thirteen villages contained in each of the three largest groups agrees well with an early ethnohistoric statement indicating that thirteen rancherías were united under a particular Chumash chief (Bancroft 1886:377; Geiger 1965:14).

Our assumption to this point has been that villages which held intermarrying populations would also tend to be united politically because of kinship connections, but as I mentioned above, there are a number of variables which may influence marriage patterns. It is the purpose of the following analyses to explore some of the different factors that influence marriage mate selection in order to test the reality of our notions regarding Chumash political groups. Those variables that will be used to develop and test a model of Chumash social interaction include (1) geographic propinquity, (2) number of available marriage partners, (3) economic exchange, and (4) political alliances.

SOCIAL GRAVITY MODEL

In considering marriage patterns among Chumash villages, the effects of distance and population size will be considered initially. It has long been recognized that geographic propinquity is a strong determining factor in spousal selection (Davie and Reeves 1939; Marches and Turbeville 1953; Nelson 1975:5). It is also obvious that the number of available marriageable partners will constrain the number of marriages that occur. Recognition that geographic propinquity and the size of interacting groups are important influences on social interaction has led to the formulation of the social gravity model. Like Newton's Law of Gravity, the social gravity model in its simplest form proposes that the interaction between two communities is directly proportional to the product of their sizes and inversely proportional to some power of the distance separating them (Olsson 1965:43-45; Haynes and Fotherington 1984:11-12). The formula expressing this relationship may be written as:

$$I_{ij} = a\frac{P_i P_j}{D_{ij}^{b}}$$

in which I_{ij} is the interaction between centers i and j, P is the population of a center, D_{ij} is the intercenter distance, and a and b are constants. The a constant scales the overall equation to be proportional to the type of interaction being predicted. The b exponent to the distance variable measures the effect of friction of distance and is usually estimated through least squares regression. The size of the exponent indicates the importance of spatial separation on social interaction, e.g., the

larger the exponent, the fewer the marriages occurring within a particular distance range (MacKay 1958; Haynes and Fotherington 1984:12-16). A friction of distance value of 1 or less indicates that spatial separation is not too important, while a value of 2 or higher suggests a greater role for distance in limiting social interaction.

In order to compare the social gravity model to Chumash marriage patterns, several considerations were necessary. First, the anthropological literature on gravity model applications emphasizes that only the population segments involved in the interaction, not the entire village size, should be counted for the population variables (Johnson 1977:485; Kasakoff and Adams 1977; Crumley 1979:150). Ideally this would limit the investigation to just those marriageable partners belonging to different clans, assuming a rule of clan exogamy among the Chumash (see Johnson 1988a:Chap. 8). Unfortunately, clan information was not recorded at all for the Chumash baptized at the missions, so in my application of the gravity model to the Chumash, I only used the segment of population who married out of their own villages. The number of exogamous marriages for each village were summed from the marginal totals in Tables 1 - 3 to measure the interacting population variables. This allowed comparison to be made between the ideal pattern of marriages predicted by the gravity model and the actual distribution of marriages.

Another important consideration in applying the gravity model is the "plateau effect." Within a certain radius surrounding a community, distance seems to lose its effect on the frequency of interaction (Olsson 1965:52-53; Crumley 1979:150). To compensate for the "plateau effect," two modifications were made in the data set. The adjacent communities, Miguigui and Cuyamu, known as "Dos Pueblos," were considered as one. Second, all village pairs which were within 8 km from each other were deleted from consideration.[3]

A final adjustment to the data set also involved considerations of distance. Because linear regression was to be the means of analysis employed, it was desirable to reduce the number of cases where there were no instances of intermarriage because of the great distance separating villages. For villages located widely apart, there was a correspondingly low gravity model prediction for social interaction. These cases, then, were essentially "zero-zero" points on a scatter diagram, thereby tending unduly to strengthen the correlation coefficient in a positive direction by their inclusion in the data set (cf. Speth and Johnson 1976). An examination of the Chumash intermarriage data revealed that there were no cases where marriages occurred between villages which were situated more than 59 km apart. Thus, only village pairs with intercommunity distances less than 60 km were utilized in the regression analysis.

Linear regression was performed on the modified data set by comparing the number of marriages between each pair of villages

with the gravity model prediction for that same pair and calibrating the exponent of the distance variable to achieve the maximum coefficient of determination (r^2). The results of the analysis are presented in Table 4a. The friction of distance effect of 1.337 suggests that within the region as a whole spatial separation exerted only a moderate influence on intervillage marriage frequency. The coefficient of determination was fairly low, at about 0.43, indicating that geographic proximity and number of available marriage partners alone do not completely explain the observed marriage patterns.

EFFECTS OF ENVIRONMENTAL VARIABILITY ON MARRIAGE PATTERNS

Economic exchange was mentioned earlier as a factor which may have influenced marriage patterns. This hypothesis warrents further discussion before a variable related to economic exchange is introduced into the regression analysis. Several theories regarding Chumash social organization have incorporated economic variables as important determinants of certain aspects of Chumash social behavior. Landberg (1965:34) proposed that economic diversity within village federations was related to political solidarity. Blackburn (1976:242) noted that intervillage fiestas provided contexts where economic exchange and redistribution could occur. L. King suggested that Chumash marriages in the Santa Monica Mountains served to create alliances between coastal and inland people in order to gain access to important nonlocal economic resources (L. King 1982:135). C. King (1981a:325) argued that environmental diversity within Chumash territory led to the importance of the exchange system and the development of a secular economy, loosening the control of traditional leaders.

Insights provided in these previous studies of Chumash socioeconomic behavior may be used to develop a hypothesis of Chumash social geography that may be put to an empirical test using the mission register data on intervillage marriages. Given the importance of economic exchange among Chumash villages described in many ethnographic and ethnohistoric sources and confirmed by archaeological data (C. King 1976), it may be proposed that social interaction probably would correlate positively with evidence of economic activity. This would be true both because kin relationships among villages would function to facilitate economic transactions and because recurrent interaction for economic purposes would result in more frequent contacts with potential spouses, leading to more marriages between villages which were partners in economic exchange.

The proposed relationship between intervillage marriages and frequency of economic interaction may be tested by recourse to the model offered by C. King relating environmental variability to economic exchange (C. King 1976:289-290; see Introduction above). If we modify King's model to read "the greater the differences between the two resource areas, the greater the intensity of economic interaction and the greater the number of social bonds, including marriages," then test implications may be developed using the data set of intervillage marriages derived from mission register information.

TABLE 4

REGRESSION RESULTS FOR PREDICTING MARRIAGES FROM SOCIAL GRAVITY MODEL CALCULATIONS

a. All Village Pairs without Considering Interaction Effects

Variable	*Parameter Estimate*	*t Value*	*P > |t|*
Intercept	0.010	0.16	0.8725
Gravity Model	0.093	20.36	0.0001

$r^2 = 0.432404$

Number of Observations = 546

Friction of Distance Effect for Gravity Model = 1.337

b. Model with Environmental Differences Considered

Variable	*Parameter Estimate*	*t Value*	*P > |t|*
Intercept	0.138	1.65	0.0996
Environmental Type (*E*)	-0.352	-2.78	0.0057
Gravity Model (*G*)	0.087	17.30	0.0001
Interaction Effect (*E* X *G*)	0.338	2.66	0.0080

$R^2 = 0.441800$

Number of Observations = 546

The environmental differences between the Santa Barbara Channel coast, where the emphasis was on marine resource procurement, and the neighboring Santa Ynez Valley, where inland resources were the major focus of subsistence, provide the test case which fits the conditions of our model. Previous researchers have used this same study area, which encompasses two adjacent resource bases of differing seasonal patterns, to develop hypotheses regarding aspects of Chumash economic behavior (Tainter 1971; Spanne 1975; Glassow 1979). The innovation presented here is to use social interaction, reflected by intervillage marriages, as a correlate of recurrent economic exchange. Given the expectations of this model, it would be expected that marriages between coastal and inland villages would be favored over marriages between villages located in the same environmental zone.

Based on the discussion in the preceding paragraphs, our predictions regarding the influence of economic exchange on marriage patterns may be tested through the introduction of another variable in the regression analysis. The tendency for marriages to fortify economic interaction is included along with the social gravity model in a new regression equation:

$$M=a+b_1E+b_2G+b_3EG$$

where $\underline{M}$ = intervillage marriages, $\underline{E}$ = environmental type, $\underline{G}$ = gravity model predictions, and $\underline{a}$, $\underline{b}_1$, $\underline{b}_2$, and $\underline{b}_3$ are estimates of the parameters for the assumed linear relationship between marriages and gravity model predictions. The variable $\underline{E}$ is a "dummy variable," i.e., a dichotomous nominal variable with a value of either 0 or 1. The presence of an interenvironmental marriage is coded as a 1, and an intraenvironmental marriage is coded as a 0.

With marriages as the dependent variable and gravity model predictions as the independent variable, our specific expectation would be that the slope of the regression line for marriages between environmental zones (coast-valley cases) would be greater than for marriages between villages in the same environmental zone (intracoastal and intravalley cases). This in fact proves to be the case. From the statistics in Table 4b, the slope of the interenvironmental regression line may be calculated to be 0.121 while that for the intraenvironmental line is 0.087. There appears to have been a general tendency throughout the region under study for marriages to have occurred in greater frequency across ecological boundaries, that is between inland and coastal villages. The estimated slopes for the interenvironmental regression line and the intraenvironmental regression line (intracoastal and intravalley cases combined) are statistically significant at the 0.01 level of probability. The coefficient of multiple determination (R^2) is improved slightly to about 0.44 from the r^2 of 0.43 in the previous regression (Table 4).

EFFECTS OF POLITICAL ALLIANCES ON MARRIAGE PATTERNS

The cluster analysis presented in Figure 2 produced village groups which bore resemblance to expectations regarding political federations, based on ethnohistoric information. It is probably

obvious that marriage patterns would be influenced by political alliances. Intervillage feuding undoubtedly resulted in decreased opportunities for social interaction leading to marriage (unless women were forcefully abducted during raids). Whether marriages occurred across political boundaries or within a group of politically allied villages was another variable considered to be an important factor to be built into our model of Chumash social interaction.

In order to test the proposition that political boundaries influenced marriage patterns, the study area was divided into three subregions that cross-cut environmental zones. These three "political" subregions correspond closely to the divisions indicated by the cluster analysis diagramed in Figure 2, but were not determined solely by that source. The easternmost province, here called "Barbareño" for convenience, is the best documented as a group with some political cohesiveness (Johnson 1988a:117-121). It contained the villages in the Goleta Valley, the Santa Barbara area, the Carpinteria Valley, and most villages in the upper Santa Ynez watershed. The enmity shared by villages in this group towards Dos Pueblos and its allies has been documented elsewhere (Johnson 1988a:121-127).

The westernmost "political" province corresponds almost exactly with the Purisimeño dialect area. If linguistic distinctiveness mirrored sociopolitical unity, we might be justified in assuming a group cohesiveness that may have affected marriage patterns. It should be noted, however, that there exists no ethnohistoric evidence indicating a strong political boundary between this group and settlements to the east similar to that which existed between the Barbareño group and its neighbors to the west.

The remaining "political" province has been created by a process of elimination, that is, by grouping together those villages within the study area that did not fall into to either the Barbareño or Purisimeño provinces. This group is termed the "Central" province and consists of Dos Pueblos and the next two coastal villages to the west along with Ineseño communities in the central portion of the Santa Ynez Valley. The Central province was almost certainly not politically united in the same sense that the Barbareño group was, although there are some slight indications that alliances among adjacent political groups might have existed within this subregion.[4]

Regression analysis was conducted separately for each of the postulated "political" provinces, incorporating both the interaction effects of political group and environmental variables. For each province, four kinds of intervillage interaction were theoretically possible: (1) intragroup and interenvironmental, (2) intragroup and intraenvironmental, (3) intergroup and interenvironmental, (4) intergroup and intraenvironmental. If group boundaries were strong and correctly represented by the division of the study area into three provinces, then regression of marriages against the gravity model predictions should result in the largest ("steepest") slope for Case 1, intragroup and interenvironmental interaction,

TABLE 5

REGRESSION RESULTS CONSIDERING EFFECTS OF ENVIRONMENTAL AND POLITICAL DIFFERENCES

a. Barbareño Group

Variable	*Parameter Estimate*	*t Value*	*P > |t|*
Intercept	0.044	0.58	0.5628
Political Boundary (*B*)	-0.052	-0.46	0.6473
Environmental (*E*)	-0.072	-0.66	0.5074
Gravity Model (*G*)	0.216	8.00	0.0001
B X *G*	0.370	5.89	0.0001
E X *G*	0.179	1.93	0.0549

r^2 = 0.305334 (without interaction effects considered)
R^2 = 0.428705 (with interaction effects considered)

Number of observations = 323

Friction of distance effect for gravity model = 1.898

b. Purisimeño Group

Variable	*Parameter Estimate*	*t Value*	*P > |t|*
Intercept	0.024	0.19	0.8532
Political Boundary (*B*)	0.804	3.86	0.0002
Envronmental[a] (*E*)	-0.693	-3.57	0.0004
Gravity Model (*G*)	0.059	7.59	0.0001
B X *G*	0.009	0.73	0.4678
E X *G*	0.049	3.41	0.0008

r^2 = 0.435753 (without interaction effects considered)
R^2 = 0.557162 (with interaction effects considered)

Number of observations = 209

Friction of distance effect for gravity model = 1.266

[a] For the Purisimeño group, marriages from *Nocto* and *Silimastus*, located north of Pt. Concepción, to coastal villages south of the point were considered interenvironmental cases.

TABLE 5 (continued)

c. Central Group

Variable	*Parameter Estimate*	*t Value*	*P > |t|*
Intercept	0.083	0.79	0.4276
Political Boundary (*B*)	1.192	1.05	0.2953
Environmental (*E*)	-0.342	-2.29	0.0225
Gravity Model (*G*)	0.040	9.28	0.0001
B X *G*	0.031	4.70	0.0001
E X *G*	0.009	1.00	0.3202

r^2 = 0.475810 (without interaction effects considered)
R^2 = 0.549327 (with interaction effects considered)

Number of observations = 330

Friction of distance effect for gravity model = 1.186

TABLE 6

COMPARISON OF SLOPES OF REGRESSION LINES, ILLUSTRATING THE EFFECTS OF POLITICAL AND ENVIRONMENTAL DIFFERENCES ON MARRIAGES

	Gravity Model Coefficient (Slope)		
Type of Interaction	*Barbareño Subregion*	*Purisimeño Subregion*	*Central Subregion*
(1) Intragroup / interenvironmental ($B = 1, E = 1$)	0.765	0.107	0.080
(2) Intragroup / intraenvironmental ($B = 1, E = 0$)	0.586	0.068	0.071
(3) Intergroup / interenvironmental ($B = 0, E = 1$)	0.395	0.108	0.049
(4) Intergroup / intraenvironmental ($B = 0, E = 0$)	0.216	0.059	0.040

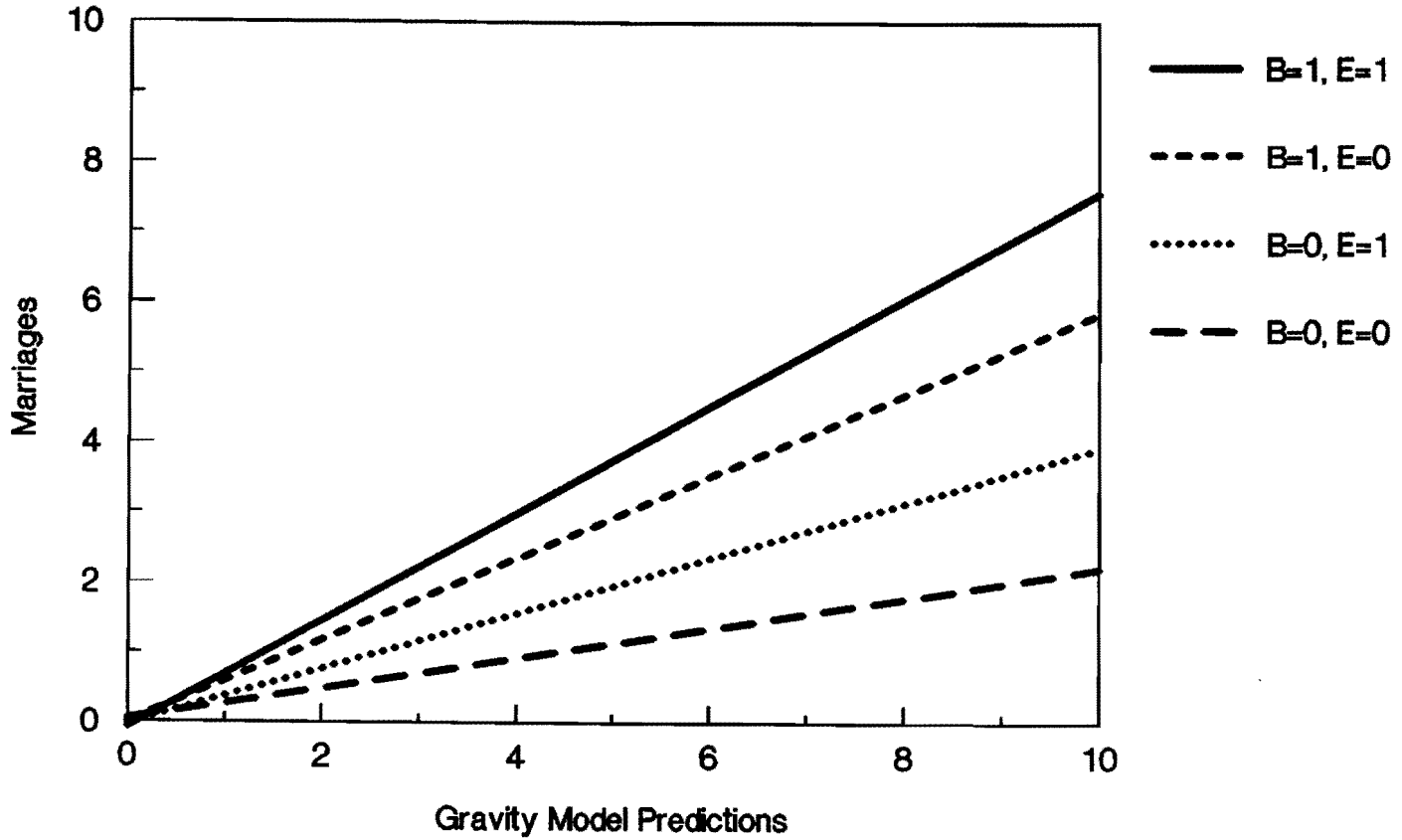

FIGURE 4. Regression analysis of Barbareño intervillage marriage patterns. The slopes of the regression lines appear in their predicted order based on similarities and differences between political (B) and environmental (E) variables.

followed by Case 2, then by Case 3, and then by Case 4. If the political boundaries were not correctly estimated or if such boundaries did not exist, then little deviation would be found from the previous regression analysis showing the effects of interenvironmental vs. intraenvironmental interaction.

The regression equation for the new model, incorporating both environmental and political effects on marriages, is:

$$M=a+b_1B+b_2E+b_3G+b_4BG+b_5EG.$$

The effect of political boundaries was added to the model in the form of the dummy variable B. For an intragroup marriage, B was 1, and for an intergroup marriage, B was 0. Tables 5 and 6 present the results of the regression analyses for each hypothetical political province. I also calculated the r^2 separately for each province without considering the effects of the environmental and political boundary variables. This allowed a comparison to be made to examine the improvement in the coefficient of multiple determination by adding political and environmental variables to the model. As before, I calibrated the friction of distance effect for the social gravity model to achieve the maximum r^2 in the regressions for each group.

The strongest case for a validation of the hypothesized effect of the political and environmental variables is represented by the Barbareño group. The estimated slopes of the four regression lines appear in their predicted order and are statistically significant (Table 5a and Figure 4). The coefficient of multiple determination (R^2) of approximately 0.43 is somewhat weak, but is a good improvement over 0.31, which was the r^2 for the Barbareño group marriages compared to gravity model predictions without the effects of environmental or political variables considered. For the Barbareño case, the hypotheses regarding the influence of group boundaries and of economic interaction among villages with different resource bases are confirmed.

For the Purisimeño province, the hypothesis regarding the influence of political group boundaries is definitely not born out. Based on the information presented in Table 6, the major distinction in the slopes of the regression lines appears to be between interenvironmental and intraenvironmental interaction, regardless of supposed political affiliations. Also, the coefficient (b_4) associated with the interaction between the political variable and the gravity model (B X G) is not statistically significant (Table 5b). However, the R^2 of about 0.56 is substantially larger than 0.44 for the model without the effects of the environmental and political variables considered. I conclude that there either was not an important political boundary between the Purisimeño "province" and settlements in the Central "province" or that boundaries existed in locations which did not correspond to purported linguistic divisions.[5]

For the Central province, the results are inconclusive. The slopes of the four regression lines appear in their predicted

order (Table 6), but the coefficient (b_5) associated with the environmental variable interacting with the gravity model (E X G) is not statistically significant (Table 5c). The analysis of Central group marriages includes social interaction data with both the Barbareño and Purisimeño groups. The strong boundary between Dos Pueblos and the Barbareño group is undoubtedly a factor in producing the differences in slope between intragroup and intergroup regression lines in Table 6. The hypothetical boundary between the Purisimeño and the Central "provinces" has already been shown to have had no effect on marriage patterns between the two areas. Regression of marriages against gravity model predictions for villages in the Central group resulted in an r^2 of approximately 0.48. This was improved to about 0.55 when the interaction effects of the environmental and political variables were included in the analysis.

The impact of spatial separation on social interaction within each subregion may be assessed by comparing the calculated friction effects of distance. The estimated exponent for the distance variable in the social gravity model was 1.898 for the Barbareño, 1.266 for the Purisimeño, and 1.186 for the Central subregion. The greater effect of distance within the Barbareño province may result from the rugged character of the mountains in the upper Santa Ynez watershed behind Santa Barbara. It may also be that the effect of distance on Barbareño marriages has been unduly magnified because of the imperfect nature of our sample. The absence of an early padrón (census) for Mission Santa Bárbara resulted in fewer reconstructed marriages for villages in the surrounding territory (Johnson 1988b:26).

CONCLUSION

Despite the failure to substantiate village federation boundaries between the Purisimeño and Central subregions of the study area, regression analysis of marriage patterns has resulted in support for two hypotheses regarding Chumash social interaction. First, in all three subregions, the tendency was confirmed for marriages to occur with greater frequency across ecological boundaries. It has been postulated that this pattern was related to the importance of economic exchange between villages located in resource areas possessing different patterns of seasonality and/or reliability. Second, a strong political boundary between Dos Pueblos and the Goleta/Santa Barbara group was demonstrated to have a pronounced effect on intermarriage. It is also significant that this boundary crosscut environmental zones, lending some support to Landberg's notion that environmental diversity may have played an important role in extending the boundaries of village federations.

This paper has used several quantitative techniques as a means of studying geographic patterns in intervillage marriages. Cluster analysis (D'Andrade 1978), the social gravity model (Haynes and Fotheringtон 1984), and regression analysis (Achen 1982; Schroeder, Sjoquist, and Stephan 1986) provided the methods needed to test ideas about Chumash social interaction. Statistical tests like those offered here are necessary in order to gain confidence in our theories about cultural behavior in California Indian societies. It is to be hoped that the

beginning attempted here will stimulate further development of quantitative techniques for deriving information about social networks. Archaeological studies will benefit from a better understanding of interaction spheres reconstructed from ethnohistoric evidence. For example, archaeologically observed patterns of exchange among Historic Chumash villages may henceforth be studied with recourse to empirical information about intercommunity social relationships.

NOTES

1. This paper is slightly revised from part of Chapter 9 in the author's doctoral dissertation (Johnson 1988a:248-271).

2. Sucu had fourteen marriages to Ventureño villages, Misopsno had eight, Coloc had two, and Salagua had three. These marriages to Ventureño villages notwithstanding, other ethnohistoric data suggest that the Montecito-Carpinteria villages may have been under the authority of the paramount chief of Siujtu at Santa Barbara (Johnson 1986:25).

3. Eight kilometers was the maximum distance used to estimate the "plateau effect" radius in many previous gravity model studies (Plog 1976:258-259). Also, a preliminary analysis of a sample of coastal Chumash marriages indicated that deleting village pairs located about 8 km from each other significantly improved the correlation between marriages and gravity model predictions (Johnson 1980).

4. These indications include Alexander Taylor's mid-nineteenth century comment regarding the former existence of a "Council Grove" of seven rancherías in the Santa Ynez Valley (L. King 1982:166) and political alliances indicated by patterns of kinship connectedness between chiefly families of Dos Pueblos and Casil and villages in the Santa Ynez Valley (Englehardt 1932:7; Johnson 1988a:285-286).

5. Glassow (personal communication) suggests that the significant economic role of the Purisimeño as suppliers of chert implements may have served to stimulate marriage connections across linguistic boundaries, thereby resulting in no apparent political divisions.

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