ARTICLES

CENTRAL-PLACE ANALYSES IN THE LA ENTRADA REGION, HONDURAS: IMPLICATIONS FOR UNDERSTANDING THE CLASSIC MAYA POLITICAL AND ECONOMIC SYSTEMS

Takeshi Inomata and Kazuo Aoyama

Analyses of archaeological data from the La Entrada region in northwestern Honduras demonstrate that central-place theory applies to the regional settlement system during the Late Classic period. The configuration of the regional central-place system appears to have been oriented to the local exchange of subsistence goods and to the minimization of energy expenditure in their movement. The distribution patterns of obsidian artifacts vary significantly among the hypothetical sustaining areas of centers, corroborating the reconstruction of a central-place system. This also suggests that political factors affected the circulation of certain materials and that basic economic spatial units in Classic Maya society were relatively small.

Los análisis de datos arqueológicos de la región de La Entrada, departamentos de Copán y Santa Bárbara, Honduras, demuestran que la teoría de las localidades centrales se aplica al sistema regional de asentamientos durante el periodo Clásico Tardío. El Proyecto Arqueológico La Entrada llevó a cabo el reconocimiento completo de un área de 150 km², el levantamiento y mapeo de casi todos los sitios con estructuras visibles, y excavaciones de sondeo en 37 sitios, lo cual presenta una base de datos adecuada para dichos análisis. La configuración del sistema de lugares centrales sugiere la tendencia a reducir el gasto de energía invertida en el movimiento de gente y el transporte de material. Se asume que los alimentos formaban una parte importante de las finanzas de las entidades políticas mayas. Puesto que los mayas no tenían animales de carga ni vehículos con ruedas, es probable que la ineficiencia del transporte de materiales voluminosos y pesados regulaba la distribución de los centros. Es importante notar que un sistema de lugares centrales, el cual es orientado al intercambio local, se presentó en la frontera entre diferentes áreas culturales. Esto enfatiza la importancia del intercambio local en la sociedad maya durante el periodo Clásico. Además, los patrones de distribuciones de artefactos de obsidiana son distintos entre los teritorios hipotéticos de los centros, lo cual indica que factores políticos afectaban las circulaciones de ciertos materiales y que las unidades espaciales básicas de la economía maya fueron relativamente pequeñas.

The application of central-place theory, particularly Marcus's model on Classic Maya political organization, had a significant impact on Maya archaeology (Flannery 1972; Hammond 1974:315; Marcus 1973, 1976). Marcus (1973, 1976) analyzed the distribution of emblem glyphs and proposed hierarchical political relations between Maya centers by applying central-place theory. This model, however, invited substantial criticisms, and the influence of central-place theory also appears to be diminishing (see Crumley 1995). Criticisms to Marcus's model are concerned mainly with two points: recent hieroglyphic decipherment and the rationale of central-place theory.

Advances in epigraphic studies have revealed the meaning of emblem glyphs as well as contexts in which they are mentioned (Mathews 1991). Some epigraphers argue that complex dynastic histories reconstructed through these achievements do not accord well with Marcus's hypothesis (Culbert, ed. 1991; Houston 1993). Other scholars contend that central-place theory is strictly based on market-economy principles and that Marcus's application of it to the interpretation of political organization is invalid (e.g., Smith 1974).

Although such specific criticisms of Marcus's model appear to be valid, we believe that more strict central-place analyses in the Maya area still would be productive. Building both on prior works (Flannery 1972; Hammond 1974; Marcus 1973, 1976, 1993) and on the criticisms of them, we demonstrate the applicability of central-place

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theory and discuss its theoretical implications. For this purpose, settlement data from the La Entrada region in northwestern Honduras is used as a test case.

Central-Place Theory and Its Application

Central-place theory, originally developed by geographers Christaller (1966) and Lösch (1954), proposes that a regular hexagonal distribution of hierarchically ordered central places is optimal for minimizing the cost of travel and transport and for maximizing economic profits. In other words, the original theory was developed for market economies, and deals with the interaction between central places and the local population.

Reevaluation of Its Theoretical Basis

Further considerations are required when we apply the theory to archaeological contexts where we are not certain whether the market-economy principle was prevailing. In this regard, Smith (1974:171) states that the theory predicts only the distribution of retail-market centers (in contrast to wholesale markets or administrative centers) and that some archaeologists who have attempted to predict or explain settlement distributions by using central-place theory without data on market functions (e.g., Flannery 1972; Johnson 1972; Marcus 1973) are going far beyond the limitations of the theory.

We believe, however, that the essence of central-place theory can be legitimately condensed to the theoretical spatial pattern that minimizes the cost of travel and transport. With regard to this problem, Johnson (1975:288) has suggested that central-place theory may be applicable to a wide range of contexts, as locational decisions for nodes of human activities are made in general to minimize energy expended in movement. In other words, even in situations where the economic theories of market exchange do not apply, the economics of transportation or movement exists, i.e., the cost or energy expenditure for transportation or movement correlates with the distance traveled and the amount transported. Any society tends to minimize this cost or energy expenditure to some extent (Steponaitis 1978:428–430).

Hence, we contend that the essential proposition of central-place theory holds in archaeological contexts. The purpose of central-place analyses in archaeology is not to predict the location of unknown centers or to simply describe the pattern of settlement distribution but to assess the underlying factors that affected the distribution of centers by comparing archaeological settlement data and the theoretical pattern predicted by central-place theory (see Evans and Gould 1982; Smith 1979, 1980). In other words, if an archaeologically observed distribution of centers closely accords with the theoretical pattern, it is probable that cost minimization in the interaction between centers and the local population was an important factor affecting the distribution of centers. If not, we need to consider other factors—e.g., locational advantages for interregional exchange and ideological reasons such as geomancy—critical for the configuration of spatial patterns.

Limitations of the Theory

At the same time, the evaluation of the theoretical basis clarifies the limitations of the theory. First, central-place analyses are more effective at regional levels than at interregional levels, because the theory deals with the interaction between central places and the local population (see Crumley 1979:152). Also, its applicability to the entire Maya Lowlands is difficult to evaluate, for the quality of data on settlement patterns differs widely from one region to another.

Second, the theory was originally developed as an economic model and is not adequate for studies of high-level political organization such as interdynastic relations. As described below, central-place theory does incorporate the interaction between political and economic factors, yet we need to distinguish high-level from low-level political organizations. In the case of the Classic Maya, high-level political organization refers to the interactions between different dynasties recorded in hieroglyphic texts, while low-level political organization encompasses the interaction between political authorities and the local population, which operated at regional levels. High-level organization may have been detached from economic factors, whereas low-level organization was strongly related to economic activities through the collection of tribute and the mobiliza-

tion of labor. It is this low-level organization that central-place theory addresses.

To recapitulate, the application of central-place theory to ancient Maya society may be more effective as a regional-level analysis, and it should focus specifically on the political and economic interaction between centers and the local population. Marcus (1976:25) indeed presented two separate levels of analysis of Maya centers. According to her scheme, the higher-level pattern comprises the entire southern Maya Lowlands resulting from a cosmological view, whereas lower-level patterns refer to smaller spatial units and were affected by economic factors. Although her application of central-place theory to the higher-level pattern invited criticism, her original insight is still valid with regard to the lower level.

Analytical Procedures

In central-place analyses, the hierarchy of central places is established on the basis of the size of centers. Subsequently, the distribution of central places of distinct hierarchical levels is compared to theoretically predicted patterns, and underlying factors are deduced.

The first and critical step is to measure the size of central places. In the original central-place theory, the size of central places refers to functional size, i.e., the amount of functions performed by central places. It is practically impossible, however, to measure each function possessed by Maya centers archaeologically. Thus, archaeologists have proposed various other methods for rank-ordering Maya centers. These include the distribution of emblem glyphs (Marcus 1976), courtyard counts (Adams 1981, 1983), types of architectural complexes such as pyramids and ball courts (de Montmollin 1989), and the combination of various elements such as architectural and cultural traits (Turner et al. 1981).

We need to examine carefully what these measurements represent and whether they are adequate for the purposes of central-place analyses. As mentioned above, the distribution of emblem glyphs in a large area represents high-level political organization, which is beyond the analytical reach of central-place theory. Types of architectural complexes are dependent on cultural traditions and do not provide adequate measurements in such a case as the La Entrada region, where more than one cultural sphere is represented (see below). The combination of various elements is useful as an all-purpose measurement (de Montmollin 1988:158) but is not specific enough for our purposes. Courtyard counts approximate the population and may serve as a better measurement than those mentioned above.

We believe, however, that the most appropriate measure for our purpose is the architectural volume of a center's main group. Architectural mass is affected by various factors, such as culture and the availability of construction material. Yet, it is a relatively stable indicator of the economic and political power of the central authority to collect tribute and to organize labor (de Montmollin 1989:103–104), because the mass of buildings directly reflects the amount of labor investment (Abrams 1989; Price 1978:165). Thus, the architectural mass of main groups provides adequate measurements for the analyses of the interaction between centers and the local population.

Although we exclude glyphic information and other cultural elements from the measurement of the size of centers, our intention is by no means to disregard these data. Instead, we later compare the distribution of these elements with the central-place system reconstructed through the measurement of architectural mass. In this way, we try to assess the relative importance of cost minimization as a factor affecting the distribution of centers in comparison to other factors such as high-level political organization, ideology, and cultural tradition.

In addition, we compare the hypothetical central-place system with the distribution of exchange goods, i.e., obsidian artifacts, in hopes of strengthening our argument. As central-place theory is based mainly on the theoretical consideration of the circulation of people and goods, the reconstruction of a central-place system based solely on settlement data is quite tenuous. It becomes significantly more solid when supported by the distribution of exchange goods such as obsidian.

La Entrada Region

As the foregoing argument indicates that central-place theory is most effective for regional analy-

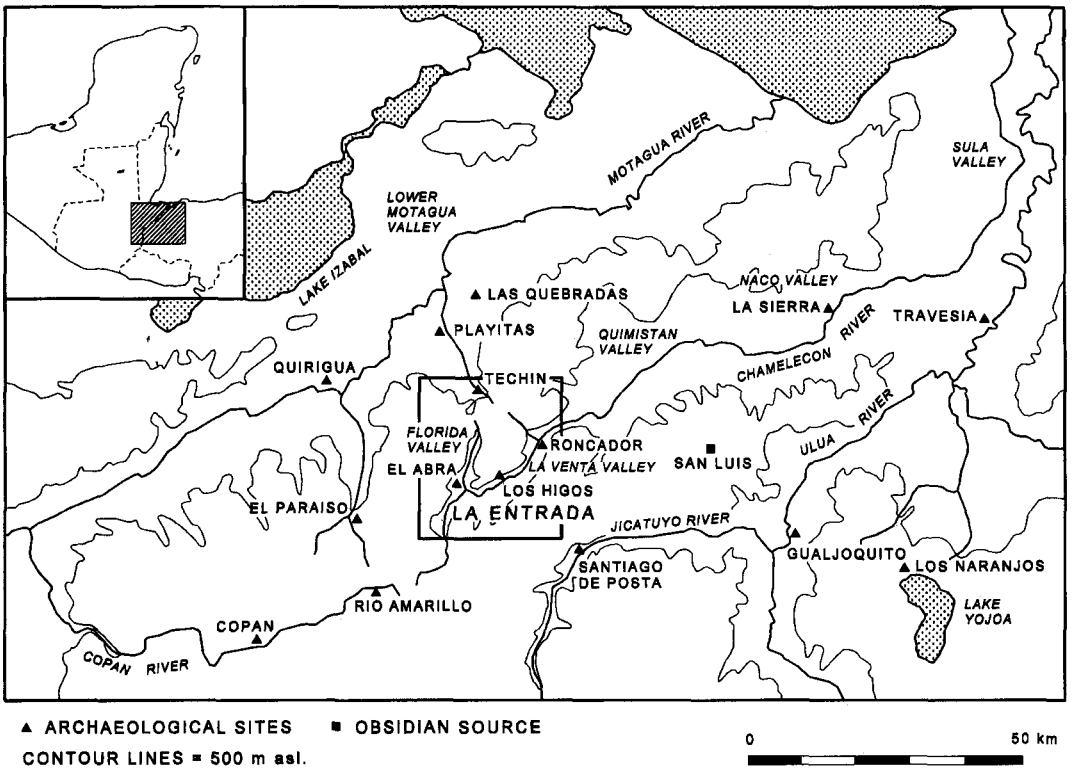

Figure 1. Map of the La Entrada region and surrounding areas showing the location of major archaeological sites. The area shown in Figure 2 is indicated by the central rectangle.

ses, we confine our analyses to the settlement data from the La Entrada region in northwestern Honduras (Figure 1). The database for our analyses was obtained by the La Entrada Archaeological Project, which has been carrying out archaeological investigations in the region since 1984 (Nakamura et al. 1991). The project study area comprises the adjoining La Venta and Florida valleys and natural corridors that lead to adjacent regions. The valley bottoms are situated between 390 and 550 m asl, covering an area of roughly 150 km^2 (Figure 2). The climate of the region is classified as tropical dry forest and subtropical forest, with annual precipitation of 1,200–2,000 mm and a mean annual temperature of 21–24°C (AID Resources Inventory Center 1966; Secretaría de Comunicaciones, Obras Públicas y Transporte 1986).

Prior to the La Entrada Project, survey, mapping, and epigraphic studies had been conducted sporadically in the region (Lothrop 1921; Morley 1920:384–386; Pahl 1977; Richardson 1940; Yde 1938:48–57). The La Entrada Project was the first systematic archaeological investigation of the area. By the end of the 1989 season, the intensive survey program of the project covered the entire valley bottoms (see Nakamura et al. [1991] for a detailed description of survey techniques).

The survey located a total of 635 sites in the region, which were classified into six categories: Category 1 encompasses sites without visible structures (268 sites); Categories 2–5 refer to sites with visible structures (356 sites [Category 2 is the smallest and Category 5 is the largest]); and the "Special Category" represents sites with special characteristics such as caves (11 sites). Almost all sites of Categories 2–5 (350 sites) were mapped (Nakamura et al. 1991).

This classification, however, was developed rather subjectively as an "all-purpose typology" (de Montmollin 1988:158). Although it provides a general picture of the settlement distribution (Figure 2), it is not adequate for our analyses. As mentioned above, we use architectural mass of

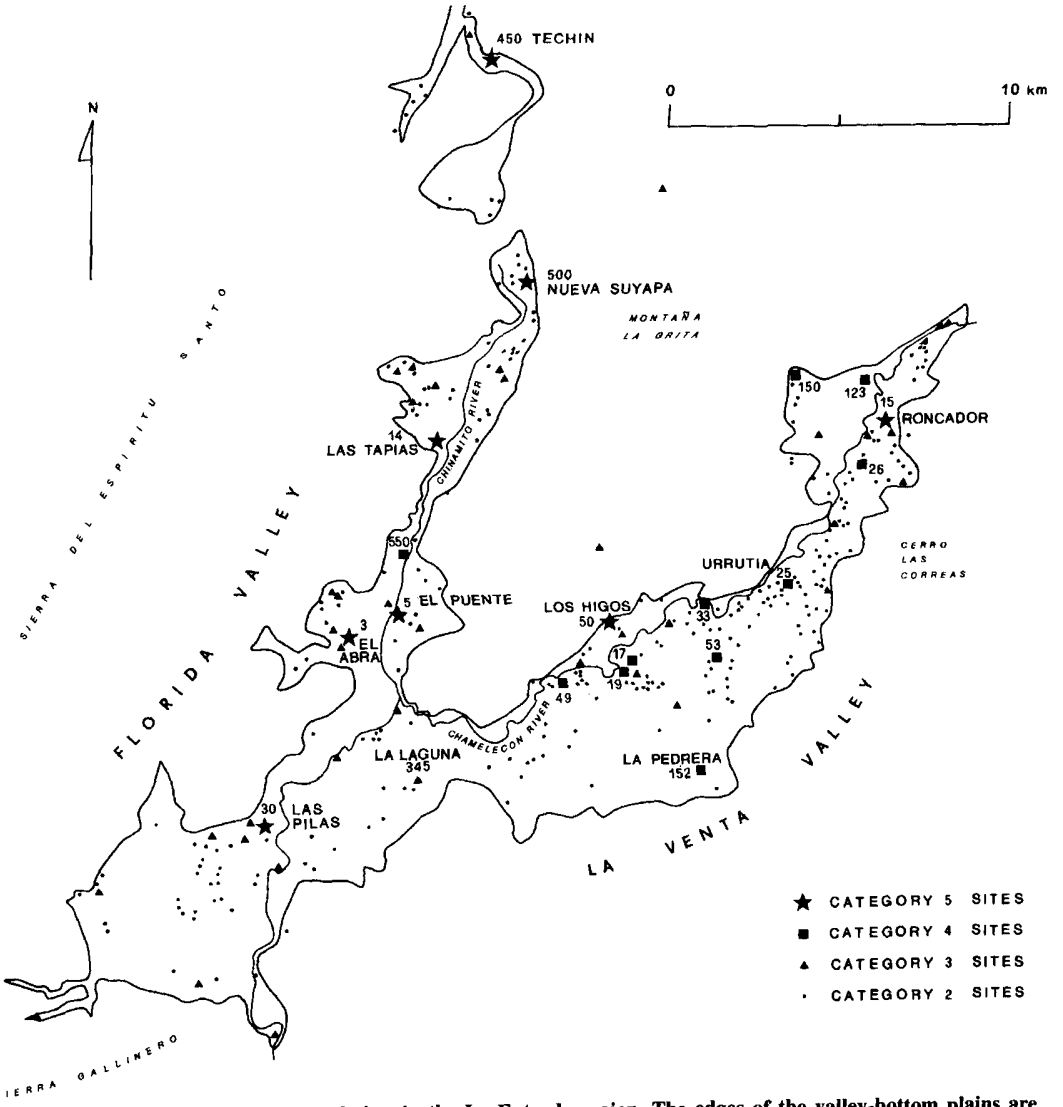

Figure 2. Distribution of archaeological sites in the La Entrada region. The edges of the valley-bottom plains are indicated.

main groups as a more problem-oriented measurement of the size of centers.

Test excavations were conducted at 37 sites, each selected by a stratified random sampling strategy. Although occupation in the region spanned the Middle Preclassic period through the Late Classic period, a large portion of excavated and surface-collected materials dates to the Late Classic period (A.D. 600–900) (Nakamura et al. 1991). It is most likely that the majority of Category 2–5 sites, including all the centers, were occupied contemporaneously during this period. In addition, glyphic texts from the region date to the eighth century, suggesting that the power of local political authorities reached its apogee during this century. Moreover, excavation data indicate that the region experienced a construction boom during the eighth century (Nakamura 1994; Nakamura et al. 1991). Thus, it appears reasonable to assume that the final construction mass of main groups represents a rough relative indicator of the power of political authorities to draw trib-

ute (de Montmollin 1989:103–104) during this century.

As discussed below in more detail, during the Late Classic period the La Entrada region appears to have been situated at a crossroads of different cultures from surrounding regions, namely, Copán, Quiriguá, and the Naco, Sula, lower Motagua Valley, central Santa Bárbara, and Yojoa regions. Our task of determining cultural affiliations of La Entrada settlements was greatly facilitated by the fact that prior research had been conducted in the adjacent areas (Baudez 1983; Baudez and Becquelin 1973; Henderson et al. 1979; Joyce 1991; Sanders 1986–1990; Schortman 1993; Sharer 1990; also see papers in Boone and Willey [1988]; Robinson [1987]; and Urban and Schortman [1986]).

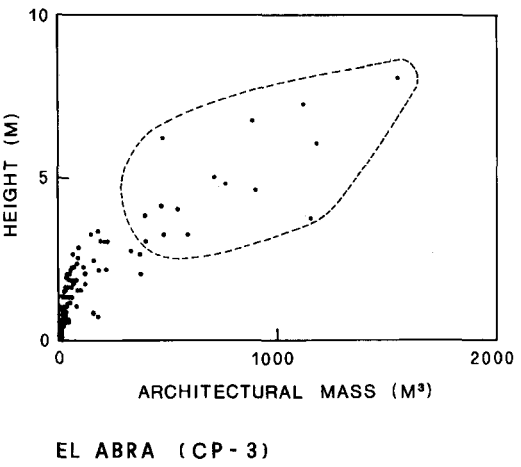

Figure 3. Graph plotting the architectural mass and height of each structure at El Abra (CP-3).

Figure 4. Archaeological map of El Abra (CP-3). The main group is shaded.

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Central-Place Analyses in the La Entrada Region

Several variables were analyzed, including architectural mass of the main groups, rank-size relations, central-place hierarchy, and type of central-place system.

Architectural Mass of Main Groups

The construction mass of each structure was calculated first to define the main group of each center.[1] Calculated volumes and heights of structures were plotted. As an example, Figure 3 shows the plot for El Abra (CP-3) (number in parentheses is the site number). The figure shows that some structures are considerably larger than others in terms of volume and height. These considerably larger structures were defined as monumental structures; they are circled in Figure 3. We determined that a group composed of these monumental structures was the main group of a site. The total volume of a main group was calculated by summing the mass of these monumental structures and of other smaller buildings belonging to the same group. Figure 4 illustrates the main group of El Abra as an example. Table 1 shows the total volume of main groups and of whole sites. These numbers demonstrate that a large part of the construction volume of a whole site is accounted for by its main group.

Rank-Size Relation

In order to establish a central-place hierarchy, we first analyze the rank-size relation between centers. This analysis is useful for understanding the overall regional pattern of a hierarchy. The rule of rank-size relation was originally developed rather empirically by geographers (Berry 1961; Haggett 1965:101–107; Stewart 1958) and also has been applied by archaeologists (Adams 1983; Adams and Jones 1981; Blanton 1976, 1978; Hodder 1979; Hodder and Orton 1976:69–73; Welch 1989). The rule proposes that the sizes of cities and their rank are plotted as straight lines on a

Table 1. Number of Structures and Architectural Mass.

Site			No. of	Architectural Mass m^3	
Name	No.	Category	Structures	Whole Site	Main Group
El Abra	CP-3	5	193	18,200	13,500
Los Higos	CP-50	5	31	11,700	11,300
Techín	CP-450	5	66	12,000	9,900
El Puente	CP-5	5	200	11,800	9,800
Roncador	CP-15	5	208	12,800	8,300
Nueva Suyapa	CP-500	5	16	7,800	7,700
Las Tapias	CP-14	5	34	7,700	7,500
Urrutia	CP-25	4	113	6,400	5,000
Las Pilas	CP-30	5	197	?	4,700
La Meca	CP-17	4	25	3,900	3,900
Las Cañadas	CP-49	4	45	3,800	3,200
El Cedral	CP-33	4	48	3,300	2,900
La Venta	CP-19	4	14	3,000	2,900
El Llanón	CP-150	4	96	3,300	2,800
La Pedrera	CP-152	4	32	2,500	2,200
Diablo	CP-26	4	92	3,100	2,000
Los Laureles	CP-550	4	23	2,000	1,900
El Jagua	CP-53	4	50	2,000	1,700
	CP-460	3	11	1,700	1,600
	CP-283	3	10	1,200	1,200
	CP-333	3	82	1,500	1,100
	CP-40	3	18	1,100	1,000
	CP-2	3	75	1,900	900
	CP-203	3	62	800	400

Note: Architectural mass less than 100 m^3 was rounded. Data are from Inomata 1987:Tables 3.1 and 3.2 and Nakamura et al. 1991:Table VIII-1.

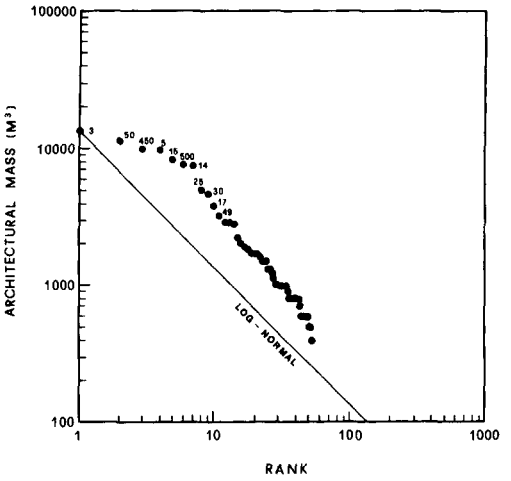

Figure 5. The rank-size distribution of centers in the La Entrada region.

logarithmic scale. Although this is the expected pattern, deviations from the rule are often observed.

One variant is referred to as a primate distribution. This pattern presents a concave curve under the expected straight line and indicates that a single settlement is considerably larger than the rest. In this case, the central-place hierarchy of a region, if any, is probably dominated by only one highest-level center. The other end is called a plural distribution, which shows a convex curve over the expected straight line. This pattern means that there are several centers of similar size and that the highest level of the central-place hierarchy is likely to include more than one center.

Figure 5 presents the rank-size relation between centers of the La Entrada region. It shows a typical plural distribution, indicating that the central-place system of the La Entrada region, if it existed, is likely to have consisted of more than one highest-level center.

Central-Place Hierarchy

The largest nine centers, El Abra (CP-3), Los Higos (CP-50), Techín (CP-450), El Puente (CP-5), Roncador (CP-15), Nueva Suyapa (CP-500), Las Tapias (CP-14), Urrutia (CP-25), and Las Pilas (CP-30), are distributed fairly regularly along the rivers (Figure 6). If we add two sites that are located off the main river lines—La Pedrera (CP-152) and La Laguna (CP-345)—they show a two-dimensionally regular pattern. Figure 6 shows circles with a radius of 3 km centered on these sites, indicating that the centers are regularly spaced at 6-km intervals. Although El Abra and El Puente are close together, the two sites are separated by a river and a swampy area (see Flannery 1976:179).

Among these centers the three largest ones—El Abra (CP-3), Los Higos (CP-50), and Techín (CP-450)—may be classified as higher-level centers. The larger circles in Figure 6 possess a radius of 9 km, indicating that the higher-level centers are roughly 18 km apart. El Abra and Los Higos are considerably closer, but they are located in different valleys separated by a mountain range.

In sum, the equidistant distribution among them suggests that there was a central-place system with a two-tier hierarchy, with El Abra, Los Higos, and Techín being the highest-level centers.

Type of the Central-Place System

The distribution of centers in the La Entrada region appears to fit a type of central-place system based on the administrative principle. Our argument mainly relies on Christaller's (1966) theory, although some archaeologists argue that Lösch's (1954) scheme better approximates the situation in Classic Maya society (e.g., Ball and Taschek 1991; Marcus 1976:24, 1993:154). Lösch's theory pursues a strict theoretical formulation in purely economic space, and its proper application to archaeological contexts seems rather difficult. Christaller's theory, on the other hand, takes other factors such as administrative and religious services into consideration, and we believe that his theory is more useful for archaeologists.

Considering the interaction between economic and other factors, Christaller proposed three basic patterns of hierarchical distributions of central places: (1) $K = 3$ system (the market principle); (2) $K = 4$ system (the transport principle); and (3) $K = 7$ system (the administrative principle) (Figure 7). The underlying factors and implications of these patterns have already been described by others (e.g., Bray 1983; Haggett 1965; King 1984; Morikawa 1980; Smith 1974). Here we simply reiterate important points characterizing each pattern.

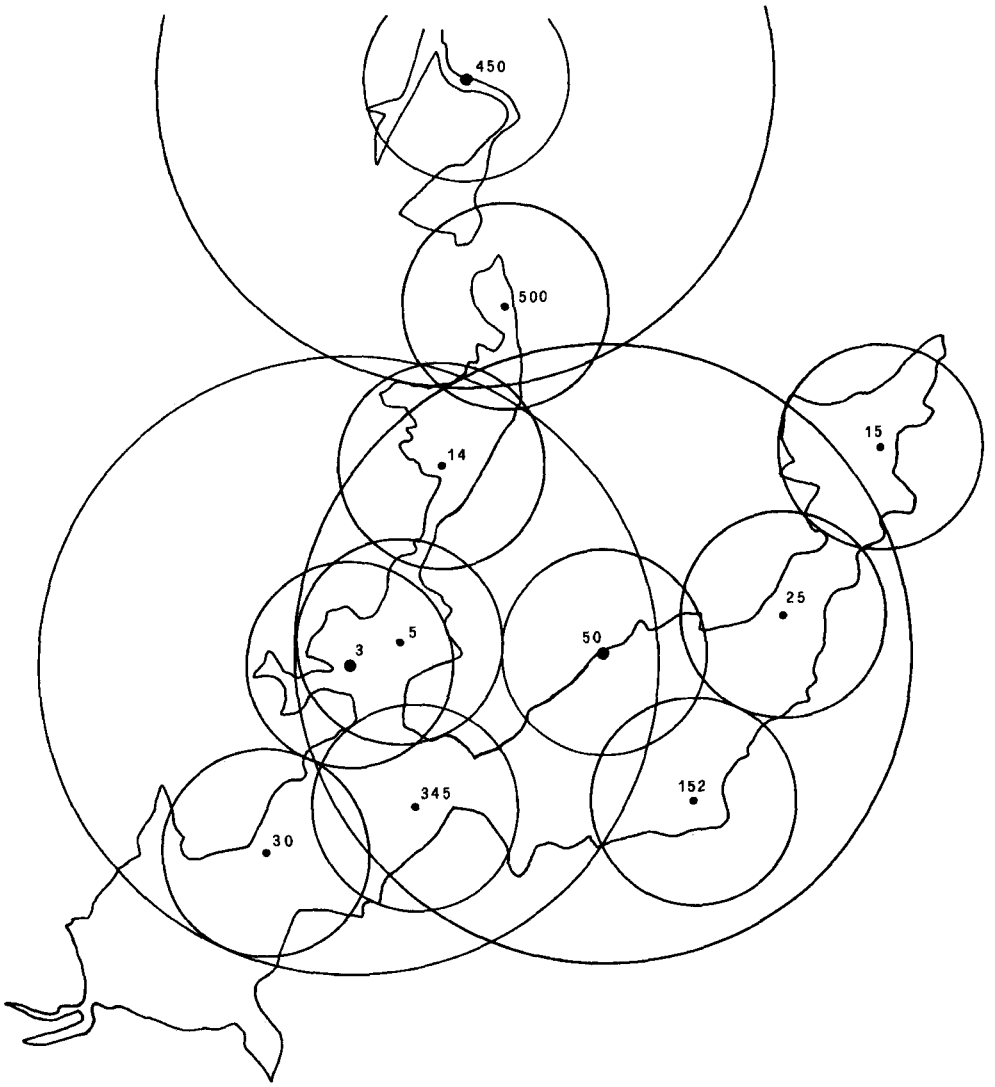

Figure 6. Equidistant distribution of centers in the La Entrada region. The smaller circles have a 3-km radius and the larger circles have a 9-km radius.

It is necessary to note that the economic principle of minimizing the cost of transport and travel is the most dominant factor in all three types and that the difference in configurations results from other interfering factors. Whereas in the $K = 3$ system the economic principle operates optimally, in the $K = 4$ system the transport principle is important, minimizing the number and length of roads. In the $K = 7$ system, the administrative principle interferes with the economic one. In this system, the sustaining area of a lower-level central place is completely encompassed in that of a single higher-level central place, and economic activities are considerably affected by political factors.

As we apply Christaller's (1966) theory to the La Entrada region where settlements were distributed somewhat linearly along the valley bottoms, we need to modify his original models to one-dimensional patterns. Central places also are also assumed to be distributed equidistantly in one-dimensional situations (Burghardt 1959:322; Dacey et al. 1974; Flannery 1976). Because transport routes generally pass all central places in

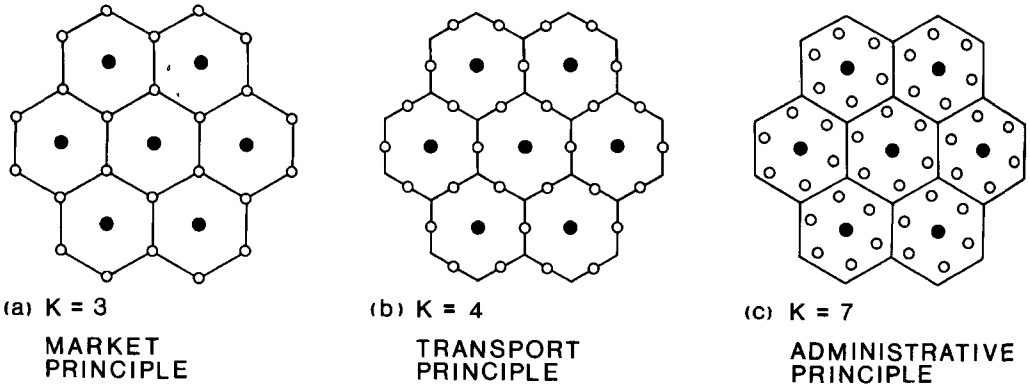

Figure 7. Distribution patterns of central places in two-dimensional space.

these cases, the market and administrative principles are more important as determinants of patterns (Figure 8). A pioneering work by Willey et al. (1965) on Maya settlement patterns in the Belize Valley provides an example of a linear distribution of central places. Its central-place system (Flannery 1976:Figure 6.7) appears to be based on the administrative principle.

The distribution of centers in the La Entrada region also roughly corresponds to a central-place system based on the administrative principle, where the sustaining area of higher-level central places completely nests those of lower-level central places. Figure 9 shows the hypothetical sustaining areas of Techín, El Abra, and Los Higos, reconstructed according to the theoretical pattern. They also are demarcated by mountain ranges surrounding the La Venta and Florida valleys. As mentioned above, the presence of a central-place system demonstrates the strong tendency to minimize the cost of travel and transport. Yet, the pattern in the La Entrada region implies that the administrative principle also was strongly operating, controlling certain areas of economic activities.

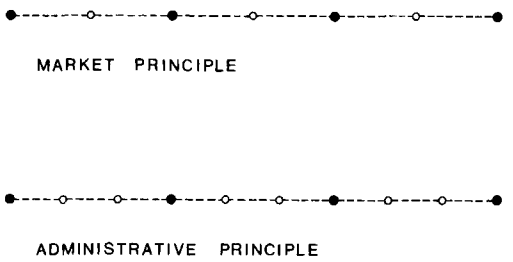

Figure 8. Linear distribution of central places. The distribution of centers in the La Entrada region roughly corresponds to the pattern based on the administrative principle, in which a pair of low-level centers are located between high-level ones.

Distribution of Cultural Traits

Analyses of data from monuments, glyphic texts, and other cultural traits help to understand factors other than cost minimization that affect the distribution of centers, such as interdynastic politics, cultural traditions, and interaction with other areas.

Monuments and Glyphic Texts

The two largest sites—El Abra and Los Higos—are the only centers in the La Entrada region where complete glyphic texts have been discovered. Los Higos possesses a stela, a monolith, and altars (Morley 1920:384–386; Nakamura et al. 1991; Pahl 1977), indicating that this center was a seat of administrative authority. At El Abra, we have not found any stelae, but the landowner of the site found an alabaster vase with a glyphic text that contains the name of Copán's sixteenth ruler, Yax Pac (Riese 1988:88; Schele 1991), which indicates the political importance of this center. Fragmentary glyphic texts have been reported from Las Pilas (including a possible emblem glyph [Schele 1991]) and from El Puente (Yde 1938:48–57), suggesting the high political status of these centers.

These glyphic data concur with the hypothetical central-place system in which El Abra and Los Higos are the highest-level centers of the region.

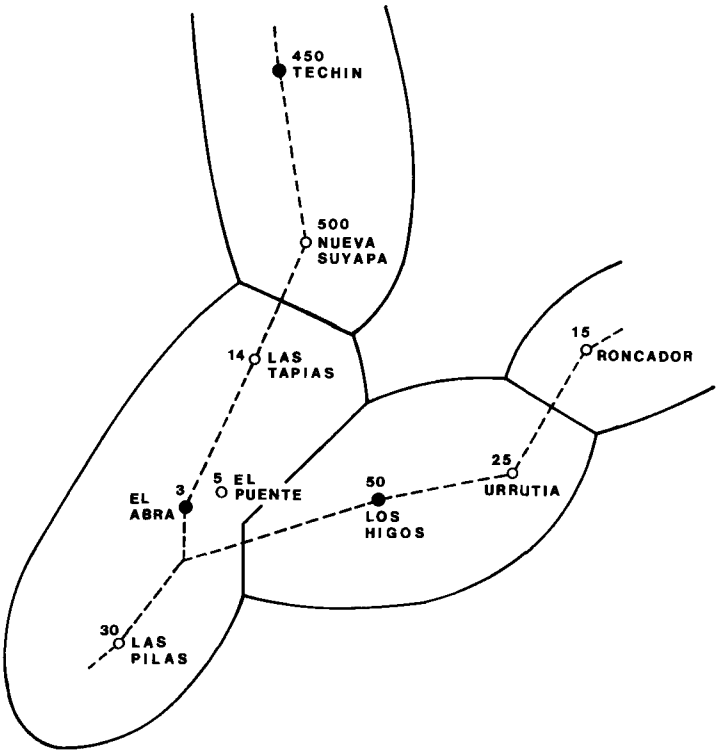

Figure 9. The central-place system in the La Entrada region. The hypothesized sustaining areas of Techín, El Abra, Los Higos, and Roncador are indicated.

Some lower-level centers, however, appear to have had considerable political autonomy. A question remains about the political status of centers in the northern and eastern extremes, namely, Techín and Roncador. To address this problem, we consider cultural traditions in the region and surrounding areas.

Other Cultural Traits

The La Entrada region appears to have been located on a boundary between the Maya area and other cultures. Its cultural affinities with surrounding areas have been thoroughly discussed elsewhere (Nakamura et al. 1991; Schortman and Nakamura 1991). Here we shortly summarize them and discuss their implications on the formation of a central-place system.

The hypothetical sustaining areas of El Abra and Los Higos exhibit a high degree of cultural similarity to Copán in terms of ceramics (Sato 1991), architectural styles such as pyramids and cut-stone masonry, and the tradition of stone carving. On the other hand, the northern extreme of the region possesses a stronger affinity to the lower Motagua Valley, which is seen in ceramics, architectural styles including step terraces, and site-planning patterns such as enclosed-court complexes (Schortman 1993). Also, some ceramic types from the northeastern part of the La Venta Valley are identical to those of the Naco and Sula valleys (Sato 1991).

Thus, the apparent absence of stone sculptures in the northern and eastern extremes of the La Entrada region is probably due to their cultural affiliation to non-Maya areas. Although Techín lacks monuments and glyphic texts, we believe that it can be classified as a higher-level center. Likewise, there are no known glyphic texts from Roncador. However, it is the only site in the La Entrada region with a ball court, suggesting the importance of this center. Although Roncador was classified as a lower-level center through analysis of architectural mass, we still believe that it maintained an autonomous position in the central-place system.

An interesting point is that the configurations

of these cultural spheres do not correspond with natural boundaries demarcated by mountains. This suggests significant interactions between the Maya area and non-Maya cultures, in which Techín and Roncador probably played important roles. It is also necessary to note that the complex configuration of cultural spheres within the region did not hinder the formation of the central-place system as a coherent regional system (see Crumley 1979).

Obsidian: Distribution of Exchange Goods

The hypothesized central-place system was tested against the distribution of obsidian artifacts, which are considered to be imported exchange goods. Obsidian has often been used to reconstruct economic systems in the Maya region as well as other areas because of the relatively reliable identification of its sources (e.g., Arnauld 1991; Dreiss and Brown 1989; Hammond 1972; 1976; Healy et al. 1984; McKillop 1989; Moholy-Nagy et al. 1984; Pires-Ferreira 1976; Sidrys 1976, 1977). However, obsidian sources are so limited that archaeologists use obsidian mainly for reconstructing long-distance trade routes and for analyzing the differential access to it by social strata. Thus, the examination of intraregional spheres of exchange through obsidian distribution has been rather rare. The La Entrada region, located between two different obsidian-source areas, provides an unusual occasion to address this issue.

The two obsidian-source areas refer to Ixtepeque and the area around San Luis. Ixtepeque is a distant source (115 km) to the southwest with high-quality obsidian. Its obsidian was imported to the La Entrada region mainly in the form of large polyhedral cores during the Late Classic period. The San Luis area is located in the department of Santa Bárbara, 30 km to the east of the La Venta Valley, and probably includes two sources (San Luis and Source Y) (Aoyama 1994; Aoyama et al. 1992; Metal Mining Agency and the Japan International Cooperation Agency 1978). Obsidian from the San Luis area was obtained as small cobbles that were never useful for prismatic-blade manufacture. In other words, it was of considerably lower quality than Ixtepeque material, and it was used only for production of small flakes (Aoyama 1991, 1994).

Sources of obsidian collected through excavation were identified by combining neutron-activation analysis (NAA [Aoyama and Glascock 1991; see Glascock et al. 1991 for the chemical composition of San Luis area obsidian]) and visual examination (Aoyama 1988, 1991). An advantage of identifying obsidian sources by visual examination is that one can analyze obsidian artifacts quickly and cheaply without damaging them. This allows us to analyze entire collections, opening up possibilities not only for interregional comparisons but also for intraregional and intrasite studies. The reliability of the visual identification was confirmed by a blind test against 100 obsidian artifacts sourced with NAA, which showed a 98 percent correlation (Aoyama and Glascock 1991).

A total of 1,323 obsidian artifacts excavated from unmixed deposits of the Late Classic period was analyzed (Aoyama 1991, 1994). The majority of obsidian (968 samples, 73.2 percent) came from the Ixtepeque source and the second largest group (337 samples, 25.5 percent) was from the San Luis area. Only 18 (1.3 percent) obsidian pieces were classified into other source groups.

The frequency percentage of Ixtepeque obsidian from each excavated site (Figure 10) was calculated, and the percentages and the distances from Los Higos and El Abra along the valleys are plotted in Figure 11, excluding the sites with less than 10 obsidian artifacts. The figure presents an intriguing combination of two patterns. One is the difference among the hypothetical sustaining areas of Techín, El Abra, Los Higos, and Roncador deduced from central-place analyses. The other refers to higher percentages of Ixtepeque obsidian in large sites than in small ones.

In the hypothesized sustaining area of El Abra, the percentages of Ixtepeque obsidian are consistently higher than 84 percent (mean = 92.7, s.d. = 6.05). Although the difference within this area is small, the percentages from centers (Las Tapias, El Abra, and Las Pilas) are higher than those from smaller settlements. The sample size from the sustaining area of Techín is small, but it appears that Ixtepeque obsidian is similarly prevailing. In the hypothetical sustaining area of Los Higos, on the other hand, figures vary widely from 61 to 100

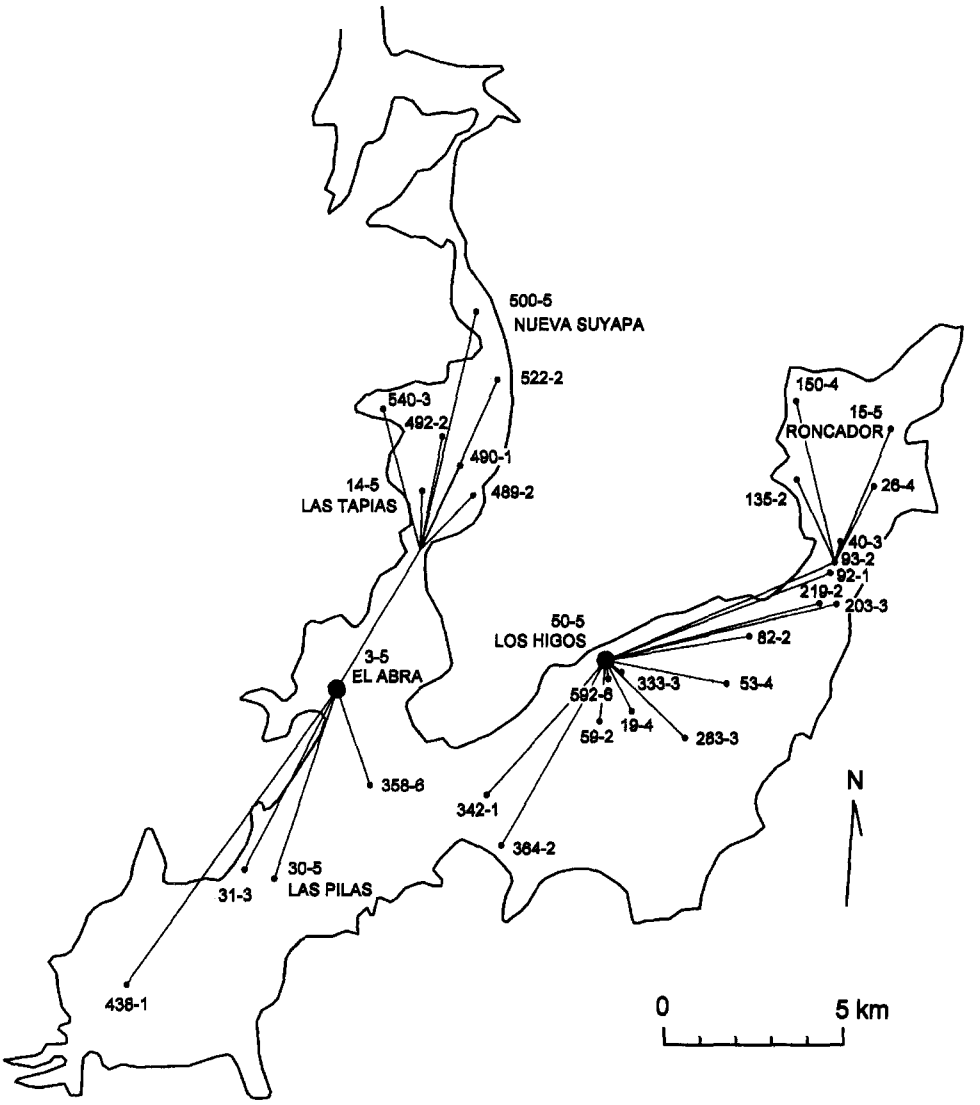

Figure 10. Locations of test-excavated sites. Numbers indicate site numbers and site categories. The lines from El Abra and Los Higos show the way in which the distance to each site was measured (see Figure 11).

percent (mean = 84.3, s.d. = 12.63). Again, large sites such as Los Higos, CP-19, and CP-26 tend to have more Ixtepeque obsidian than smaller ones. In the area of Roncador, the percentages are all smaller than 61 (mean = 39.8, s.d. = 18.38), with Roncador possessing the highest portion.

The patterns recognized in the graph also were confirmed by probabilistic tests. Distinct distributions between hypothesized sustaining areas were examined with chi-square tests for the obsidian frequencies in each area (excluding the sustaining area of Techín, whose sample size is too small). Results indicate a moderately strong yet extremely significant difference between the sustaining areas of El Abra and Los Higos (chi-square = 9.86; $.01 < p < .001$; $V = .1$) and a very strong and extremely significant difference between those of Los Higos and Roncador (chi-square = 403.56; $p < .0005$; $V = .62$).

Although the number of excavated sites in the sustaining area of Roncador is small, our argument may be reinforced by surface-collected

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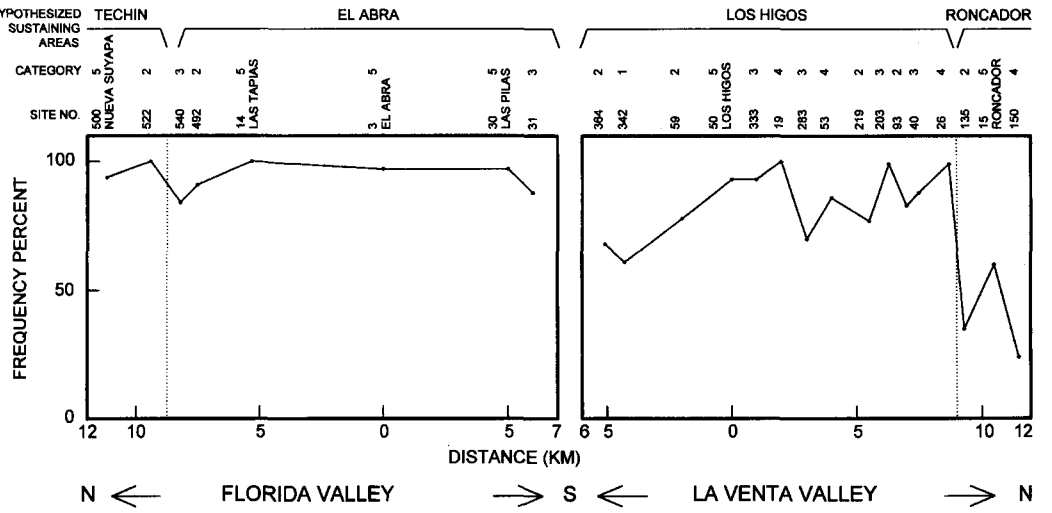

Figure 11. A graphic plot of the frequency percentage of Ixtepeque obsidian at each site and the distance from El Abra or Los Higos. Distances were measured according to Figure 10.

materials. Obsidian from the San Luis area forms 72 percent of 748 samples collected at 22 sites in the northern extreme of La Venta Valley and in the adjacent western Quimistán Valley, whereas Ixtepeque obsidian makes up 26 percent (see Aoyama 1991:Tables VI-19 and VI-21 for detailed data). Because a large portion of surface-collected ceramics from the region date to the Late Classic period, it is likely that most of these obsidian artifacts are from the Late Classic. Hence, it is inferred that sites in the sustaining area of Roncador possess considerably higher percentages of obsidian from the San Luis area than those in the sustaining area of Los Higos.

The assumption of higher access to Ixtepeque obsidian by large centers was tested by regression analysis for the percentages of Ixtepeque obsidian (Y) and the site categories of settlements in the hypothesized sustaining areas of El Abra and Los Higos that contained a sufficient number of excavated sites (X). The result indicates a very strong and extremely significant correlation ($r = .744$; $p < .0005$; $Y = 6.98X + 64.52$).

These patterns provide information about the nature of economic and political systems in the region. The marked distinction between these sustaining areas indicates that this pattern resulted not only from the difference in the proximity to obsidian sources but also from the political control over obsidian exchange. Where the economic principle operates without interference from other factors, the amount of obsidian supply is expected to fall off gradually over distance (Renfrew 1975). The sharp drops shown in Figure 11 demonstrate that the circulation of obsidian was politically controlled within each sustaining area (see Hodder 1980:152; Soja 1971:36–39, Figure 11). Furthermore, the higher portion of Ixtepeque obsidian at centers than at small sites within each area suggests that obsidian from this source was supplied mainly through redistributive channels (Sidrys 1976, 1977).

One may argue that the sharpest drop between the sustaining areas of Los Higos and Roncador is partly due to cultural differences. However, because obsidian from Ixtepeque was of much higher quality than that from the San Luis area, it is unlikely that the difference in obsidian distribution resulted from cultural preference. Rather, this pattern suggests that the configurations of political territories and cultural spheres roughly correspond. It is important to note that the difference in obsidian distributions is noticeable between the sustaining areas of El Abra and Los Higos, which probably shared the same cultural background.

In conclusion, distribution patterns of obsidian strongly support the hypothetical reconstruction of a central-place system. Moreover, the probable political control over obsidian circulation corrob-

orates the existence of the central-place system based on the administrative principle.

Factors Underlying the Formation of a Central-Place System

Here we discuss several different factors underlying the regular spacing of Classic Maya centers, first by comparing the settlement pattern of the La Entrada region with those of other areas and second by comparing the central-place theory with other theoretical models.

Factors Regulating the Spacing between Centers

The applicability of central-place theory indicates that there existed a strong tendency to minimize energy expenditure in movement. In central-place theory, distance itself is a significant factor, as compared to population density or the size of centers.

This point becomes even clearer when we compare the settlement pattern of the La Entrada region with those of other areas. For example, Tikal, one of the most important Classic Maya centers, provides a good comparative case. The extension of the assumed sustaining area of Tikal varies according to the type of evidence: the distance to the adjacent center (Uaxactún), the location of earthworks and bajos (Haviland 1970; Jones et al. 1981; Puleston and Callender 1967), or the distributions of artifacts such as ceramics (Fry and Cox 1974:223). Yet, the north-south extension of its sustaining area seems to fall in the range between 13 and 22 km. The extension of the hypothetical sustaining areas of El Abra and Los Higos along the valley is about 18 km (Figures 6 and 9). In other words, one of the largest Classic Maya centers and the small regional centers in the La Entrada region possessed roughly the same extension of sustaining area.

El Abra and Los Higos are considerably smaller centers than Tikal, and their sustaining areas seem to have had much smaller population and lower population density than Tikal. The density of structures in the La Entrada region is approximately 39 per km^2 on average and 80 per km^2 in the most densely occupied area of 20 km^2 along the rivers (Inomata 1986:101; Nakamura 1991:256–257), whereas the density is 119 per km^2 in the central zones of Tikal and Uaxactún, and 39 per km^2 in the intersite areas between the two centers (Puleston 1974:308). If the area of swampland is excluded from the calculation for Tikal and Uaxactún, the density is 197 per km^2 and 88 per km^2, respectively, for the central zones and for the intersite areas (Puleston 1974:308). When we consider these gaps in population and in the size of the centers, the difference in the extension of the sustaining areas is remarkably small. In other words, the spacing around a center is not proportional to the physical size of the center, to the population, or to the population density.

Although there are regional differences, we can see a certain uniformity in spacing between centers. In the Belize Valley, major centers are 10–15 km apart (Willey et al. 1965:573). Harrison (1981:274–276) has suggested that major centers occur at intervals of 26 km and minor centers occur at intervals of 13 km in southern Quintana Roo. In the northeastern Petén, the average spacing between centers is 15.8 km (Bullard 1960; Marcus 1983:464).

Similar spacings are observed among contemporary rural markets. In highland Guatemala and in Oaxaca, market towns tend to be spaced at intervals of 10–20 km (Cook and Diskin 1976; McBryde 1947; Sanders and Santley 1983:246–247). Hodder and Orton (1976:58) suggest that, in preindustrial societies in which travel is on foot or by cart, rural local markets are often separated by distances averaging approximately 10 km. They further argue that these distances lead to the most efficient and effort-minimizing arrangement of settlements in rural societies. Although we are not directly addressing marketplaces, it is quite probable that the distribution of Maya centers as central places had the same tendency.

We argue that two basic factors underlying the regular spacing of Classic Maya centers are the ineffective transportation and the system of finance in political units. As for the first factor, ancient Maya society lacked beasts of burden and wheeled carts, and human porters were probably the only means of transport except for canoes. The distance covered and the amount carried by human porters are, therefore, seriously limited (see Drennan 1984a, 1984b; Sanders and Santley 1983).

Furthermore, regarding the second factor, it is most probable that Classic Maya polities had a system of finance referred to as "staple finance," which involves obligatory payments of subsistence goods from commoners to political authorities (Brumfiel and Earle 1987:6; D'Altroy and Earle 1985:188; Polanyi 1968). This system contrasts with "wealth finance," in which some form of wealth as currency is used as a means of payment. Although staple-finance systems prevail in a broad range of complex societies from fairly simple chiefdoms to early imperial states, its major disadvantage is that the transportation of heavy and bulky subsistence goods across distances is difficult and costly (D'Altroy and Earle 1985:188; see also Rowlands 1973:594).

Given the limitation of human porters carrying heavy loads, the tendency of cost minimization was probably a critical factor affecting the distribution of Classic Maya centers. Sanders and Webster (1988:541) contend that in Prehispanic Mesoamerica the movement of staple food was generally limited to a distance of 10–15 km. Marcus (1983:464) has also suggested that the 26- to 28-km spacing between major centers corresponds to a day's walk and that 13- to 16-km spacing between minor centers corresponds to one-half day. The arrangements of central-place systems with these spacings are considered to be most economically efficient.

It also is important to note that similar conditions do not necessarily lead to the formation of a central-place system, particularly when political and ideological factors strongly operate. For example, during the Teotihuacan era, central Mexico was dominated by a single primate city (Sanders et al. 1979), a pattern in contrast to a central-place system. In other words, the Classic Maya do not appear to have developed a strong state ideology or effective administrative systems that would have overcome technological and economic factors.

Nevertheless, we reiterate that the tendency of cost minimization was not the only factor that affected the configuration of spatial patterns in the La Entrada region. As seen in the formation of a central-place system based on the administrative principle, political factors interfered with economic ones to a certain degree. This system indicates that managerial authorities exercised control over some economic activities and that political boundaries had significant effects on economic exchanges. The distribution of obsidian most clearly demonstrates the importance of political factors for exchange of certain items, although the circulation of goods with lower exchange value may have been considerably free from political control (see Fry 1979, 1980; Marcus 1983:477; Rands 1967; Rands and Bishop 1980; Rice 1987:79).

Local and External Economic Factors

Because the La Entrada region is located on the boundary between the Maya area and non-Maya areas, the region provides a critical case to test the nature of interactions and economic exchange between these areas. Ethnohistoric accounts (e.g., Tozzer 1941:39) suggest that the Sula (Ulúa) region was an important trade partner of the Maya during Postclassic times. The La Venta Valley and the southern Florida Valley are located in adequate positions as a communication route between the Sula Valley and the Maya area.

With this context in mind, it might be productive to compare the central-place system with other theoretical models. Whereas central-place theory is more oriented toward explaining local interactions, geographers have developed models oriented toward long-distance exchange of goods in large quantities, namely, the dendritic-system model (Hayashi 1986:404–408; Johnson 1970; Smith 1974:177, 1975:100). In a dendritic system, all lower-level centers are vertically tied to a single higher-level center without horizontal links among them (Smith 1974:177), and the rank-size distribution of centers shows a primate pattern. This configuration is more efficient for intensive economic activities with outside areas, and dendritic systems are expected to emerge in bounded areas such as along natural trade routes. Hirth (1978) has adapted the concept of gateway communities, which are strongly oriented to external economic relations with dendritic settlement patterns, and applied it to the case of Chalcatzingo.

The natural and social environments around the La Entrada region seem suitable for the occurrence of a dendritic system, but the actual settlement pattern does not fit the model. The plural

pattern of the rank-size distribution also contradicts the dendritic model. One may argue that Copán was the primate center of the entire zone (or a gateway community) and that the La Entrada region was its hinterland. It is quite probable that Copán had an important function of controlling trade, and our analyses show that the communication between the La Entrada region and adjacent areas was an important factor affecting the configuration of the central-place system. However, the distribution of centers in the La Entrada region indicates the importance of horizontal links between regions, contradicting the dendritic model characterized by a vertical structure without horizontal links (Smith 1974:177). In other words, major factors for the formation of the regional settlement system were local exchange and interactions with adjacent regions rather than long-distance trade or mass transportation of goods between the Maya and non-Maya areas.

Conclusions

The presence of a central-place system underscores the importance of local exchange of staples for the maintenance and evolution of Classic Maya polities (Marcus 1983:479). The close spacing between high-level centers suggests that the transportation of bulky commodities was limited to short distances. Also, the configuration of the central-place system based on the administrative principle implies that the pattern of political territories affected the circulation of strategically important goods such as staples and of scarce material such as imported high-quality obsidian.

The exchange of subsistence goods is a critical issue in the study of complex societies, but it is difficult to address without written records. We believe that central-place analyses and the comparison with other theoretical models provide an effective means for this purpose. It is indeed important to test the inferences from such theoretical analyses against more solid archaeological data. Our contention of the limited transportation of bulky commodities is supported by ceramic studies proposing that the circulation of utilitarian ware was confined to quite small areas (Fry 1979, 1980; Rands 1967; Rands and Bishop 1980). Also, effects of political boundaries on the exchange of important goods are demonstrated by the distributional analysis of Ixtepeque obsidian in the La Entrada region.

Further Implications for Understanding the Classic Maya Political and Economic Systems

The results of our analyses contribute to the ongoing argument about the nature of Classic Maya political organization, i.e., whether organization accords with the segmentary-state model (Ball and Taschek 1991; Demarest 1992; Houston 1993; Sanders and Webster 1988) or to the unitary- or regional-state model (Adams and Jones 1981; Culbert 1991).

Although these models involve various assumptions concerning the morphology and mechanism of political organization, two points are most relevant to our argument. First, the segmentary-state model proposes centripetal political organization in which the boundaries of political territories are fluid and indeterminate. This leads to the second issue, that is, the size of territories or political units. Although the segmentary-state model does not address this question directly, its opponents seem to favor large regional political organization.

The hypothesized central-place system based on the administrative principle and the distribution of obsidian suggest that political boundaries *did* exist, although we do not know to what degree such boundaries restricted interaction across them. Political boundaries are generally difficult to detect archaeologically. Territories in the La Entrada region were visible because of their rather unusual location between two different obsidian sources. In most lowland Maya areas where obsidian was obtained from distant highland sources, such territorial behavior in obsidian exchange may be intangible in the archaeological record. Also, it is probable that the exchange of low-value goods was not affected by political boundaries.

As to the second issue, the question of the size of Maya polities is not a simple matter, because different variables such as political control over economic activities and the interdynastic relation of subordination may have had quite different spatial configurations. A model of small Maya polities has been proposed based on the assumption that emblem glyphs represent the

autonomous status of centers (Mathews 1991). On the other hand, recent glyphic decipherment has revealed marriage alliances, war engagements, and even some types of political control between distant centers (Houston 1993; Martin and Grube 1995; Schele and Freidel 1990). Our study provides information on the economic aspect of this issue, suggesting that political control over important materials such as staples and imported goods was limited to rather small areas. Although Maya centers were engaged in power struggles that involved wide areas, their economic bases appear to have remained in relatively small spatial units. In this sense, the Classic Maya do not appear to have developed stable regional states substantiated by strong state ideology and by effective administrative systems.

In conclusion, the results of our analyses do not favor either of the models outlined above. Although these models facilitate conceptualization, a simple dichotomy between two models sometimes blinds us to important details of political and economic organization (see de Montmollin 1989:16–29). For better understanding of ancient Maya society, we need to examine how different variables operated in different social and spatial spheres.

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Note

1. In archaeological maps of the La Entrada Project, an ancient building is stylized into inner and outer polygons, representing the upper plane and base of the mound, respectively (Figure 4). When inner and outer polygons approximate rectangles, the volume of the mound is given as:

$$\text{volume} = (2ab + ad + bc + 2cd)h/6$$

where a is the length of the inner rectangle; b is the width of the inner rectangle; c is the length of the outer rectangle; d is the width of the outer rectangle; and h is the average height of the mound. When a mound possesses a complex shape, it is divided horizontally or vertically or both into two or more rectangles that best approximate the original form.

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