CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

LANDSCAPES OF COMPLEXITY:
AN ANALYSIS OF ANCIENT SETTLEMENT PATTERNS IN THE MUNICIPIO OF OCÓS, GUATEMALA

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Arts

in Anthropology

By

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May 2011

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DEDICATION

This thesis is dedicated to the memory of my friend Carole Urzua, Ph.D. Thank you, Carole, for your steadfast, indeed relentless, enthusiasm and encouragement.

ACKNOWLEDGEMENTS

The assistance and support of my thesis advisor, Dr. Michael Love, and committee members Drs. Helen Cox and Matthew Des Lauriers is gratefully acknowledged. I also acknowledge my appreciation for the guidance provided over the course of my studies by other faculty of the CSUN Departments of Anthropology and Geography, particularly Drs. Sabina Magliocco, Cathy Costin, Matthew Boxt, Christina Campbell, Martin Cohen, Christina Von Mayrhauser, Claudia Garcia Des Lauriers, Eugene Turner, Yifei Sun, and Shawna Dark. I am also in debt to the assistance and encouragement of my dear wife Beth, my daughter Jennifer, and my sometimes incredulous extended family.

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ABSTRACT

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Geographic Information System (GIS) and other statistical tools were used to analyze ancient Mesoamerican settlement patterns in an area approximately coterminous with the *Municipio* of Ocós in the Department of San Marcos, bordering Mexico on the Pacific Coast of Guatemala. The overall goal was to characterize the level of complexity of ancient society in the study area using a well-established model of complexity, and to trace its evolution over time. The datasets supporting the analysis were compiled from a nearly 100% survey of the region by Michael Love in the mid-1980s, supplemented by additional earlier surveys extending back into the 1940s. The primary analytical tool was Weights of Evidence, a statistical technique for assessing the strength of possible associations of settlement locations to environmental and cultural patterns. The analysis examined settlement relationships to soil types and other agricultural factors, resource zones such as mangrove lagoons and rivers, trade resources such as salt and plumbate

clay, and terrain features. It also tested for clustering and dispersion of settlements, and alignments to cardinal directions, mountains, and solstice sunrise and sunset points.

The strongest apparent influences on settlement location were found to be a preference for safe distances from the rivers but close proximity to the aquatic resources of the coast and mangrove lagoons. The selection for aquatic resources persisted through all time periods studied, while there was no statistical preference for highly productive agricultural zones, suggesting that foraging remained an important component of subsistence at all times. Settlements were found to be dispersed rather than clustered, a possible strategy to maximize foraging territories and agricultural plot sizes while minimizing the likelihood of total crop failure. There was no settlement pattern evidence for organized warfare or restricted access to trade resources, suggesting a rural population conducting its affairs relatively independently of elite centralized control. However, possible evidence for positioning of settlements to associate monumental structures with the presumed sacred power of nearby volcanoes may reflect the development of shared public ideology, and elite manipulation of ritual to maintain luxury lifestyles and prestige.

CHAPTER 1

INTRODUCTION

This thesis explores settlement pattern analysis as a tool for the study of social complexity, using as a case study Mesoamerican datasets from the Pacific coast of Guatemala, 1500 BC to 900 CE.

Social Complexity and Settlement Patterns

Anthropologists and archaeologists have long been concerned with the question of how and why societies develop from small groups of foragers into large agricultural and industrial states. Since the mid-20th century the focus has sharpened from a vague notion of the "advance of civilization" into a study of the emergence and maintenance of complexity in social systems. The ordinary meaning of complexity is that of intricacy or of a system having confusingly interrelated parts (Mirriam-Webster 2004). When applied to anthropology and archaeology the system is usually a culture, society, chiefdom, state or other grouping of people; the parts are sub-units such as individual agents or small groups; and the interrelationships generally involve power in some form, such as physical, economic, or ideological. These power relationships are manifested in the archaeological record by evidence of pronounced and enduring inequality of access to resources.

Archaeological evidence of inequality can take many forms, such as unequal quality and distribution of food, or unequal distribution of prestige goods, particularly burial goods. Analysis of skeletal remains can identify elites by their robust good health, nutrition, longevity, and access to health care, compared to the poor health of commoners. Monumental construction and organized warfare both demonstrate the ability of elites to command the time, labor and resources of commoners. Ritual and religious paraphernalia and iconography can provide evidence of elite ability to manipulate ideology to legitimize power and privilege.

However, one of the best approaches to the archaeological study of social complexity is the analysis of settlement patterns. This approach goes beyond the examination of individual sites to consider larger questions of social organization, such as site hierarchies or stratification by size, function or other attributes; the dominance or subordination of sites relative to each other; their organization into informal groupings or formal polities; their linkages to the physical environment or cultural landscape; and the evolution of all of these relationships over time.

The settlement analysis in this thesis takes advantage of a unique and privileged set of circumstances. The study area is a region surrounding the village and archaeological site of La Blanca in the *Municipio* of Ocós, Department of San Marcos, on the southwest Pacific coast of Guatemala near the border with Mexico. This region offers evidence of some of the earliest social complexity in Mesoamerica[1], contemporary with and interacting with the Olmec culture of the Gulf of Mexico. Archaeological surveys conducted from the 1940's through the 1980's have provided detailed datasets giving a nearly 100% complete picture of settlement in this region from the Early Formative through the Late Classic periods. The recent availability of Geographic

[1] The study area is part of what is now called the "Maya Area", which extends from the Mexican State of Chiapas through the Yucatan Peninsula, Belize, Guatemala and Honduras into El Salvador. However, the language and culture of the study area during the Formative period is uncertain, so the more general term "Mesoamerica" is used in this thesis in preference to "Maya".

Information System (GIS) computer software now enables more comprehensive statistical analysis of these data than could be conducted heretofore.

Goal and Objectives

The overall general goal of this thesis is to use an analysis of settlement patterns to characterize the level of complexity of ancient society in the study area and to trace its evolution over time.

A specific primary objective is to extend Michael Love's (1989) analysis of Early and Middle Formative period survey data into the Late Formative and Classic periods. Love's original analysis found the mean center of household settlement to be 11.4 km from the coast during the Ocos phase of the Early Formative period, and nearly the same at 10.3 km during the subsequent Cuadros and Jocotal phases of the Early Formative. However, by the Middle Formative Conchas phase the mean center of household settlement had shifted 8.9 km to the north into more highly productive soils, suggesting a transition from foraging to agriculture at that time. The present analysis revisits these results with more powerful statistical tools, and also considers Late Formative and Classic period data which were collected in the survey but not included in the original analysis.

A second objective is the adoption of a holistic landscape perspective. Most settlement studies published to date have a processual focus on the relationship of settlements to the physical environment, such as preferences for soil types or proximity to water sources. The present study considers these environmental factors in depth. However, it also broadens the analysis to consider human agency factors such as preferences for defensive locations and other evidence of warfare; clustering around minor ceremonial centers; settlement patterns as influenced by the major center of La Blanca; and settlement alignments in cardinal directions or in reference to prominent features of the landscape.

A third objective is to apply new spatial analysis techniques to the problem. The Weights of Evidence method, for example, is now frequently used for predictive modeling of unknown archaeological site distributions to identify priority areas for cultural resource management (Diggs and Brunswig 2009; Ford, et al. 2009; Johnstone 2003). In the present study, however, the same tool is instead used in a retrospective Bayesian mode to identify environmental and cultural factors responsible for the observed distribution of known sites and the changes in that distribution over time. In addition, use of GIS to analyze nearest neighbor distances allows computation of quantitative indexes of site clustering and dispersion, adding precision to the consideration of clustering for mutual defense or clustering around ritual centers. GIS line-of-sight and viewshed computations were used to test for defensive positioning for mutual intervisibility, or preferences for settlement locations visible from or to prominent features in the natural or constructed landscape.

Overview

Chapter 2, "Mesoamerican Settlement and Landscape Research", discusses current concepts and theories of how archaeological evidence of settlement patterns can provide information about ancient Mesoamerican life ways and social complexity. Chapter 3, "Scope of Study", defines the geographic and temporal scope of the study and describes the survey datasets upon which the study is based. Chapter 4, "Analysis of Settlement Patterns", reports and explains the findings of GIS and statistical analysis of settlement relationships to subsistence resources and landscape features, and evidence for trade, manipulation of ideology, and clustering and dispersion of settlements. Chapter 5, "Interpretations and Conclusions", draws these findings into general statements about the development of social complexity in the study area.

CHAPTER 2

MESOAMERICAN SETTLEMENT AND LANDSCAPE RESEARCH

This chapter discusses how archaeological evidence of settlement patterns can provide information about the development of ancient Mesoamerican life ways and social complexity. The chapter begins with a brief review of the history and current state of settlement studies in Mesoamerica including issues of environmental determinism, the landscape concept, the relationship of settlement patterns to social organization, and settlement classification schemes. The chapter next considers contemporary spatial analysis techniques, and discusses settlement patterns as potential indicators of specific environmental, social and cultural conditions in Mesoamerican society at various levels of complexity. The chapter concludes with a summary of the specific settlement patterns to be tested in the remainder of the thesis.

History and Current Status

Bishop Diego de Landa provided one of the earliest descriptions of Mesoamerican settlement patterns (Tozzer 1941). He reported that in a typical Maya town the most important people lived in the center of town near the temples and plazas. Priests and civil officials lived further out from the center, and the common people lived on the outskirts of town. He explained that people lived in towns for defense from their enemies. He also noted that Maya farmers preferred to maintain small scattered plots rather than large concentrated land holdings, to minimize the risk of losing an entire crop due to crop failure.

Subsequent archaeological research in Mesoamerica up through the mid-twentieth century had mainly a culture-historical orientation and a focus on large cities, ceremonial centers and monuments, with relatively little attention to non-elite residential patterns and settlements. J. Eric S. Thompson (1954), for example, extrapolated from his observations of modern Lacandón and other highland groups to assert that the ancient Maya lived in isolated homesteads scattered throughout the forest, only occasionally visiting distant ceremonial centers which otherwise remained vacant. Thompson's assertion was not supported by any actual residential settlement survey data, however.

Attention began to shift more explicitly to non-elite residential settlement with the publication by Gordon R. Willey of his research in the Virú Valley, Peru (Willey 1953) and subsequently at Barton Ramie in the Belize River Valley (Willey, et al. 1965). The investigations at Barton Ramie and other sites along the Belize River revealed a dense and nearly continuous pattern of residential settlement in close proximity to large centers with monumental construction. These early studies were largely descriptive and atheoretical. However, interest in settlement studies continued and increased through the 1970's, 80's and 90's, with notable large projects in the Basin of Mexico (Sanders, et al. 1979), the Valley of Oaxaca (Kowalewski, et al. 1989) and, in the Maya area, at Tikal (Arnold and Ford 1980), Copan (Fash 1983), and other major sites. A representative recent project is the Belize River Archaeological Settlement Survey (BRASS) project (Fedick 1995; Ford 2008). The BRASS project has the multiple objectives of studying Maya ecological adaptation and social complexity and also identifying ancient sustainable agriculture practices that might be relevant to modern development and conservation programs.

There is now a general acceptance of settlement surveys as a routine part of archaeological projects, and of the need for more large-scale regional surveys (Balkansky 2006). It is also generally recognized that settlement studies cannot rely on survey alone. As Gordon Willey observed, "In trying to answer questions about the relationship of settlements to society and culture, the archaeologist must rely not only upon constructions and modifications of land forms but upon all aspects of the archaeological record – artifacts, burial arrangements, the human remains themselves – the totality of what can be recovered from the past." (Willey 2005:27)

Spatial Analysis

Some of the earliest analyses of Mesoamerican settlement survey data were efforts to identify sociopolitical polity boundaries. Hammond (1974), for example, estimated polity configurations by constructing Thiessen polygons with boundaries passing through the midpoints between pairs of major sites in the Maya area. This rather mechanical process disregarded the size, population and nature of the settlements and their cultural interrelationships, and produced anomalies such as small settlements at the center of large polities while very large settlements, such as Tikal, had small polity areas. Subsequent attempts improved the process somewhat by various schemes to weight the bounded areas in proportion to settlement size, population, construction volume, or other factors. Other researchers such as Joyce Marcus (1982) identified settlements having shared emblem glyphs and combined them into larger polygons. The overall approach, however, lacked substantial theoretical foundation and the results remained unsatisfactory.

Apart from the polity boundary issue, another question of early and continuing interest is simply why settlements are located where they are. Central Place Theory is one approach to this question. The original theory was developed by Walter Cristaller (1972) from studies of modern market and distribution networks in Europe. The theory predicts that major production centers will be distributed in a hexagonal pattern, with minor distribution centers surrounding them also in a hexagonal pattern. The theory has had some success in the Maya area, helping explain observed regularities in the central lowlands (Marcus 1973) and, in modified form (Hammond 1974), the linear distribution of major and minor sites along the Belize River (Driver and Garber 2004). However, the theory assumes highly idealized isotropic conditions ignoring topography, economic inequalities, competition, etc. Settlement patterns in many parts of Mesoamerica do not fit the predictions of Central Place theory. General application of the theory to non-industrial societies such as the rain forest civilization of the ancient Maya has been criticized for lack of connection to archaeological theory and appears to be declining in influence (Bell and Church 1985; Inomata and Aoyama 1996).

Clifford Brown and Walter Witschey (2003) offer an interesting alternative to Central Place analysis. Their approach is based on the mathematical theory of fractals as well as archaeological theory. They note that Maya residence, settlement, and city architectural patterns tend to replicate themselves at successively higher levels of aggregation -- "clusters within clusters". They claim that this general pattern can be predicted by fractal equations. They relate this type of settlement pattern to Maya social patterns where Maya family structure is similarly replicated upward through successive levels of lineage, clan, chiefdom, etc. William Fash (1983) came to a similar conclusion in his study of Classic period settlement patterns in the Copan Valley in light of ethnographic analogies such as modern Zinacantan. He found that large sites tend to be geographically paired, which he contends represent established patrilineal, patrilocal lineages that were closely related through intermarriage. Smaller sites, dispersed throughout the remainder of the region, represent groups that split off from the major lineages. At a larger scale, he argues that Copan and other Maya cities are organized into zones based on lineage relationships, rather than market areas or functional activity areas. He claims that Copan accords well with the view that "... the center [is] merely a lineage cluster writ large" (Fash 1983:262).

Perhaps the most popular use of settlement survey data currently is for predictive modeling and factor analysis. Early predictive models used discriminant analysis or modified linear regression, but logistic regression and Weights of Evidence are the currently favored methods (Dallal 2001; Sawatzky, et al. 2009; Warren 1990). All of the methods calculate some measure of the probability of an archaeological site being at a given location. The calculation uses an equation calibrated ("trained") through analysis of the relationship of known site locations and non-locations to multiple environmental variables such as topographic elevation, slope, aspect, soil type, rainfall, temperature, and distance to water. Cultural resource managers use the predictive capabilities of these models to identify high-probability areas for priority investment of exploration, conservation and management resources (Johnstone 2003; Kvamme 1999; Reed 2009). Of perhaps more interest for the present purpose, however, is the ability of Weights of Evidence models to provide measures of statistical significance for each of the influencing factors (the coefficients of the prediction equation). Thus a well-calibrated model supplied with an appropriate set of environmental variables might be able to determine, for example, if the locations of sites identified in a survey were selected more for their proximity to water sources or elevation above surrounding terrain than for access to particular types of soils, and to what degree.

The predictive modeling approach, and in fact the entire field of settlement research, has been criticized for environmental determinism. Most of the studies to date have focused on geophysical factors such as terrain, hydrology and soils, for which data are readily available from published maps and remote sensing datasets and which can be easily manipulated by GIS software (Kvamme 1999; McCoy and Ladefoged 2009). In counterpoint to this trend, however, has been the broadening of the "settlement" concept into that of "landscape". Wendy Ashmore and Gordon Willey defined Maya settlement as "…the total disposition of Maya remains over the landscape." (Ashmore and Willey 1981:33) Ashmore defines landscape more expansively – "…an embracing environment and the human activities and settlements supported there. Centrally important are not only the physical characteristics of terrain, but also the multiple ways humans interact with it – economically, politically, and with respect to meaning and belief." (Ashmore 2004:171) Incorporation of landscape concepts into settlement studies requires consideration of social and cultural factors such as warfare and defense (Golden, et al. 2008); relationships of settlements to mountains, volcanoes, caves, water and other features of "ideational landscapes" (Brady and Ashmore 1999); and geographical alignments in cardinal directions or in accordance with astronomical phenomena such as solstices (Ashmore 2005). Some researchers (e.g. Fedick 2007; Tourtellot, et al. 2003) have extended these ideas to the recognition of "cosmograms", where Maya settlements and buildings are arranged relative to bodies of water or features of the landscape in correspondence to a world view encompassing four sacred directions and a central world tree or *axis mundi*. Michael Smith (2005), however, takes issue with the idea of cosmograms. He concedes that astronomical alignments and orientation to landmarks may have been factors in the organization of Maya centers, but argues that there is no evidence supporting a conclusion that the Maya therefore considered their buildings, cities or settlements to be models of their conception of the cosmos.

Settlement Patterns and Social Complexity

One of the key questions in contemporary archaeological theory, perhaps the preeminent question, is that of the development of social complexity and inequality. When, where, how and why did people abandon egalitarian lifestyles and submit to hierarchical power structures? Can settlement surveys and spatial analysis of settlement patterns contribute anything to the understanding of the development of social complexity? Gordon Willey believed that "…a hierarchical arrangement of settlement … undoubtedly reflects political structuring" and that "In a general way … the archaeologist operates with the assumption that site, center, or city size denotes ancient power and importance…" (Willey 2005:31). Others such as Gyles Iannone (2004), however, caution that settlement patterns do not necessarily correlate directly with function. Middle level settlements, for example, may have served multiple functions such as residences, administrative centers, markets, water control, agricultural management, and border control point management. Similarly, diversity in size and settlement pattern does not necessarily imply social hierarchy or ranking. Modern Los Angeles, for example, is the largest city in California but is not the political and administrative capital of the State.

Nevertheless, settlement patterns can leave distinctive indications of various cultural characteristics of social complexity, particularly when considered from a broad landscape perspective and combined with other types of archaeological evidence such as architecture, burials, floral and faunal remains, lithics and ceramics, epigraphy and iconography. This point is illustrated below in the context of Allen Johnson and Timothy Earle's (2000) classification of social complexity into the three general categories of the family level group, the local group, and the regional polity. These classifications, however, are not meant to imply a unilinear evolutionary trajectory, and in Mesoamerica do not necessarily correspond to cultural periods such as the Archaic, Formative, Classic or Post Classic or their subdivisions. Mesoamerican societies, in fact, often appear to have followed a pattern of cycling.

The Family Level Group

The family level group is generally characterized by foragers, small-scale horticulturalists and part-time farmers moving in and out of family camps or hamlets (Johnson and Earle 2000). In the Maya area tropical rainforest environment foraging would leave few permanent settlement indicators visible in surface surveys, apart from lithic scatters and coastal shell middens. However, diversification of subsistence strategies would have been important given the isolated circumstances and the seasonal variability of natural resources. One form of diversification, reliance on a combination of foraging and horticulture, could be visible by the location of small house mound clusters and patio ("*plazuela*") groups close to concentrations of natural resources such as beaches, tide pools, lakes, and rivers, but in areas with soils suitable for family gardens, small *milpas* and forest arboriculture. Another diversification strategy, scattering of small agricultural plots into different micro-environmental zones, could be visible in the form of single house mounds, i.e., field houses, located in isolation apart from the main camps and hamlets. Under either strategy agricultural productivity would not have been critical and soil productive capability may have been relatively unimportant. Population density would be low, less than one person per square kilometer. Ritual and ceremonialism would have been simple and family-centered, so public monumental architecture should not be expected at this level of complexity. Violence might be common but organized warfare would not be, so defensive architecture or settlement plans should also not be expected.

The Local Group

Local groups of multiple families would have formed around common interests such as defense, food storage, ritual, craft specialization or intensive agriculture, and would also be subdivided into corporate lineages or clans (Johnson and Earle 2000). In the Maya area the characteristic settlement pattern signature at this level would be correspondingly larger settlement groupings with more numerous house mounds and possibly multiple patios. Settlements related by kinship may be found in pairs or clusters (Fash 1983), and might be organized into higher-level fractal replications of family-level group settlements (Brown and Witschey 2003).

Johnson and Earle (2000) explain that local groups may be acephalous, or may instead be larger units integrated by exchange networks headed by "big men". Big men need big houses, so elite architecture may be visible in settlement remains at the local group level. Laura J. Levi (1996) proposes another theory that could also help to distinguish between these two sub-levels of complexity. She suggests that the settlements of smaller acephalous groups would generally be found in areas having access to only one primary type of resource, such as a particular soil type or lacustrine resource. The larger big-man groups would have the population size and organizational abilities to deal with the more complex scheduling and labor requirements, and so would tend to locate in areas having access to multiple resources such as highly productive soils combined with, say, *bajos*, lakes or rivers.

Ritual and performance become more important and more public at the local group level, and so may be reflected in small-scale public architecture. Use of ritual to support social inequality may also be visible in architectural and settlement alignments intended to associate the leadership with sacred features of the landscape and, consequently, supernatural powers. Warfare may become a factor at some times and in some areas at the local group level, so settlement patterns may reveal defensive clustering (Golden, et al. 2008), defensive architecture such as palisades, or preference for defensible locations such as hills or ridge tops or the edges of swamps.

The Regional Polity

Regional polities form as previously independent local groups coalesce into chiefdoms and states (Johnson and Earle 2000). Rulers pursue wars of expansion and conquest to finance their elite lifestyles and administrative hierarchies. Apart from defensive locations and architecture, another settlement pattern indicator of warfare at the polity level is the existence of uninhabited buffers or no-man's-lands between neighboring polities, as has been suggested for Yaxchilan and Piedras Negras (Golden, et al. 2008). Elites also rely on other intensive economic strategies, such as agricultural irrigation and terraces and long-distance trade. Settlement pattern indicators of these strategies may include remains of agricultural constructions, and the placement of settlements or architecture in strategic locations intended to secure control of key trade resources such as jade or obsidian sources or salt works.

Cities are another indicator of social organization at the polity level. There are a myriad of theories about the organization of Mesoamerican cities and ceremonial centers. Wendy Ashmore and Gordon Willey (1981) bring these into correspondence with three general settlement patterns. Their Type A pattern, the "true city", was modeled after Tikal. This settlement pattern reflects a complex hierarchical society with many levels of elite power and administrative responsibility. Elite settlement is concentrated in the city center while socioeconomic status decreases in stages with outward distance from the center, consistent with Landa's (Tozzer 1941) original model of concentric rings. The Type B pattern is a two class hierarchy, with elite settlement in the city and a non-elite rural population scattered more or less at random over the surrounding countryside. Type C is the vacant ceremonial center, modeled, for example, on Zinacantan (Vogt 2003). A ring of elite population is concentrated around the vacant city center, and non-elite population in the countryside is clustered around minor ceremonial, market and administrative centers supporting the major center.

Regardless of the settlement model, most ancient Mesoamerican cities include durable major public constructions for ritual performance supporting elite power. Some cities featured architectural or settlement alignments in cardinal directions or towards landscape features such as mountains. Cities also provided high levels of security, either through walls, moats or other defensive features visible in settlement remains, or more commonly through the simple weight of population and military resources.

Summary

Table 2-1 summarizes some of the settlement patterns discussed above as indicators of the cultural characteristics of the various levels of social complexity in Johnson and Earle's (2000) model. These relationships are tested in the analysis reported in Chapter 4 of this thesis, using survey data from coastal Guatemala as described in Chapter 3.

Level of Complexity	Cultural Characteristics	Settlement Pattern Indicators
Family-level group		
	Small-scale foraging	Selection for natural resource zones
	Small-scale horticulture	No selection for agricultural zones
	Low population density	Population less than 1-2 persons per sq km
	Family-level social organization	Single and multiple household sites
	Minimal territoriality and warfare	No defensive clustering, no defensive locations
	Minimal political integration	Dispersed settlements
	Family-level leadership	No elite residences, no clustering around centers
	Family-centered ritual and ceremonialism	No monumental architecture, no sacred alignments
Local group		
	Intensified foraging	Selection for multiple resource zones
	Settled agriculture	Selection for agricultural zones
	Intermediate population density	Population 2-20 persons per sq km
	Small groups with common interests	Multi-household sites, minor centers
	Some organized warfare	Defensive locations, clustering, architecture
	Regional trade	Settlements controlling regional trade resources
	Local-level leadership	Elite residences, clustering around minor centers
	Public ritual and ceremonialism	Minor ritual centers, sacred alignments
Regional polity		
	Intensified agriculture	Canals, terraces, field boundaries
	High population density	Population greater than 20 persons per sq km
	Institutionalized central leadership	Major centers, cities
	Wars of conquest and expansion	Walls, moats, vacant inter-polity buffer zones
	Long distance trade	Settlements controlling long-distance trade resources
	Multi-level administrative hierarchies	Type A, B, C city settlement patterns
	State religion, "theater states"	Major ritual centers, sacred alignments

Table 2-1. Potential Settlement Pattern Indicators of Social Complexity.

CHAPTER 3

SCOPE OF STUDY

The western end of the Pacific coast of Guatemala provides an excellent opportunity for exploration of the settlement pattern theories and ideas discussed in Chapter 2. This region is of key archaeological significance because of evidence of some of the earliest development of social complexity and large-scale monumental construction in the Maya area, and because of its history of early interaction with other regions of Mesoamerica, notably including the Olmec culture of the Gulf coast. The Guatemala western coastal plain has been largely cleared of its tropical rain forest coverage for modern agriculture, exposing numerous settlement remains ranging from single house mounds up through major centers such as La Blanca, El Ujuxte and Takalik Abaj. Evidence of earliest occupation in the Archaic period is minimal but remains from most other periods from the Early Formative through the Post Classic are accessible for surface survey and excavation.

Geographic Scope

Three settlement survey datasets are available for the overall region shown in Figure 3-1. The first derived from multiple broad surveys conducted by Edwin Shook and colleagues starting in the 1940's (Shook 1947; Shook and Hatch 1979). Shook's surveys covered portions of the Departments of San Marcos, Quetzaltenango and Retalhuleu, Guatemala. The surveys focused on samples of settlement groups and larger settlements. Many of these records contain extensive detail with meticulous maps and drawings. However, others are based on aerial observations or second-hand reports and so are necessarily less complete. In these cases the sites are described only in very general terms (e.g., "many mounds"), and are assigned only to very broad time periods (e.g., "Preclassic period").

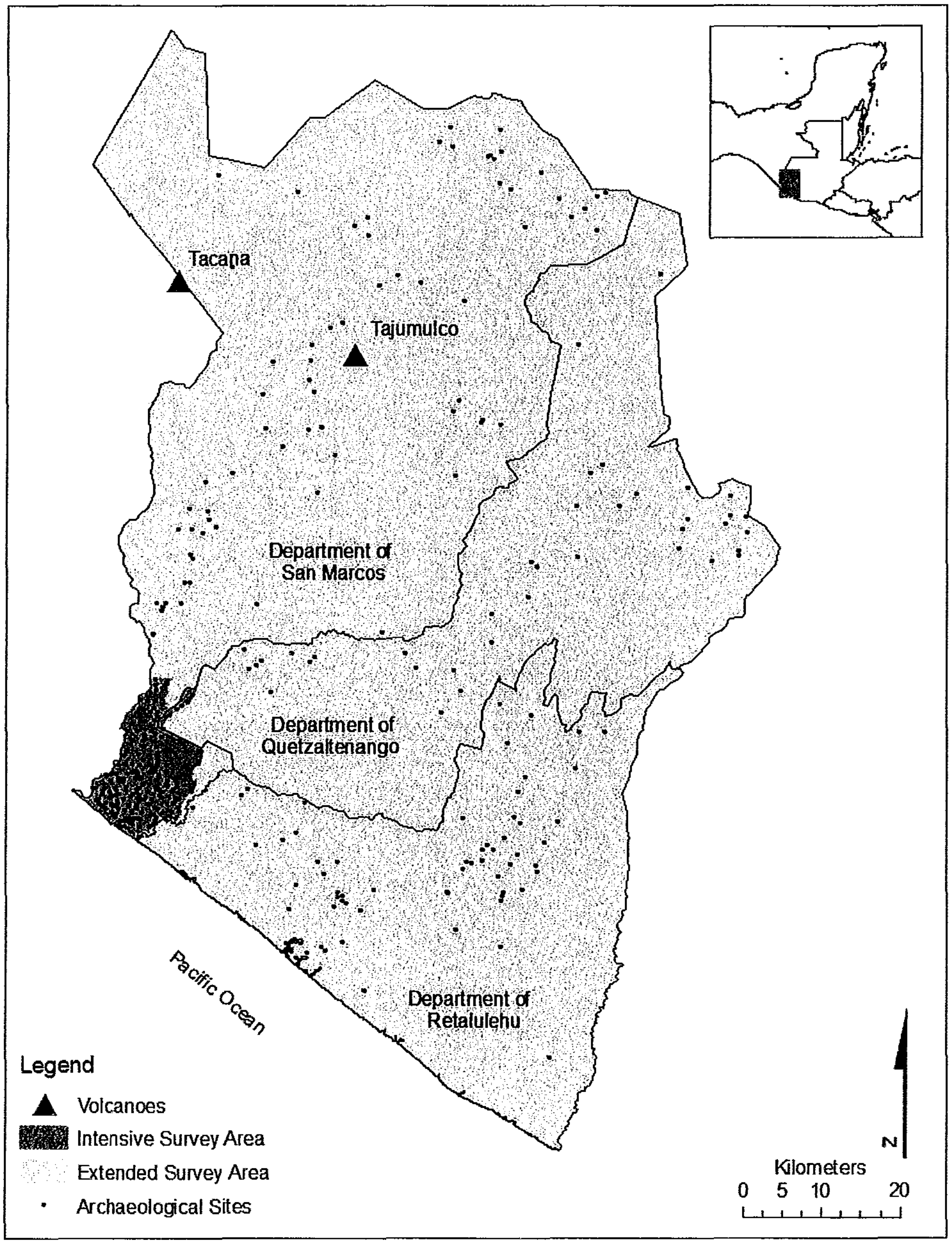

Figure 3-1. Overall Survey Area.

The second dataset came from a more limited survey of the coastal lagoon, mangrove and estuary zones by Michael Coe and Kent Flannery in the 1960's (Coe 1961; Coe and Flannery 1967). This survey also focused on larger sites.

The third dataset documents an intensive survey by Michael Love and co-workers in 1983-85 (Love 1989). Love's survey area covered approximately 168 square kilometers including the area previously surveyed by Coe and Flannery as well as the major center of La Blanca and its hinterlands. This survey was believed to identify "...all major sites having public architecture, and nearly all of the residences that were built on small mounds." (Love 1989:48) Because of the completeness and accuracy of this survey the remainder of this thesis focuses almost exclusively on the area covered by Love's survey, hereinafter referred to as the intensive survey area or simply the study area. The remainder of the overall survey area is referred to as the extended survey area.

Exhibit 3-2 shows the intensive survey area in more detail. This area corresponds approximately to the *Municipio* of Ocós in the southern end of the Department of San Marcos. The area is bounded by the Rio Suchiate on the west, the Zanjon Pacaya on the east, and the Pacific Ocean on the south. The survey area extends slightly north of the north western border of Ocós to approximately the town of Ciudad Tecún Umán. The Rio Naranjo runs through the center of the area from north to south. The terrain is a generally flat coastal plain rising gradually from sea level at the beach, coastal lagoons and mangroves to about 20 meters elevation in the North as it approaches the piedmont zone. The southern part of the survey area contains salt flats and relatively poor soils, but soil quality and general agricultural productivity improve towards the north. Average temperature, humidity and rainfall also increase in a gradient from south to north. The northeastern portion of the area is covered by seasonal wetlands and *pampas* which are agriculturally productive today but were apparently unsuitable for habitation in ancient times.

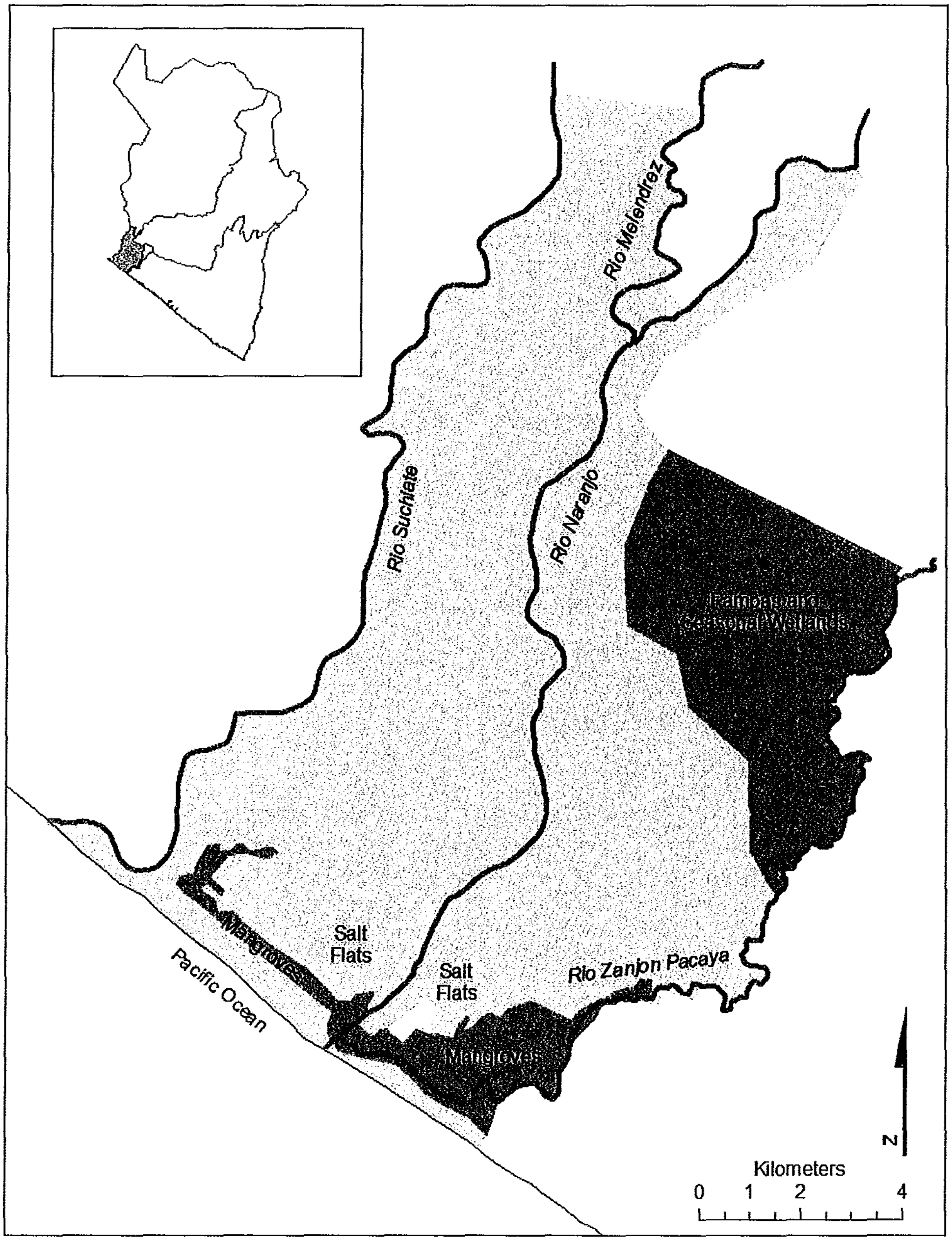

Figure 3-2. Intensive Survey Area.

Temporal Scope

Figure 3-3 shows a timeline for the cultural history of the intensive survey area. The surveys did not find significant evidence of settled occupation of the study area during the Archaic, Early Classic, or Post Classic periods. As a general pattern, population and social complexity appear to have been low and stable during the Early Formative period, to have grown rapidly during the Middle Formative into the Late Formative, collapsed to near abandonment during the Early Classic, resurged during the Late Classic, and then collapsed again during the Postclassic (Love 2007).

Calibrated Date	Cultural Period	Ceramic Phase	Notable Events
1600 CE			
1500			
1400	Late Postclassic		
1300			Region Vacated
1200			
1100	Early Postclassic		
1000			
900			
800	Late Classic	Marcos	
700			
600			
500			
400	Early Classic		Region Vacated
300			
200		Crucero	
100 CE			
0			
100 BC	Late Formative		
200			
300			Florescence of El Ujuxte
400			
500			
600			
700	Middle Formative		
800			Florescence of La Blanca
900		Conchas	
1000			
1100		Jocotal	
1200		Cuadros	
1300		Cherla	
1400	Early Formative	Ocos	
1500		Locona	
1600			
1700 BC			

Table 3-1. Study Area Time Line.

Table 3-2 lists the number of sites found in the consolidated survey records for all of the surveys, all of the time periods, and both the intensive and extended survey areas.

	Number of Sites			
Cultural Period/Ceramic Phase	Intensive Survey Area	Extended Survey Area	Unspecified Locations	Total, All Locations
Historic	--	3	--	3
Post Classic	1	7	--	8
Classic				
Late/Marcos	27	34	--	61
Early	2	1	--	3
Unspecified	44	1	1	46
Formative				
Late/Crucero	80	10	6	96
Middle/Conchas	60	2	1	63
Early/Cuadros-Jocotal	22	--	--	22
Early/Locona-Ocos	21	--	--	21
Unspecified	3	29	--	32
Undetermined Dates	41	123	9	173
All Sites *	195	186	15	396

* Columns do not total to "all sites" because some sites were occupied during more than one time period.

Table 3-2. Summary of Overall Survey Database.

The analysis reported in the remainder of this thesis excludes the sites in the extended survey area because of incomplete survey coverage of that area. It also excludes sites for which the survey records do not adequately identify the site location or assign a time period. The Historic and Post Classic period sites are also excluded because of their small sample size (one site in the intensive survey area). Although the majority of records for Classic period sites in the intensive survey area do not explicitly distinguish between Early Classic and Late Classic, the study area is known to have been substantially abandoned during the Early Classic, so all of the Classic period sites are treated as Late Classic. The records do have sufficient temporal resolution to separate the Formative period into the Late, Middle and Early Formative, and to further subdivide the Early Formative into the Cuadros-Jocotal and Locona-Ocos phases on the basis of ceramic seriation. Table 3-3 summarizes the resulting dataset extracted from the overall survey database for the settlement study.

Time Period	Number of Sites
Late Classic	73
Late Formative	83
Middle Formative	60
Early Formative, Cuadros-Jocotal	22
Early Formative, Locona-Ocos	21

Table 3-3. Settlement Analysis Dataset.

Survey Data

As the survey teams encountered a site they assigned an identifier and recorded descriptive data onto an index card. The site identifiers comprise a two-letter Department abbreviation followed by a 1 to 3 digit number (e.g., SM 18 for site 18 in the Department of San Marcos). Most sites also have a descriptive name, such as La Blanca or La Victoria.

Geo-positioning satellite (GPS) equipment was not yet commonly available at the time of the surveys, so the survey teams estimated site positions by compass bearings and tape measurements from nearby landscape features. They then marked the positions on

1:50,000 scale maps, and recorded the Universal Transverse Mercator (UTM) map coordinates onto the site record cards. Recognizing the limitations of the manual measurement procedures and the scale of the maps, they omitted the two least-significant digits of the UTM coordinates, so the positions are recorded to an accuracy of 100 meters at best.

Most of the archaeological sites in the intensive survey area consist only of an artifact scatter or a single low earthen and/or stone mound, usually five to ten meters or so in diameter and less than one meter in elevation. The site records sometimes give approximate dimensions, but often not. The mounds are commonly called "house mounds" suggesting they supported residential structures, but in some cases the structures may have had different or additional functions such as temporary field houses, craft workshops, food storage, or salt processing.

Some of the small residential sites have multiple house mounds. These are generally in a compact cluster, sometimes in a U-shaped arrangement around a courtyard or *plazuela*. The site records usually provide a count of the number of mounds and perhaps a rough layout diagram, but at other times merely note "multiple mounds".

A third type of site, a "minor center", is distinguished by multiple house mounds together with one or a few significantly larger mounds, platforms or pyramids, which are interpreted as elite residence platforms and/or "temple" platforms for public ritual performance. During the Late Formative and Classic periods some of the minor centers became fairly large and developed significant public architecture with acropolises, and so are here designated as "secondary centers" to distinguish them from the smaller minor centers which are designated "tertiary centers".

The site of La Blanca has several very large mounds as well as numerous lower mounds spread over a 200-hectare area, and so is considered the one unique primary center in the intensive survey area.

In summary, for purposes of analysis in this thesis and following Michael Love (Love N.D.; 1989), each site is classified into one of the above five types: primary center (La Blanca), secondary center, tertiary center, multiple mound site, or single mound site. It should also be noted, however, that the very definition of a "site" is somewhat problematic. It was often difficult for the survey teams to determine if multiple mounds in close proximity represented one site or separate sites, and by the Late Formative period households in parts of the region had coalesced into more or less continuous bands of settlement.

Site Distributions

Figures 3-3 through 3-7 show the distribution of sites in the intensive survey area during each of the five time periods for which archaeological remains of settlement were identified in the surveys.

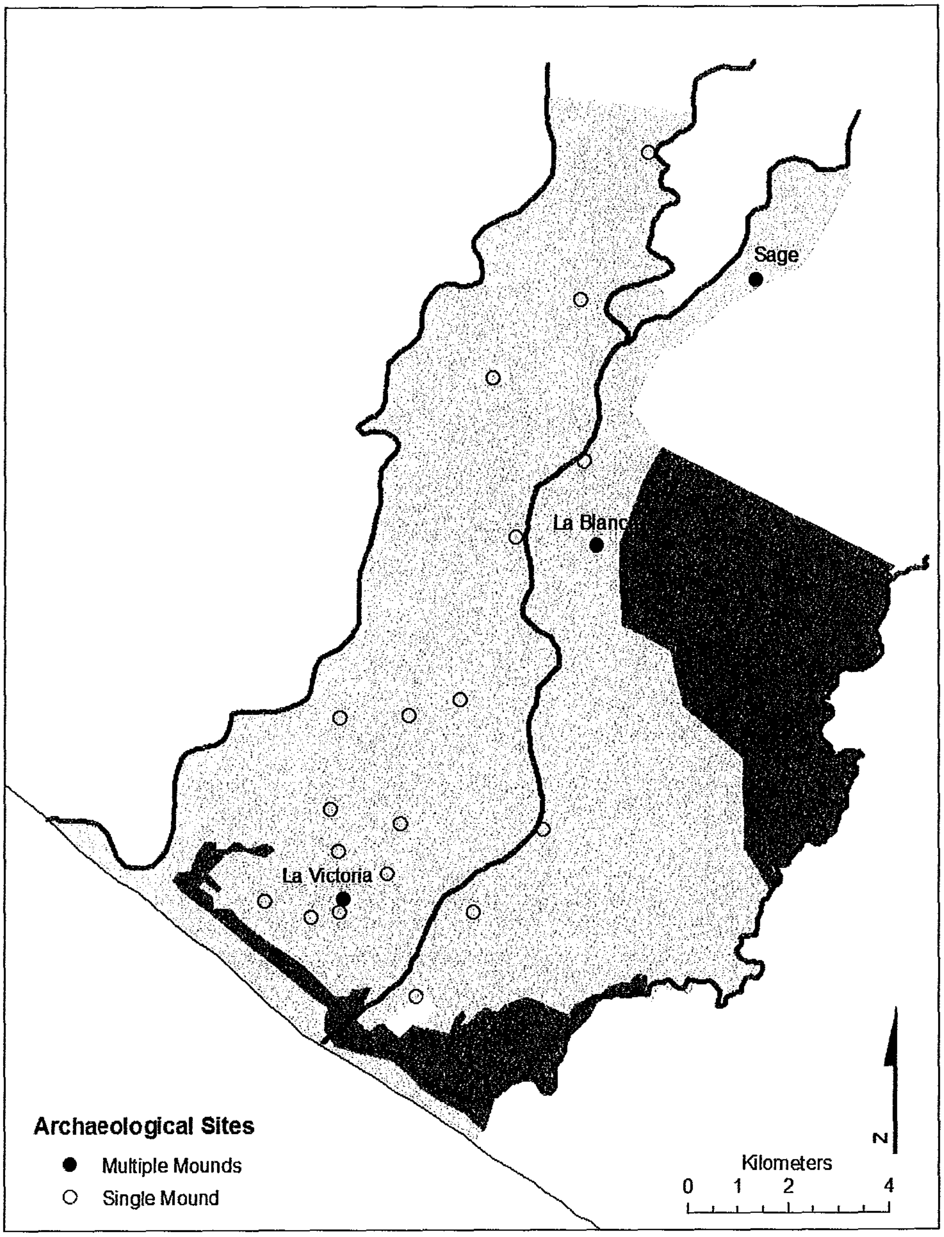

Figure 3-3. Early Formative Sites, Locona-Ocos Phase.

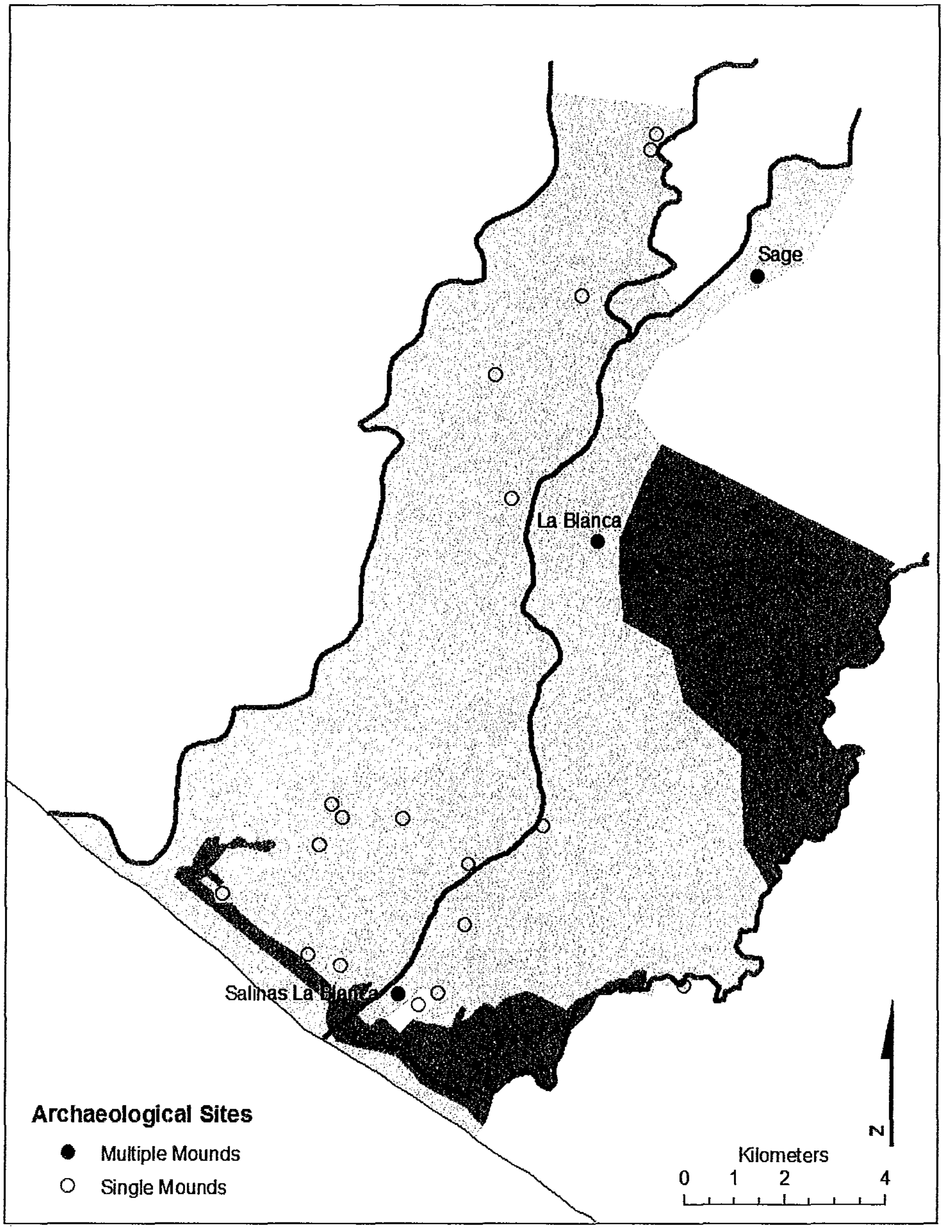

Figure 3-4. Early Formative Sites, Cuadros-Jocotal Phase.

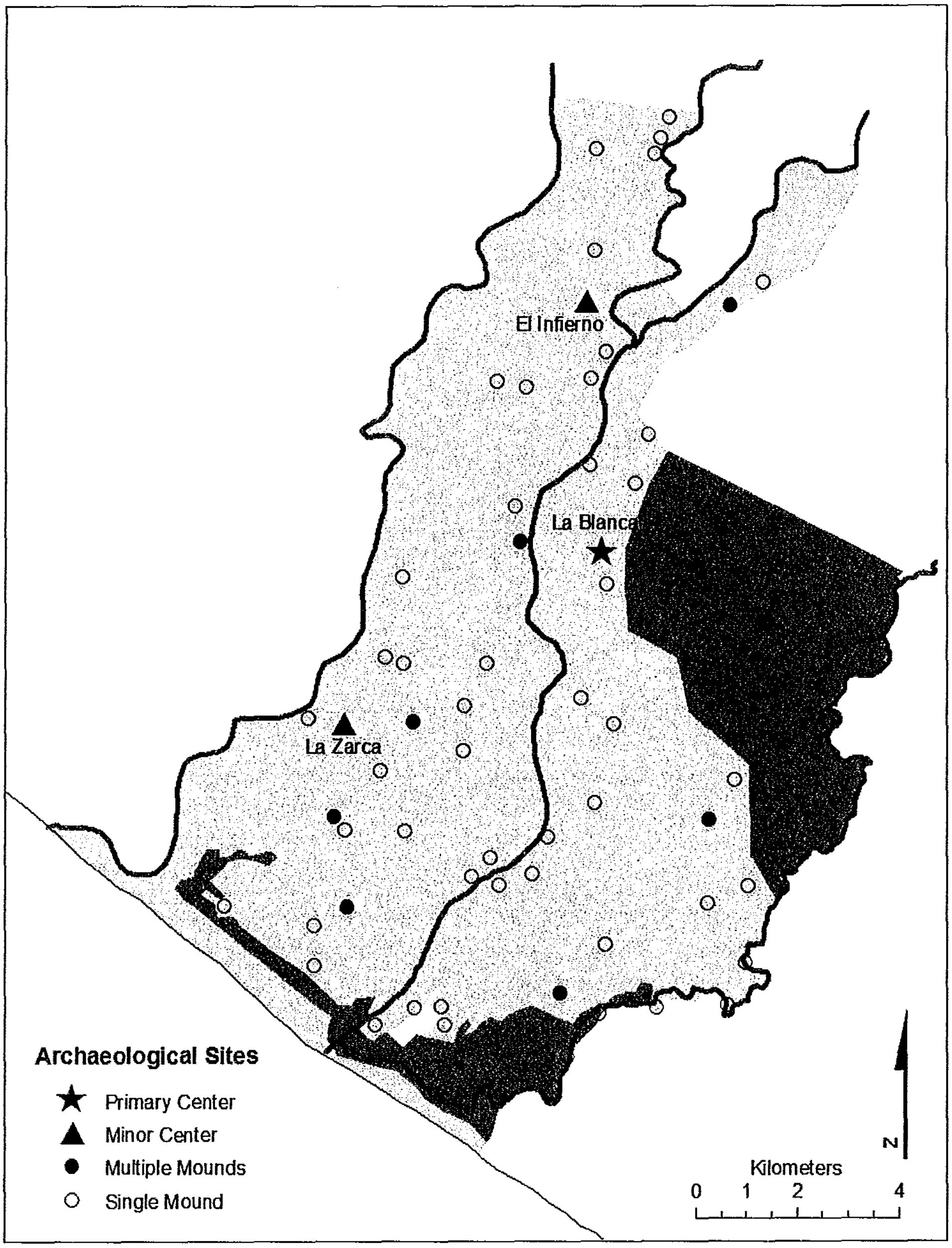

Figure 3-5. Middle Formative Sites.

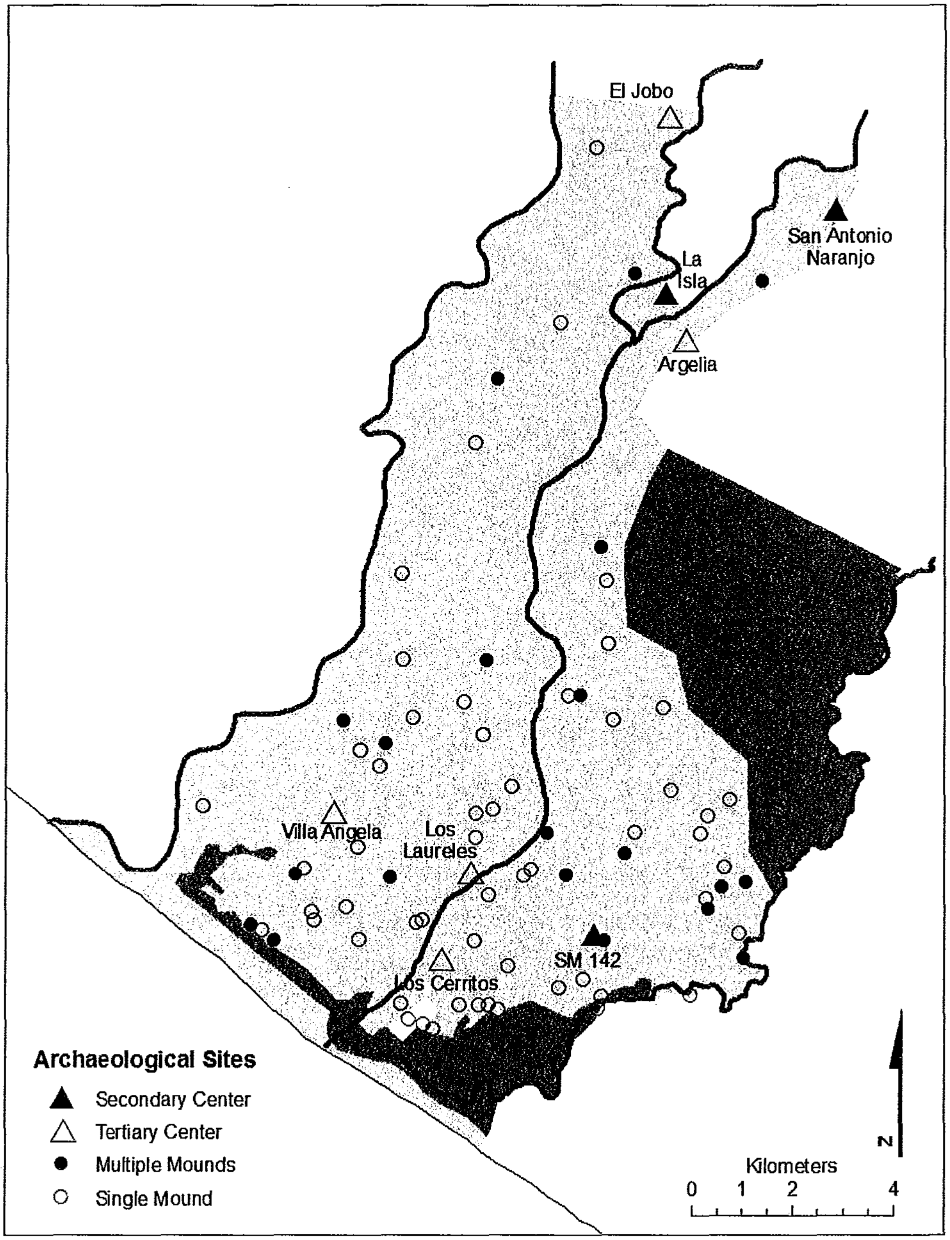

Figure 3-6. Late Formative Sites.

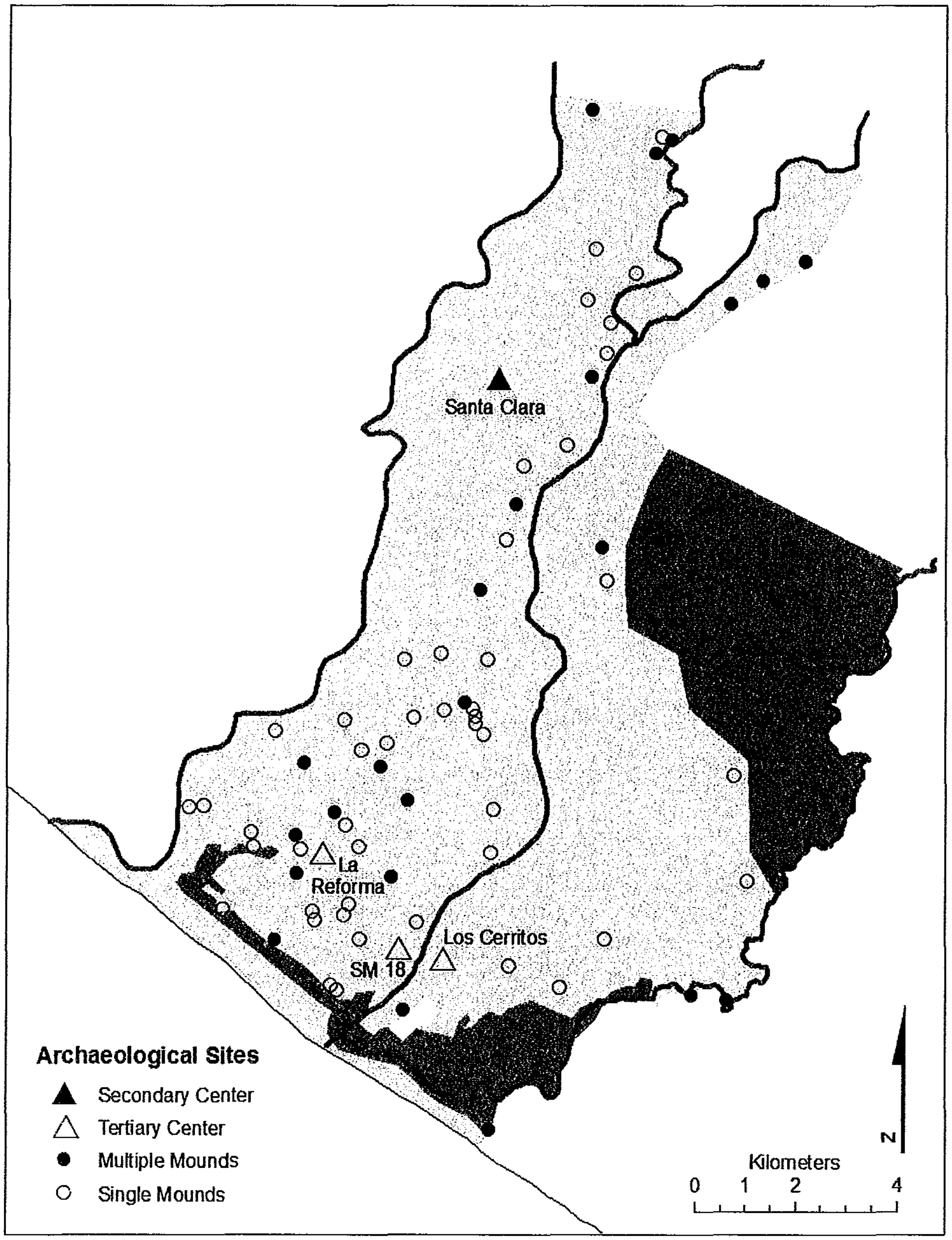

Figure 3-7. Late Classic Sites.

CHAPTER 4

ANALYSIS OF SETTLEMENT PATTERNS

This chapter reports the methodology and findings of the GIS and statistical analysis of settlement relationships to soils, agricultural resources and landscape features, and settlement evidence for trade, manipulation of ideology, and clustering and dispersion of settlements in the intensive survey zone.

Mean Center Analysis of Selection for Soil Types

Michael Love (1989) investigated the hypothesis that settlement locations were selected for their proximity to particular soil types. Love's procedure was to calculate the mean distance of households from the coast during the Locona-Ocos, Cuadros-Jocotal, and Middle Formative periods in relation to the distribution of soil types in the region. This investigation found a shift of the center of household residence southward from Tiquisate Franco Arenoso soils in the Early Formative Locona-Ocos phase to poorer Bucal soils in the Cuadros-Jocotal phase. Later, the center of household residence moved back north again into Tiquisate soils in the Middle Formative Conchas phase. This pattern was interpreted as reflecting possible abandonment of inland plain sites during Locona-Ocos times, followed by preferential selection for high quality Tiquisate soils and agricultural resources during the Middle Formative.

Figure 4-1 shows a GIS layer depicting the distribution of soils in the intensive survey area. This layer was digitized from a Guatemala government soil survey map

(Simmons, et al. 1959) at 1:250,000 scale and so provides only a very approximate estimate of soil distribution in the survey area.

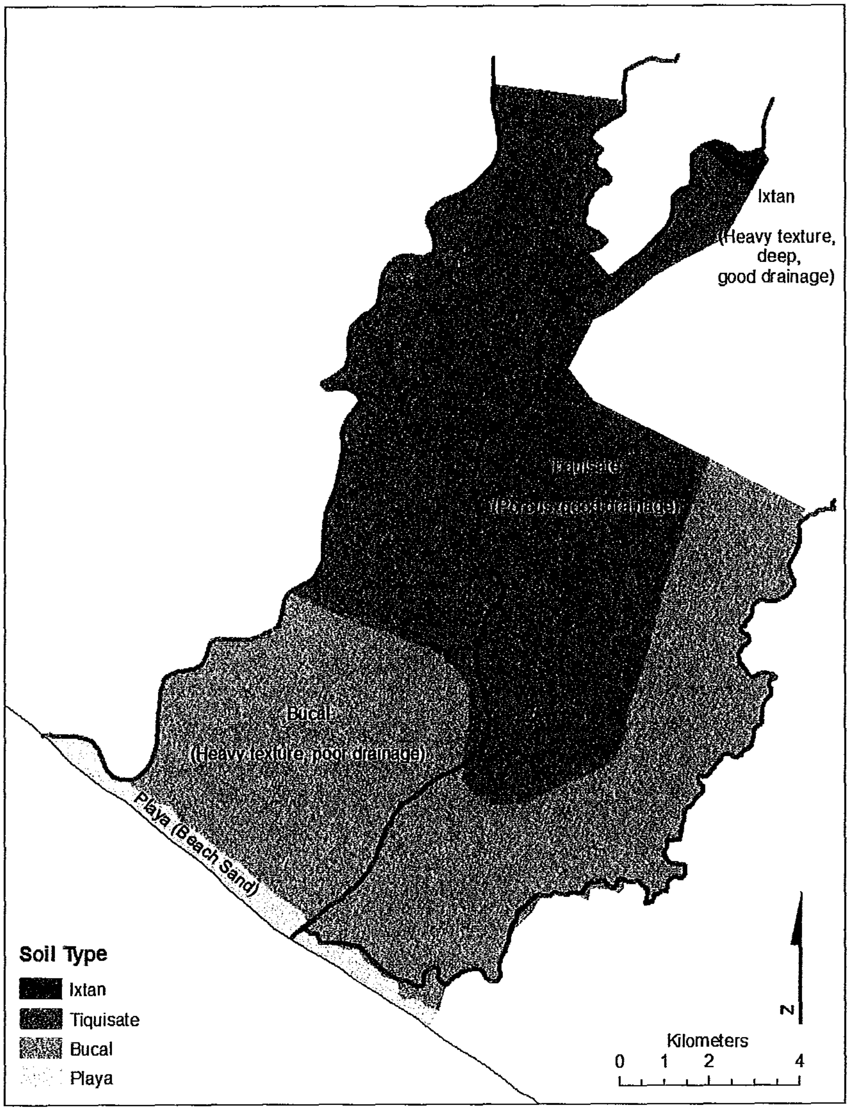

Figure 4-1. Soil Types.

Figure 4-2 shows the results of a GIS calculation similar to that performed by Michael Love. The ArcGIS Mean Center tool computed the simple spatial mean of settlement locations in each time period, as opposed to Love's calculation of the mean center weighted by an estimate of the number of households per settlement. However, the results are consistent and similar, showing slight movement southward from the Locona-Ocos phase to the Cuadros-Jocotal phase, followed by movement back northward in the Middle Formative period. However, the GIS calculation also extended into the Late Formative and Late Classic periods, and shows another cycle of movement south into Bucal soils during the late Formative period and then back again northward into Tiquisate soils in the Late Classic period. (It should be noted that during the Late Formative period the present survey area was just one part of a larger polity headed by El Ujuxte, located some 13 km east of La Blanca. If a complete data set were available for that total region the results of the mean center calculation would likely have been different.)

The comparison of mean center locations to soil type boundaries has several shortcomings. First, it is essentially a test of the hypothesis that soil quality influenced settlement locations during certain time periods, but provides no quantitative measure of the strength or statistical level of significance of that influence. Secondly, it is sensitive to the exact location of the boundaries between the various soil types, even though those boundaries are only approximations derived from a small-scale map of what is actually a gradual transition from one soil type to another. Finally, it provides no satisfactory explanation for the seemingly erratic movement of the mean center through the full range of time periods. However, an entirely different approach – Weights of Evidence – allows the formulation and testing of null hypotheses, and provides quantitative estimates of the relative strength and statistical significance of selection for soils as well as a broad range of other potentially influencing factors.

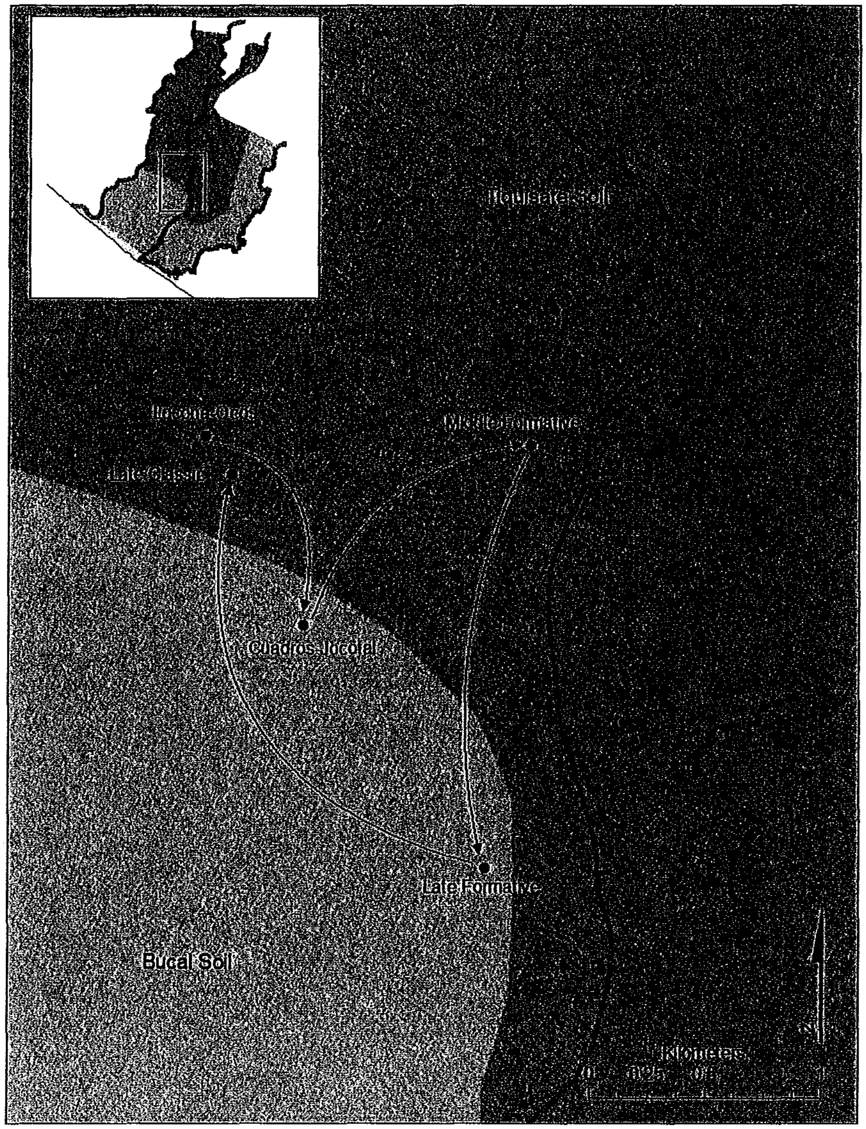

Figure 4-2. Mean Centers of Settlement.

Weights of Evidence

The Weights of Evidence method was originally developed to guide geophysical prospecting by predicting the locations of mineral deposits (Bonham-Carter 1994; Raines 1999). It has since been adapted for use in predicting archaeological site locations, including applications to ancient Maya sites in Belize (Ford, et al. 2009), and Native American sites in the Sacramento River delta (Hansen, et al. 2002), near Savannah, Georgia (Johnstone 2003), and in the Rocky Mountain National Park (Diggs and Brunswig 2009). Weights of Evidence software has been implemented as part of the System Data Modeling (SDM) extension to ArcGIS (Sawatzky, et al. 2009).

The process typically proceeds in two phases: data analysis and prediction. In the first phase, data analysis, a GIS map of the study area is overlaid with a series of patterns thought to be of potential value in predicting site locations. The patterns are binary and dichotomous, indicating the presence or absence of some feature or characteristic at each location covered. One pattern, for example, might divide the study area into locations covered by Bucal soil versus those not covered by Bucal soil. Another pattern layer might divide the same area into locations within one kilometer of a river versus locations farther away. After a large number of such patterns have been developed, each pattern is then evaluated in comparison to known archaeological site locations to develop weights measuring the relative strength of that pattern as a predictor of site locations.

In the second phase, prediction, the patterns are tested for conditional dependency. Those found to be dependent (i.e., redundant with each other) are eliminated or combined to strengthen the predictive power of the remaining patterns. The weights of the surviving patterns are then used to construct an equation, similar to a logistic regression equation, which estimates the probability of the presence of a site at any given location based on the configuration of patterns at that location. This predictive equation can then be used to prepare maps showing high and low probability areas for site locations.

The research reported in this thesis uses only the first (data analysis) phase of the overall process. There is high confidence that virtually all site locations in the intensive survey area are known (Love 1989), so there is no need for prediction of new site locations. Instead, the objective is to identify factors influencing the location of the known sites. This is accomplished by using the first phase of the Weights of Evidence process to calculate and compare weights for the potentially influencing factors.

The Weights of Evidence model requires that the study area first be divided into a grid having a large number of very small cells. Each archaeological site is modeled as occupying one and only one cell, and each cell can contain no more than one site. For this study the cell size was set to one hectare (100 meters x 100 meters), consistent with the site location survey accuracy of 100 meters. Also, the northeastern portion of the study area shown as *pampas* and seasonal wetlands in Figure 3-2, which was not occupied during any of the study time periods, was eliminated from the analysis to avoid distorting the results. The remaining habitable zone covers 137.48 sq km, or 13,748 cells.

A set of weights, one positive and one negative, is calculated for each pattern, together with the standard deviations of the weights. A positive weight, W^+, measures the strength of the pattern's contribution to predicting the presence of a site, while a negative weight, W^-, contributes to predicting the absence of a site. The weights are calculated as the natural logarithm of the odds ratio (i.e., the logit function) of the probabilities of a cell being in or out of the pattern given that it does or does not contain a site. Specifically:

$$W^{+} = \ln\frac{P(B|D)}{P(B|\overline{D})}$$

and

$$W^{-} = \ln\frac{P(\overline{B}|D)}{P(\overline{B}|\overline{D})}$$

where

ln =	The natural logarithm function
B =	The set of all cells in the pattern
D =	The set of all cells in the study area (minus the excluded wetlands zone) which contain a site
$P(B\|D)$ =	The probability that a cell containing a site is in the pattern
$P(B\|\overline{D})$ =	The probability that a cell not containing a site is in the pattern
$P(\overline{B}\|D)$ =	The probability that a cell containing a site is not in the pattern
$P(\overline{B}\|\overline{D})$ =	The probability that a cell not containing a site is not in the pattern

The probabilities are estimated on the basis of the relative densities of sites inside and outside the pattern, as calculated by the GIS. Specifically, let:

$N(X)$ = The number of cells in a set X.

Then

$$P(B|D) = \frac{N(B \cap D)}{N(D)}$$

$$P(B|\overline{D}) = \frac{N(B \cap \overline{D})}{N(\overline{D})}$$

$$P(\overline{B}|D) = \frac{N(\overline{B} \cap D)}{N(D)}$$

and

$$P(\overline{B}|\overline{D}) = \frac{N(\overline{B} \cap \overline{D})}{N(\overline{D})}$$

A positive weight can have a positive, negative, or zero value. A positive value indicates that a site is more likely to be found in the pattern than would be the case if the site locations were perfectly randomly distributed. The assumption is that the conditions represented by the pattern, such as the presence of some particular soil type, have influenced the selection of the site locations. A negative value indicates that a site is less likely to be found in the pattern than would be the case if the sites were randomly distributed. A value of zero indicates that the sites are distributed randomly and not influenced by the pattern. An absolute value between 0 and 0.5 indicates a mild association (positive or negative) of sites with the pattern, 0.5 to 1.0 a moderate association, 1.0 to 2.0 a strong association, and a value greater than 2.0 indicates a very strong association.

In the same way, the negative weight can have a positive, negative or zero value, indicating the strength of the pattern as a predictor of the absence of sites. The positive and negative weights may not be balanced. For example, a small negative value for the positive weight might be combined with a large positive value for the negative weight, indicating that the positive weight is a weak predictor of the absence of site locations, but that the negative weight is a strong predictor of their absence.

The contrast of a pattern, *C*, calculated as the arithmetic difference between its positive and negative weights, combines the positive and negative weights into an overall measure of strength of the pattern as a predictor of site locations relative to other patterns:

$$C = W^{+} - W^{-}$$

A large positive value for contrast means that there is a higher probability that sites are located inside the pattern than outside (and vice-versa for a large negative value). A small value for contrast means that the probability of a site being inside the pattern is about the same as the probability of it being outside, so the pattern would be of little or no predictive value.

Dividing the contrast by its standard deviation yields a normalized contrast closely approximating a *z* or *t* statistic for hypothesis testing:

$$z \cong \frac{C}{\sqrt{S(W^{+})^2 + S(W^{-})^2}}$$

where

$$S(W^{+}) = \sqrt{\frac{1}{N(D \cap B)} + \frac{1}{N(D \cap \overline{B})}}$$

and

$$S(W^{-}) = \sqrt{\frac{1}{N(\overline{D} \cap B)} + \frac{1}{N(\overline{D} \cap \overline{B})}}$$

By use of the normal density function the normalized contrast can be converted to a *p* value, the probability of a Type I error in falsely rejecting the null hypothesis that site locations are randomly distributed over the study area:

$$p = min[f(z), 1 - f(z)]$$

where

$$f(z) = \frac{1}{2\sqrt{2\pi}} e^{-\frac{z^2}{2}}$$

The *p* value can then be compared to a pre-determined level of statistical significance to decide whether to accept or reject the null hypothesis. For the purposes of this thesis a pattern is considered significant only if there is some theoretical justification for the belief that the pattern might have predictive value, and the *p* statistic does not exceed an arbitrarily assigned level of significance of $p = 0.02$ (i.e., 98% confidence).

The overall Weights of Evidence procedure and underlying mathematical derivations are more fully outlined by Raines (1999), Kemp et. al. (1999), and Sawatzky et. al. (2009), and are treated in depth by Bonham-Carter (1994).

Selection for Agricultural Resources

Table 4-1 shows the results of applying Weights of Evidence to compare the site distributions in each time period in Figures 3-3 through 3-7 to the soil distribution patterns shown in Figure 4-1. Statistically significant results are highlighted.

Weights are calculated separately for each pattern in each time period. The results show a statistically significant association of settlements with Bucal soils during the Late Classic and Late Formative periods. There is also a slight tendency toward the same pattern in the other time periods, but not statistically significant.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	Playa	5.0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	Bucal	58.9	45	0.3658	0.1496	-0.4004	0.1893	0.7662	0.2413	3.1750	0.001
	Tiquisate	72.9	28	-0.3256	0.1893	0.2737	0.1496	-0.5993	0.2413	-2.4837	0.007
	Ixtan	0.7	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
Late Formative	Playa	5.0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	Bucal	58.9	55	0.4391	0.1344	-0.5295	0.1893	0.9686	0.2328	4.1606	0.000
	Tiquisate	72.9	28	-0.4547	0.1893	0.3469	0.1354	-0.8016	0.2328	-3.4433	0.000
	Ixtan	0.7	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
Mid Formative	Playa	5.0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	Bucal	58.9	31	0.1878	0.1801	-0.1681	0.1860	0.3559	0.2589	1.3746	0.085
	Tiquisate	72.9	29	-0.0933	0.1861	0.0959	0.1800	-0.1892	0.2589	-0.7309	0.232
	Ixtan	0.7	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
Cuadros-Jocotal	Playa	5.0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	Bucal	58.9	14	0.3961	0.2676	-0.4526	0.3537	0.8486	0.4435	1.9133	0.028
	Tiquisate	72.9	8	0.3780	0.3537	0.3044	0.2676	-0.6824	0.4435	-1.5386	0.062
	Ixtan	0.7	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
Locona-Ocos	Playa	5.0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	Bucal	58.9	12	0.2882	0.2890	-0.2880	0.3335	0.5762	0.4413	1.3057	0.096
	Tiquisate	72.9	9	-0.2135	0.3335	0.1966	0.2889	-0.4100	0.4413	-0.9292	0.176
	Ixtan	0.7	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500

Table 4-1. Analysis of Selection for Soil Type.

Soil type is only one factor determining the overall agricultural productive capacity of land. Other factors include slope, drainage, soil depth, soil chemistry, amount of erosion, and management practices, among others. In 1980 the Government of Guatemala published a map classifying the agricultural productive capacity of land in Guatemala (Guatemala 1980). The map is at a scale of 1:500,000 and so provides only a very approximate indication of the boundaries separating the productive capacity zones. Also, the map reflects agricultural productive capacity assuming modern farming technology rather than the capabilities of ancient Mesoamericans. Nevertheless, the portion of the map covering the present study area was digitized and analyzed using Weights of Evidence to determine if it provides any insight into ancient settlement preferences.

Figure 4-3 shows the GIS layer for agricultural productive capacity as digitized from the 1980 map. The zone classifications are based on a system developed by the Soil Conservation Service of the United States Department of Agriculture and adopted by the Government of Guatemala. Five of the system's total of eight zone types are found in the study area. Type 1 land has good water supply and flat terrain, offers high productivity with a low level of management, and is suitable for mechanized cultivation with few or no limitations. Type 3 land is flat, rolling or slightly sloped, needs additional water, offers moderate productivity but only with intensive management practices, and is suitable for mechanized cultivation with moderate limitations. Type 5 has generally poor drainage and is often rocky. It is generally unsuitable for mechanized cultivation, but is suitable for pasture, forest, or wildlife. Type 6 land, often located in mountains or at the edge of forests or pastures, can be cultivated only with continual effort. Type 8 land is non-arable and suitable only for such uses as parks, recreation, wildlife, and the protection of watersheds. Type 8 land in the present study area is basically the mangrove lagoon zone and salt flats.

Table 4-2 shows the results of the Weights of Evidence analysis for agricultural productive capacity. The analysis shows a statistically significant association of settlements with low productivity Type 3 land during the Late Formative period, and for non-arable Type 8 land (mangrove area) during the Cuadros-Jocotal phase of the Early Formative period.

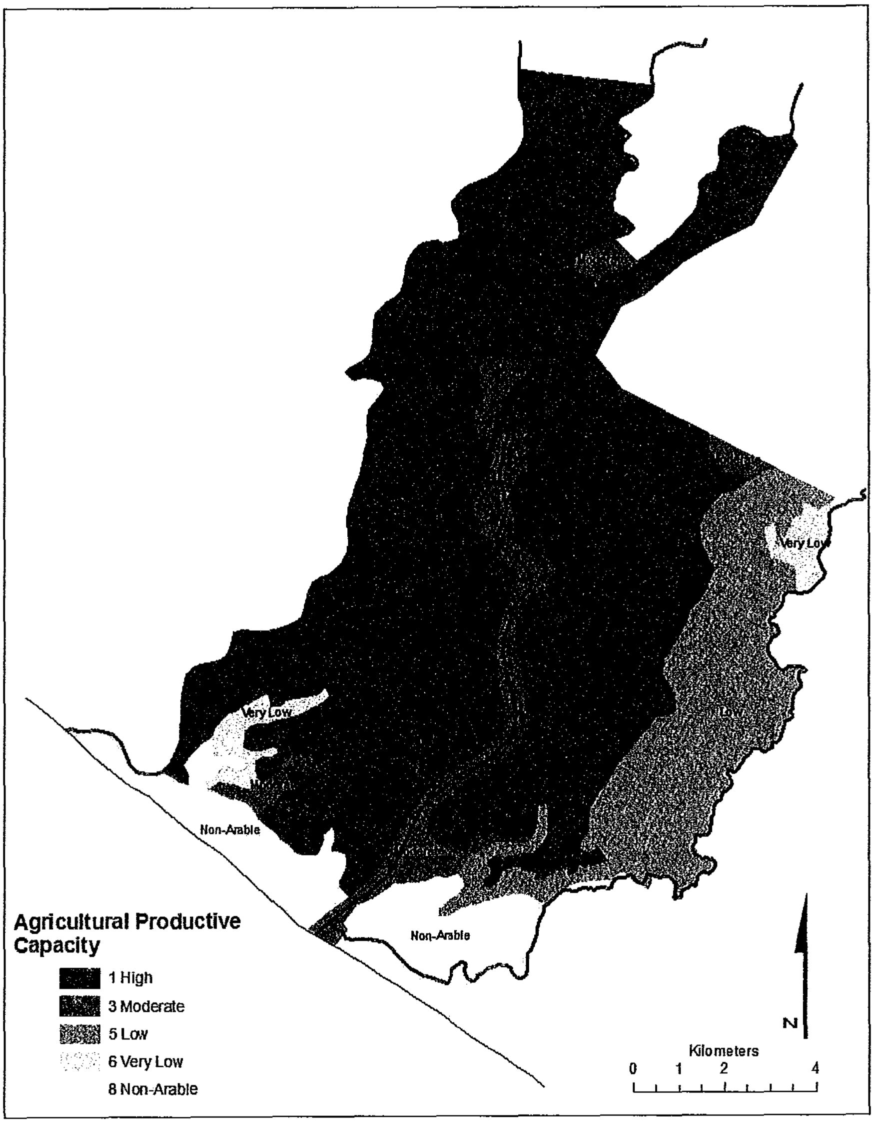

Figure 4-3. Agricultural Productive Capacity.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	1 High	97.05	57	0.1014	0.1328	-0.2953	0.2505	0.3966	0.2835	1.3989	0.081
	3 Moderate	11.42	3	-0.7068	0.5781	0.0450	0.1199	-0.7518	0.5904	-1.2734	0.101
	5 Low	10.97	6	0.0295	0.4094	-0.0026	0.1225	0.0320	0.4273	0.0750	0.470
	6 Very Low	1.94	1	-0.0290	1.0026	0.0004	0.1182	-0.0294	1.0095	-0.0291	0.488
	8 Non-Arable	16.09	6	-0.3551	0.4090	0.0389	0.1225	-0.3940	0.4270	-0.9228	0.178
Late Formative	1 High	97.05	53	-1.0090	0.1377	0.2077	0.1833	-0.3086	0.2292	-1.3463	0.089
	3 Moderate	11.42	4	-0.5474	0.5009	0.0376	0.1129	-0.5850	0.5134	-1.1393	0.127
	5 Low	10.97	16	0.8904	0.2518	-0.1317	0.1225	1.0221	0.2801	3.6496	0.000
	6 Very Low	1.94	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	8 Non-Arable	16.09	10	0.0291	0.3172	-0.0039	0.1174	0.0331	0.3382	0.0977	0.461
Mid Formative	1 High	97.05	40	-0.0575	0.1584	0.1259	0.2242	-0.1834	0.2745	-0.6682	0.252
	3 Moderate	11.42	4	-0.2212	0.5009	0.0178	0.1339	-0.2390	0.5185	-0.4610	0.322
	5 Low	10.97	7	0.3816	0.3792	-0.0410	0.1376	0.4226	0.4034	1.0477	0.147
	6 Very Low	1.94	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	8 Non-Arable	16.09	9	0.2493	0.3343	-0.0382	0.1403	0.2875	0.3625	0.7931	0.214
Cuadros-Jocotal	1 High	97.05	11	-0.3454	0.3017	0.5319	0.3019	-0.8773	0.4268	-2.0556	0.020
	3 Moderate	11.42	3	0.4963	0.5781	-0.0599	0.2296	0.5563	0.6220	0.8943	0.186
	5 Low	10.97	1	-0.5637	1.0005	0.0367	0.2184	-0.6005	1.0240	-0.5864	0.279
	6 Very Low	1.94	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	8 Non-Arable	16.09	7	1.0028	0.3788	-0.2589	0.2584	1.2617	0.4585	2.7518	0.003
Locona-Ocos	1 High	97.05	17	0.1371	0.2427	-0.4348	0.5002	0.5719	0.5560	1.0286	0.152
	3 Moderate	11.42	3	0.5429	0.5781	-0.0675	0.2359	0.6104	0.6244	0.9776	0.164
	5 Low	10.97	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	6 Very Low	1.94	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500
	8 Non-Arable	16.09	1	-0.9002	1.0003	0.0758	0.2238	-0.9760	1.0250	-0.9522	0.170

Table 4-2. Analysis of Selection for Agricultural Productive Capacity.

The current vegetative coverage and agricultural uses of the land in the study area might also provide some insight into uses in ancient times. In 1982 the Government of Guatemala published a map (Guatemala 1982) which classified the then-current coverage and use of the land. Four of the classifications are found within the present study area: Classification 2.1.1, Principally Cotton; 2.1.4, Corn, Bananas and Cultivated Pastures; 3.1, Cultivated Pastures; and 4.3, Mangroves. The map is at the very small scale of 1:500,000 so, again, the zone boundaries are only very approximate. Figure 4-4 shows the GIS layer digitized from the map, and Table 4-3 shows the results of the Weights of Evidence analysis. The table shows a statistically significant association of ancient settlement in the Classic period with areas that were used for cotton growing in 1982. It also shows a statistically significant association of Late Formative settlements with areas used for corn, bananas and pasture in 1982.

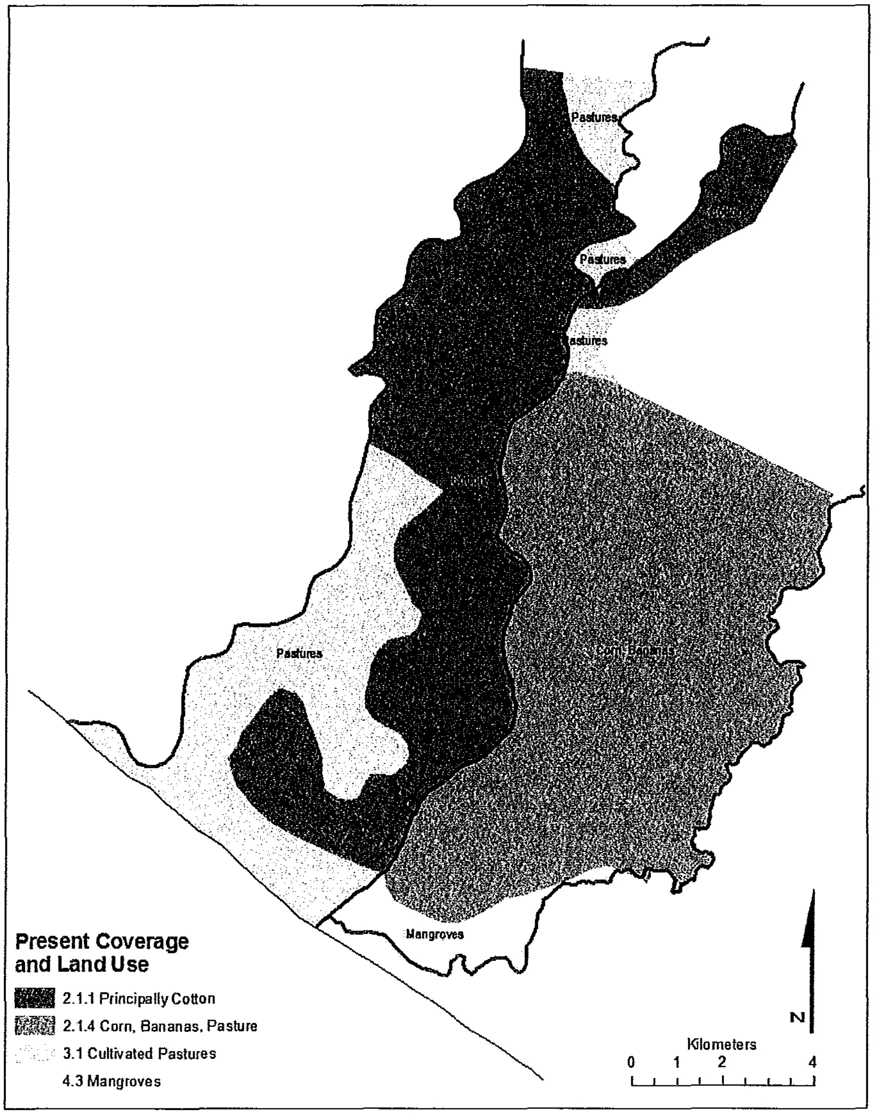

Figure 4-4. Current Coverage and Land Use (1982).

Period	Pattern	Area Sq km	No of Sites N	Pos Weight W+	St Dev Pos Wt S(W+)	Neg Weight W-	St Dev Neg Wt S(W-)	Contrast C	St Dev Contrast S(C)	Normalized Contrast z	Level of Signif p
Classic	2.1.1 Principally Cotton	57.13	40	0.2783	0.1587	-0.2581	0.1744	0.5363	0.2358	2.2744	0.011
	2.1.4 Corn, Bananas, Pasture	42.19	10	-0.8094	0.3166	0.2205	0.1264	-1.0299	0.3409	-3.0211	0.001
	3.1 Cultivated Pastures	30.55	21	0.2598	0.2190	-0.0884	0.1390	0.3482	0.2594	1.3426	0.090
	4.3 Mangroves	7.62	2	-0.7069	0.7080	0.0294	0.1190	-0.7363	0.7180	-1.0255	0.153
Late Formative	2.1.1 Principally Cotton	57.13	24	-0.3645	0.2046	0.1971	0.1307	-0.5616	0.2427	-2.3137	0.010
	2.1.4 Corn, Bananas, Pasture	42.19	40	0.4549	0.1589	-0.2927	0.1528	0.7476	0.2205	3.3911	0.000
	3.1 Cultivated Pastures	30.55	16	-0.1428	0.2507	0.0374	0.1226	-0.1802	0.2790	-0.6459	0.259
	4.3 Mangroves	7.62	3	-0.4292	0.5785	0.0203	0.1121	-0.4495	0.5893	-0.7629	0.223
Mid Formative	2.1.1 Principally Cotton	57.13	18	-0.3271	0.2361	0.1813	0.1547	-0.5083	0.2823	-1.8010	0.036
	2.1.4 Corn, Bananas, Pasture	42.19	21	0.1322	0.2188	-0.0645	0.1605	0.1967	0.2713	0.7252	0.234
	3.1 Cultivated Pastures	30.55	16	0.1833	0.2507	-0.0591	0.1511	0.2425	0.2927	0.8285	0.204
	4.3 Mangroves	7.62	5	0.4104	0.4487	-0.0301	0.1351	0.4406	0.4686	0.9402	0.174
Cuadros-Jocotal	2.1.1 Principally Cotton	57.13	7	-0.2674	0.3782	0.1544	0.2584	-0.4217	0.4581	-0.9207	0.179
	2.1.4 Corn, Bananas, Pasture	42.19	6	-0.1181	0.4085	0.0481	0.2502	-0.1662	0.4791	-0.3469	0.364
	3.1 Cultivated Pastures	30.55	7	0.3598	0.3784	-0.1319	0.2584	0.4917	0.4582	1.0731	0.142
	4.3 Mangroves	7.62	2	0.4963	0.7080	-0.0384	0.2238	0.5346	0.7426	0.7200	0.236
Locona-Ocos	2.1.1 Principally Cotton	57.13	9	0.0309	0.3336	-0.0226	0.2889	0.0534	0.4413	0.1211	0.452
	2.1.4 Corn, Bananas, Pasture	42.19	5	-0.2540	0.4475	0.0947	0.2502	-0.3488	0.5127	-0.6802	0.248
	3.1 Cultivated Pastures	30.55	7	0.4064	0.3784	-0.1544	0.2674	0.5608	0.4634	1.2102	0.113
	4.3 Mangroves	7.62	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500

Table 4-3. Analysis of Selection for Current Coverage and Land Use.

Selection for Foraging Resources

Settlement patterns reflecting foraging for marine and riverine resources might be expected to show significant spatial associations with the shoreline, the rivers and the mangrove lagoons. For example, there might be a preference for locations within some reasonable walking distance to the shoreline or the mangroves. In the case of rivers, Weights of Evidence studies often show a preference for locations at intermediate distances, accessible to the water and riverine resources but not so close as to be susceptible to flooding or water-borne military attack.

The ArcGIS SDM software tests patterns of incrementally increasing or decreasing distance to or from such geographic features to determine if there is a preferred or optimum distance. The present study area, for example, was divided into one kilometer wide strips parallel to the shoreline. For each time period, SDM calculated weights and contrast for the area one kilometer from the shore, then for two kilometers, etc., up to the maximum distance of 29 kilometers. The software then selected the distance having the maximum contrast. The results shown in Figure 4-5 and Table 4-4 suggest a preference for proximity to the shoreline in the Cuadros-Jocotal phase, the Late Formative period, and the Late Classic period. There was also some evidence of a similar pattern in the Locona-Ocos phase and Middle Formative period but not statistically significant.

Figure 4-6 and Table 4-5 show the results of a similar analysis for proximity to rivers. In this case the association was found to be for distance away from the rivers rather than towards the rivers. The results are statistically significant for all but the Middle Formative period.

Figure 4-7 and Table 4-6 show the results for analysis of the zone of mangroves, lagoons, and a one kilometer buffer around the mangroves. The results indicate a statistically significant association with settlement only in the Cuadros-Jocotal phase.

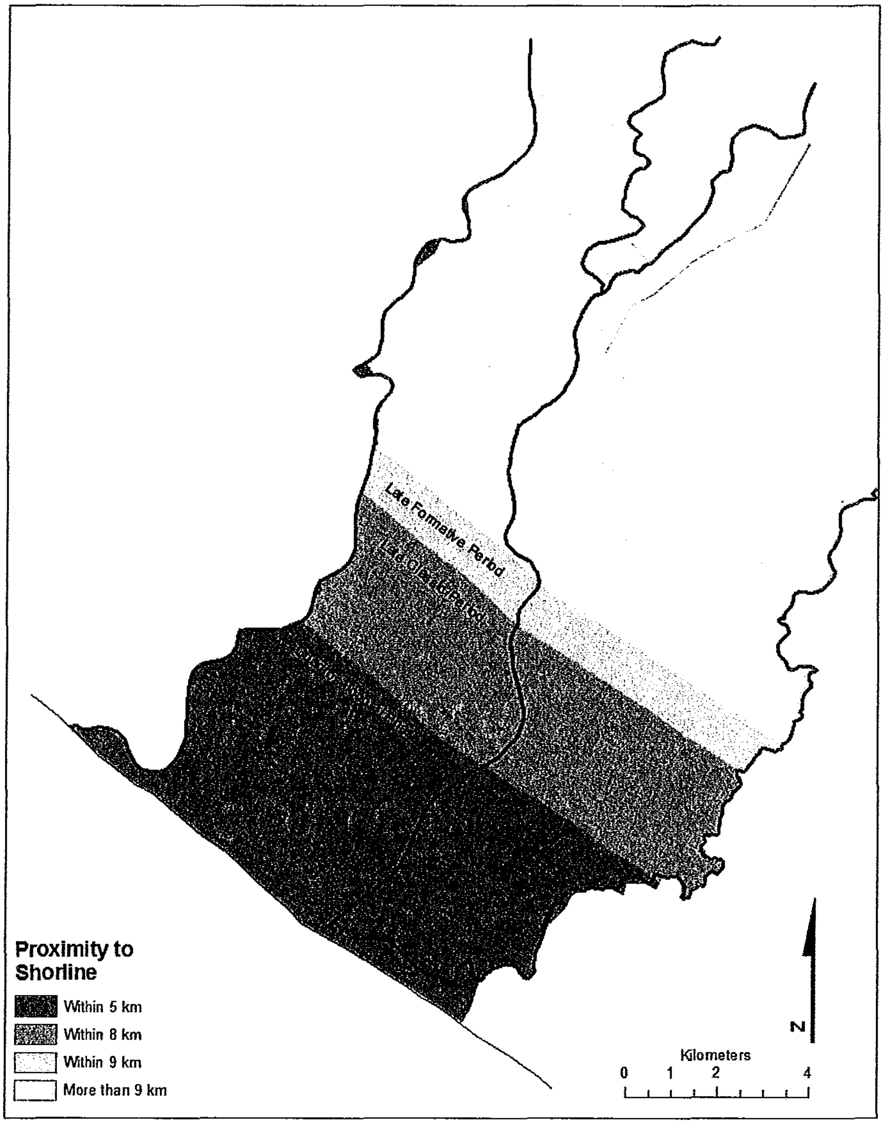

Figure 4-5. Proximity to Shoreline.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	Within 8 km of Shoreline	76.26	51	0.2206	0.1405	-0.3777	0.2135	0.5982	0.2557	2.3399	0.010
Late Formative	Within 9 km of Shoreline	85.55	69	0.2802	0.1209	-0.8904	0.2675	1.0706	0.2937	3.6457	0.000
Mid Formative	Within 9 km of Shoreline	85.55	41	0.0826	0.1565	-0.1579	0.2298	0.2404	0.2781	0.8645	0.194
Cuadros-Jocotal	Within 5 km of Shorline	45.80	14	0.6372	0.2677	-0.6014	0.3537	1.2386	0.4436	2.7922	0.003
Locona-Ocos	Within 4 km of Shoreline	36.26	9	0.4750	0.3337	-0.2497	0.2888	0.7246	0.4414	1.6417	0.050

Table 4-4. Analysis of Selection for Proximity to Shoreline.

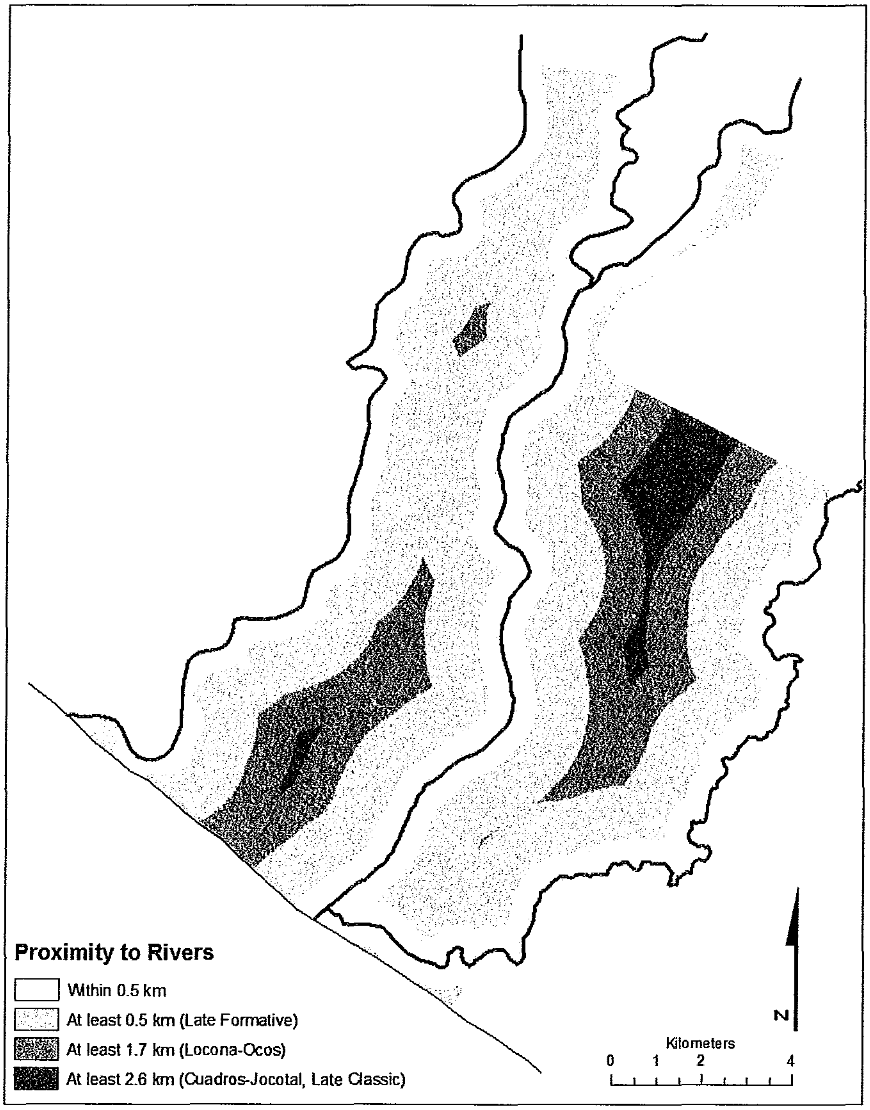

Figure 4-6. Proximity to Rivers.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	At Least 2.6 km From Rivers	1.85	4	1.4190	0.5055	-0.0430	0.1207	1.4620	0.5197	2.8132	0.002
Late Formative	At Least 0.5 km From Rivers	101.75	71	0.1458	0.1191	-0.5889	0.2892	0.7350	0.3127	2.3504	0.009
Mid Formative	At Least 2.6 km From Rivers	1.85	1	0.2134	1.0027	-0.0033	0.1305	0.2166	1.0112	0.2142	0.415
Cuadros-Jocotal	At Least 2.6 km From Rivers	1.85	2	1.9180	0.7110	-0.0819	0.2238	1.9999	0.7453	2.6832	0.004
Locona-Ocos	At Least 1.7 km From Rivers	24.25	9	0.8899	0.3340	-0.3660	0.2888	1.2559	0.4415	2.8444	0.002

Table 4-5. Analysis of Selection for Proximity to Rivers.

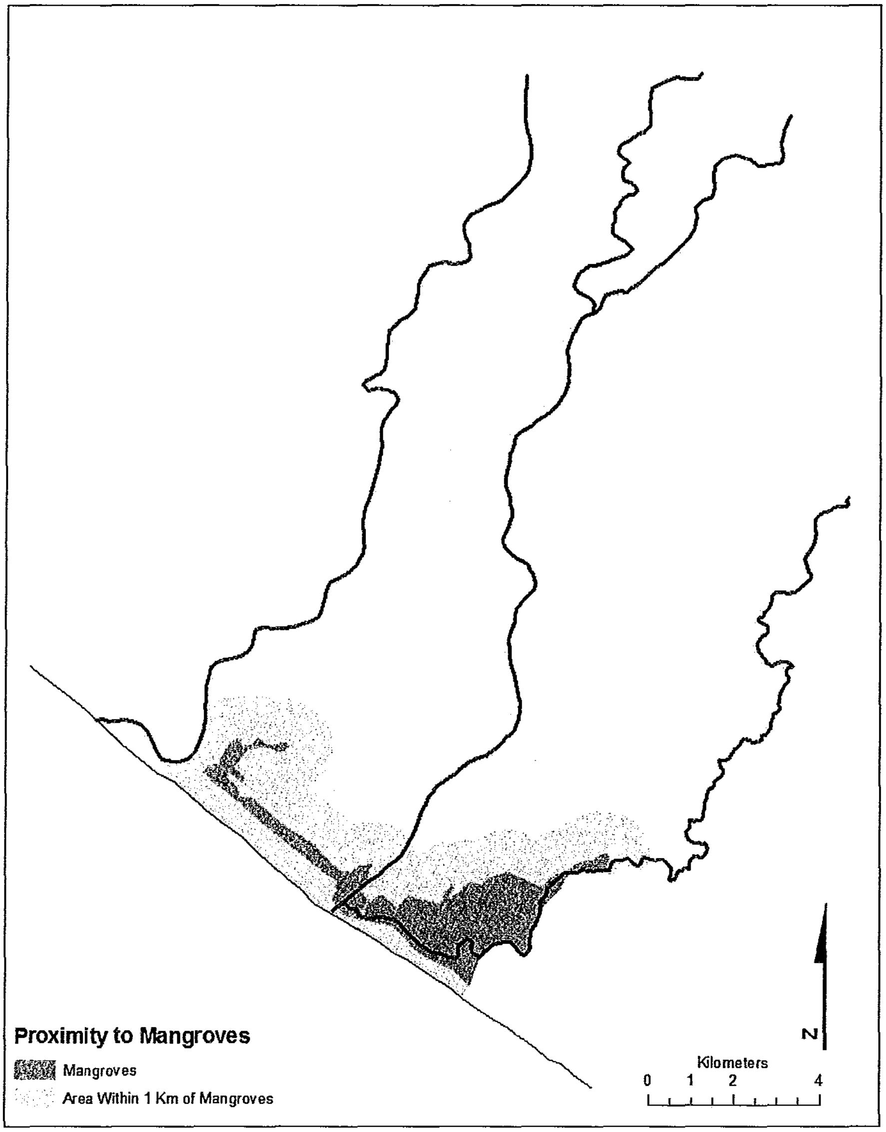

Figure 4-7. Proximity to Mangroves.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	Wiithin 1 km of Mangroves	29.25	18	0.1623	0.2364	-0.0487	0.1364	0.2110	0.2730	0.7729	0.220
Late Formative	Wiithin 1 km of Mangroves	29.25	21	0.1745	0.2190	-0.0528	0.1274	0.2273	0.2533	0.8970	0.185
Mid Formative	Wiithin 1 km of Mangroves	29.25	12	-0.0621	0.2893	0.0161	0.1447	-0.0782	0.3234	-0.2418	0.404
Cuadros-Jocotal	Wiithin 1 km of Mangroves	29.25	9	0.6553	0.3338	-0.2873	0.2775	0.9426	0.4341	2.1712	0.015
Locona-Ocos	Wiithin 1 km of Mangroves	29.25	3	-0.3988	0.5776	0.0852	0.2359	-0.4840	0.6240	-0.7757	0.219

Table 4-6. Analysis of Selection for Proximity to Mangroves.

Selection for Trade Resources

As discussed in Chapter 2, long distance trade is characteristic of the regional polity level of complexity in the classification system of Johnson and Earle (2000). Settlement pattern indicators of trade could include remains of production facilities or workshops in the resource area, or settlements in strategic positions to control access to the resource.

Two long-distance trade resources are found in the study area. The first is salt, which is still exploited today from the Salinas Las Victorias and Salinas Tilapa salt flats in the southern portion of the region. Figure 4-8 shows the salt flats and a surrounding one kilometer buffer. Table 4-7 shows a statistically significant settlement relationship to this resource zone only in the Cuadros-Jocotal phase. However, this result may be an artifact due to small sample sizes: at least one settlement was actually located in or immediately adjacent to at least one of the salt flats in every time period.

The other trade resource is plumbate clay. Plumbate pottery was widely traded throughout Mesoamerica during the Classic period. The present study area appears to contain the only known source of one of the two types of plumbate clay, the San Juan type (Neff 2002). Figure 4-9 shows a map of the approximate San Juan plumbate clay zone, redrawn from Neff (2002). However, Table 4-8 shows that a Weights of Evidence analysis of the plumbate clay zone failed to find any statistically significant association with settlement in any time period.

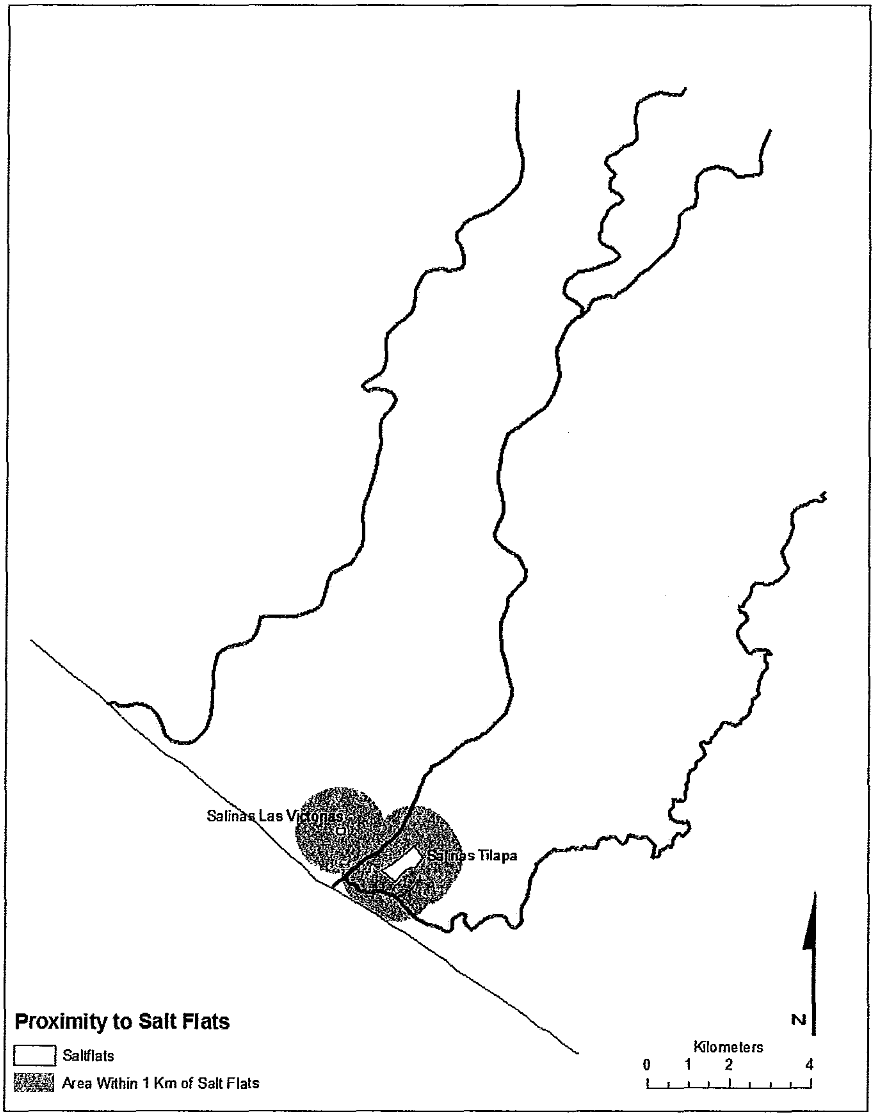

Figure 4-8. Proximity to Salt Flats.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	Within 1 km of Salt Flats	9.22	5	0.0356	0.4484	-0.0026	0.1225	0.0382	0.4649	0.0822	0.467
Late Formative	Within 1 km of Salt Flats	9.22	8	0.3659	0.3551	0.0322	0.1158	0.3981	0.3735	1.0658	0.143
Mid Formative	Within 1 km of Salt Flats	9.22	5	0.2188	0.4484	-0.0177	0.1351	0.2365	0.4683	0.5050	0.307
Cuadros-Jocotal	Within 1 km of Salt Flats	9.22	5	1.2249	0.4484	-0.1877	0.2427	1.4136	0.5099	2.7724	0.003
Locona-Ocos	Within 1 km of Salt Flats	9.22	1	-0.3423	1.0005	0.0206	0.2238	-0.3629	1.0253	-0.3540	0.362

Table 4-7. Analysis of Selection for Proximity to Salt Flats.

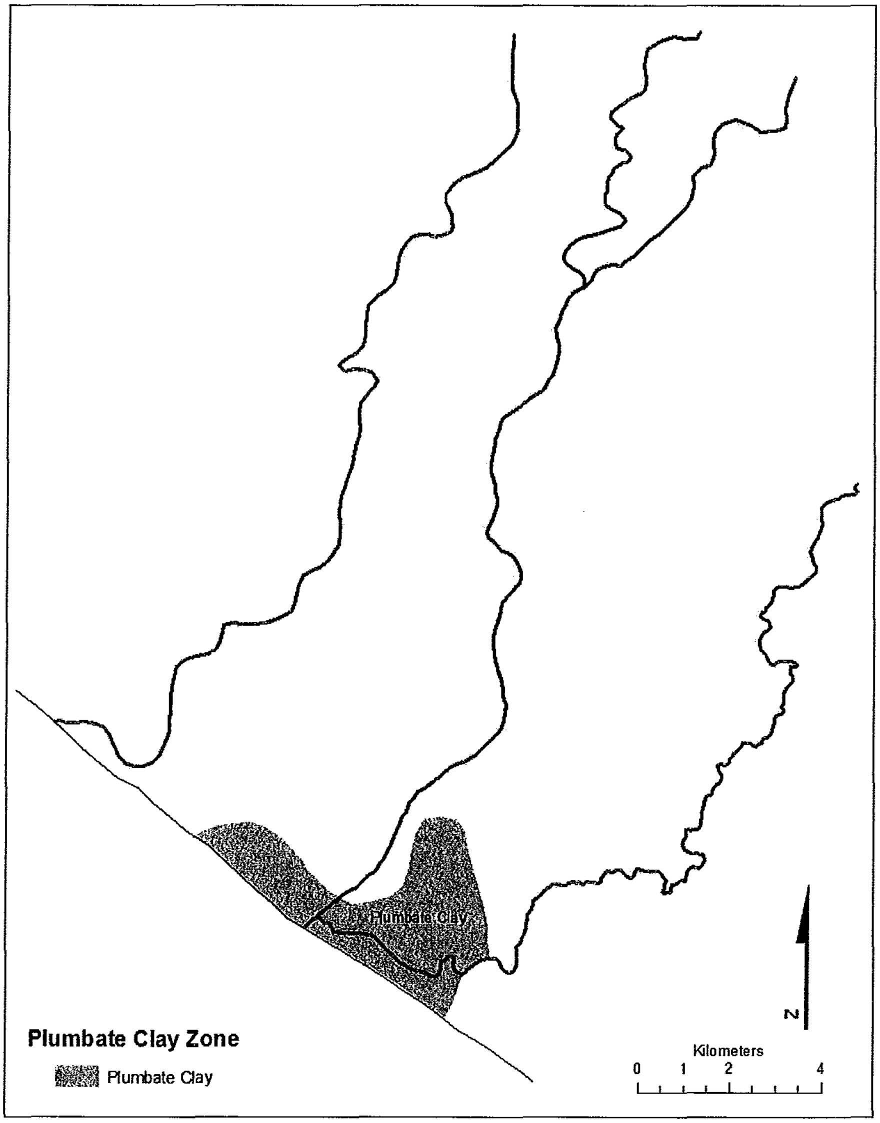

Figure 4-9. Proximity to Plumbate Clay.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	Plumbate Clay Zone	12.06	3	-0.7615	0.5781	0.0502	0.1199	-0.8117	0.5904	-1.3749	0.085
Late Formative	Plumbate Clay Zone	12.06	9	0.2130	0.3346	-0.0231	0.1166	0.2361	0.3543	0.6662	0.253
Mid Formative	Plumbate Clay Zone	12.06	3	-0.5644	0.5781	0.0407	0.1328	-0.6052	0.5931	-1.0203	0.154
Cuadros-Jocotal	Plumbate Clay Zone	12.06	4	0.7301	0.5008	-0.1090	0.2359	0.8391	0.5536	1.5158	0.065
Locona-Ocos	Plumbate Clay Zone	12.06	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.500

Table 4-8. Analysis of Selection for Proximity to Plumbate Clay.

Selection for Topography

Weights of Evidence analyses in other regions, such as the Belize Valley (Ford, et al. 2009) or Rocky Mountain National Park (Diggs and Brunswig 2009), often find preferential selection for certain topographic features such as elevation above sea level, topographic relief (elevation above or below surrounding local terrain), slope, or aspect (direction of slope). However, the present study area is a generally flat plain rising gradually from the south to the north (Figure 4-10), without prominent topographic features.

A GIS elevation layer was developed from 30-meter Digital Elevation Model (DEM) data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument aboard the Japanese Terra satellite (Japan and United States 2009). Weights of Evidence analysis was then conducted in five meter increments of elevation above sea level in the study area. However, the only statistically significant result was an association of settlement with elevations below 15 meters in the Late Formative period (Table 4-9). There was also some association with low elevations in the other periods, but not statistically significant.

Selection for topographic relief was tested in one meter increments of elevation above surrounding terrain within one kilometer (Figure 4-11). No statistically significant association with settlement was found for any time period (Table 4-10). On the basis of this result no tests were made of selection for slope or aspect.

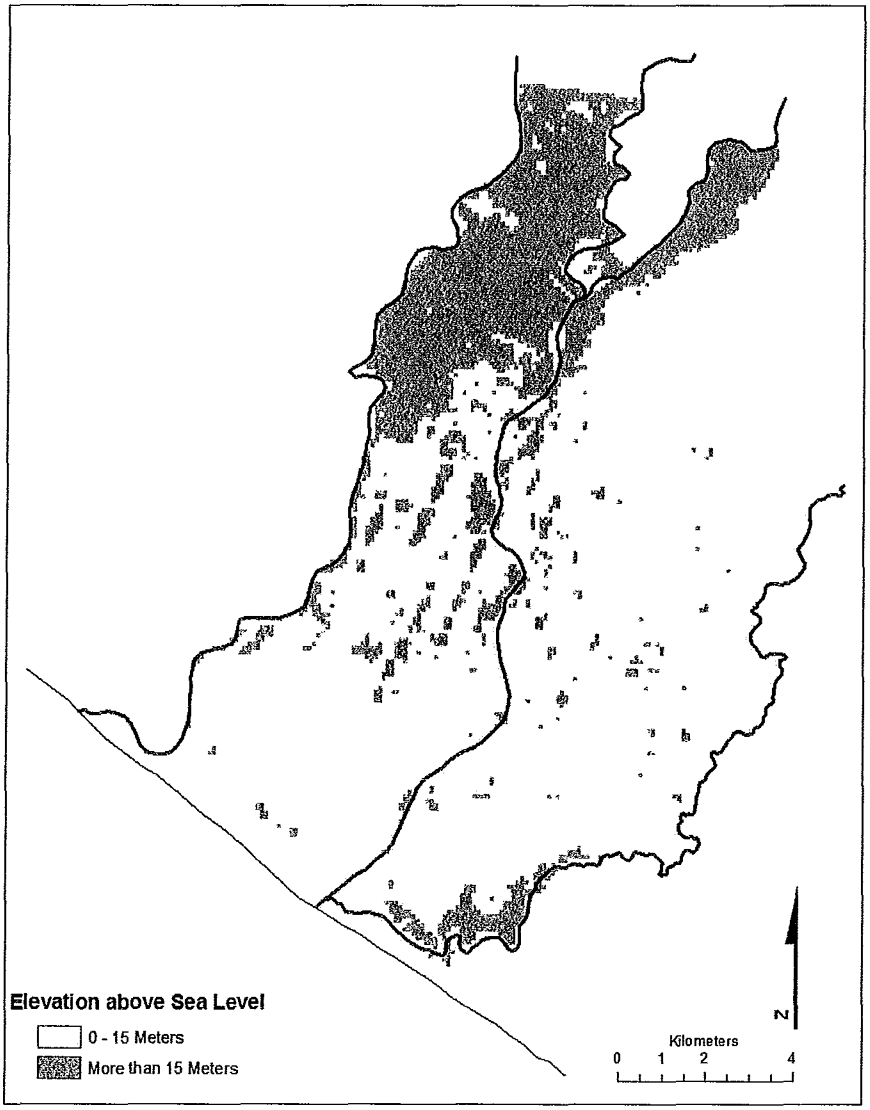

Figure 4-10. Elevation above Sea Level

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	10 Meters or Less	66.89	42	0.1616	0.1548	-0.1841	0.1800	0.3458	0.2374	1.4564	0.073
Late Formative	15 Meters or Less	97.02	69	0.1578	0.1208	-0.5421	0.2677	0.7000	0.2937	2.3830	0.009
Mid Formative	25 Meters or Less	128.95	59	0.0404	0.1305	-1.2047	1.0007	1.2451	1.0091	1.2339	0.109
Cuadros-Jocotal	5 Meters or Less	15.73	4	0.4572	0.5006	-0.0784	0.2359	0.5356	0.5534	0.9679	0.167
Locona-Ocos	5 Meters or Less	15.73	5	0.7276	0.4479	-0.1497	0.2502	0.8774	0.5131	1.7101	0.044

Table 4-9. Analysis of Selection for Elevation above Sea Level.

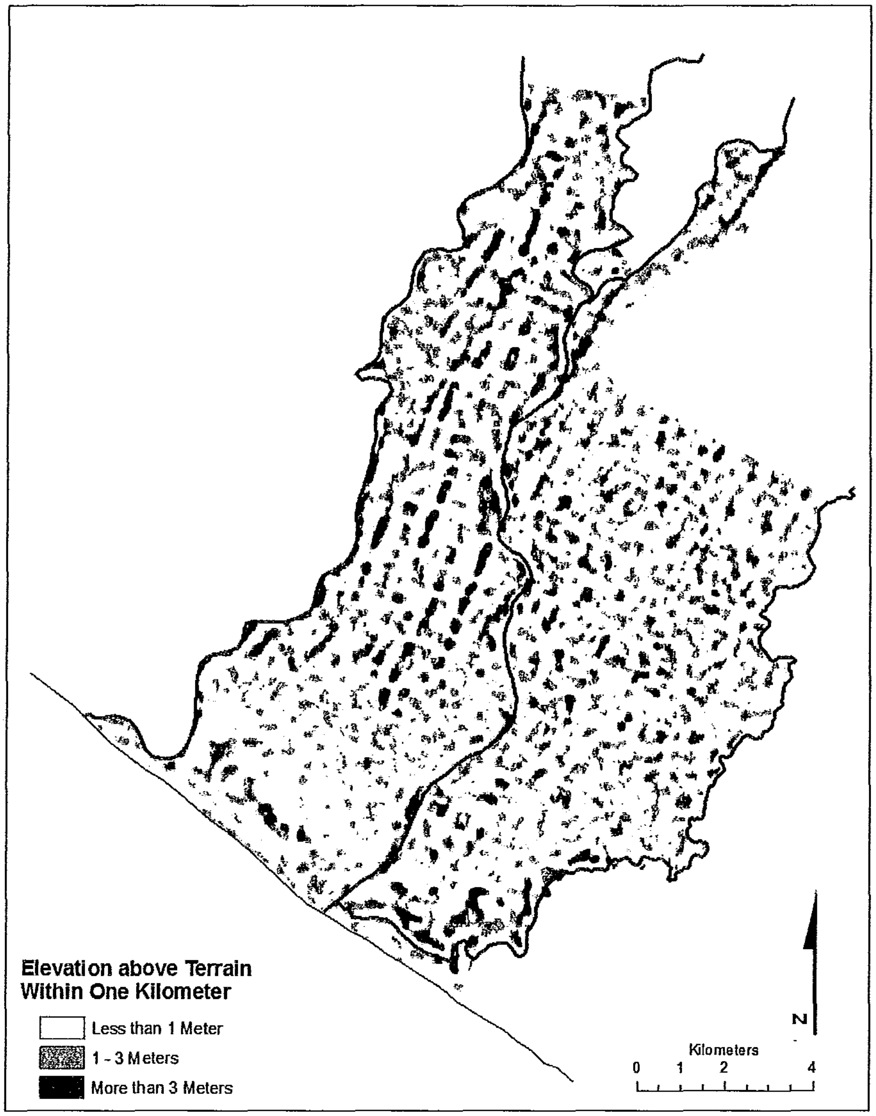

Figure 4-11. Elevation above Surrounding Terrain.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	1 Meter or less	120.76	67	0.0442	0.1225	.-.3938	0.4090	0.4380	0.4269	1.0258	0.152
Late Formative	3 Meters or less	136.14	83	0.0097	0.1101	-4.3946	10.0004	4.4043	10.0010	0.4404	0.330
Mid Formative	1 Meter or less	120.76	55	0.0429	0.1351	-0.3796	0.4479	0.4225	0.4678	0.9032	0.183
Cuadros-Jocotal	1 Meter or less	120.76	21	0.0833	0.2184	-0.9854	1.0003	1.0687	1.0239	1.0438	0.148
Locona-Ocos	1 Meter or less	120.76	19	0.0297	0.2296	-0.2451	0.7075	0.2747	0.7439	0.3693	0.356

Table 4-10. Analysis of Selection for Elevation above Surrounding Terrain.

Selection for Visibility of Volcanoes

Mountains and particularly volcanoes played an important role in ancient Mesoamerican religion and ideology (Brady and Ashmore 1999). The Tacaná and Tajumulco volcanoes, visible to the north from the present study area (Figure 3-1), are among the highest and most prominent mountains in Central America. Tajumulco is extinct, but Tacaná is only dormant: it developed cracks and emitted smoke in 1855, and currently has active fumaroles. The volcanoes would almost certainly have been important to the ancient residents of the area.

ArcGIS was used to calculate the viewshed of each of the volcanoes. Figures 4-12 and 4-13, respectively, show maps of all locations (one hectare cells) from which at least the tops of the volcanoes are visible or not visible, assuming that the line of sight is not blocked by vegetation or artificial structures. A Weights of Evidence analysis was then conducted to determine if there was a preferential selection for locations from which the volcanoes are visible. The viewshed maps show that the volcanoes are visible from virtually all habitable locations in the study area. Consequently, the Weights of Evidence analysis merely confirms that there are no special locations having statistically significant associations with views of the volcanoes.

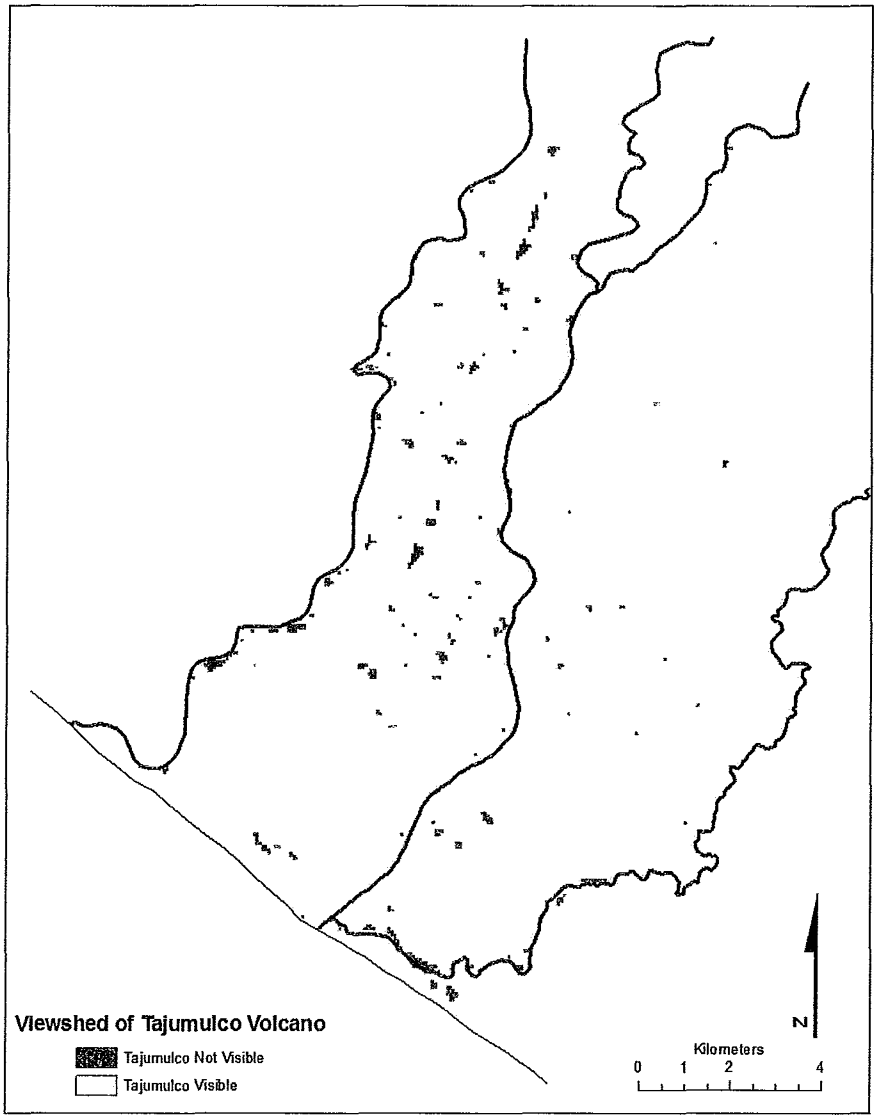

Figure 4-12. Visibility of Tajumulco Volcano.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	In Tajumulco Viewshed	135.18	72	0.0030	0.1182	-0.1961	1.0022	0.1991	1.0091	0.1973	0.422
Late Formative	In Tajumulco Viewshed	135.18	82	0.0047	0.1108	-0.3252	1.0022	0.3299	1.0083	0.3271	0.372
Mid Formative	In Tajumulco Viewshed	135.18	57	-0.0347	0.1327	1.1084	0.5812	-1.1431	0.5961	-1.9175	0.028
Cuadros-Jocotal	In Tajumulco Viewshed	135.18	22	0.0164	0.2134	-3.6024	10.0002	3.6188	10.0025	0.3618	0.359
Locona-Ocos	In Tajumulco Viewshed	135.18	21	0.0163	0.2184	-3.5558	10.0002	3.5722	10.0026	0.3571	0.361

Table 4-11. Analysis of Selection for Visibility of Tajumulco Volcano.

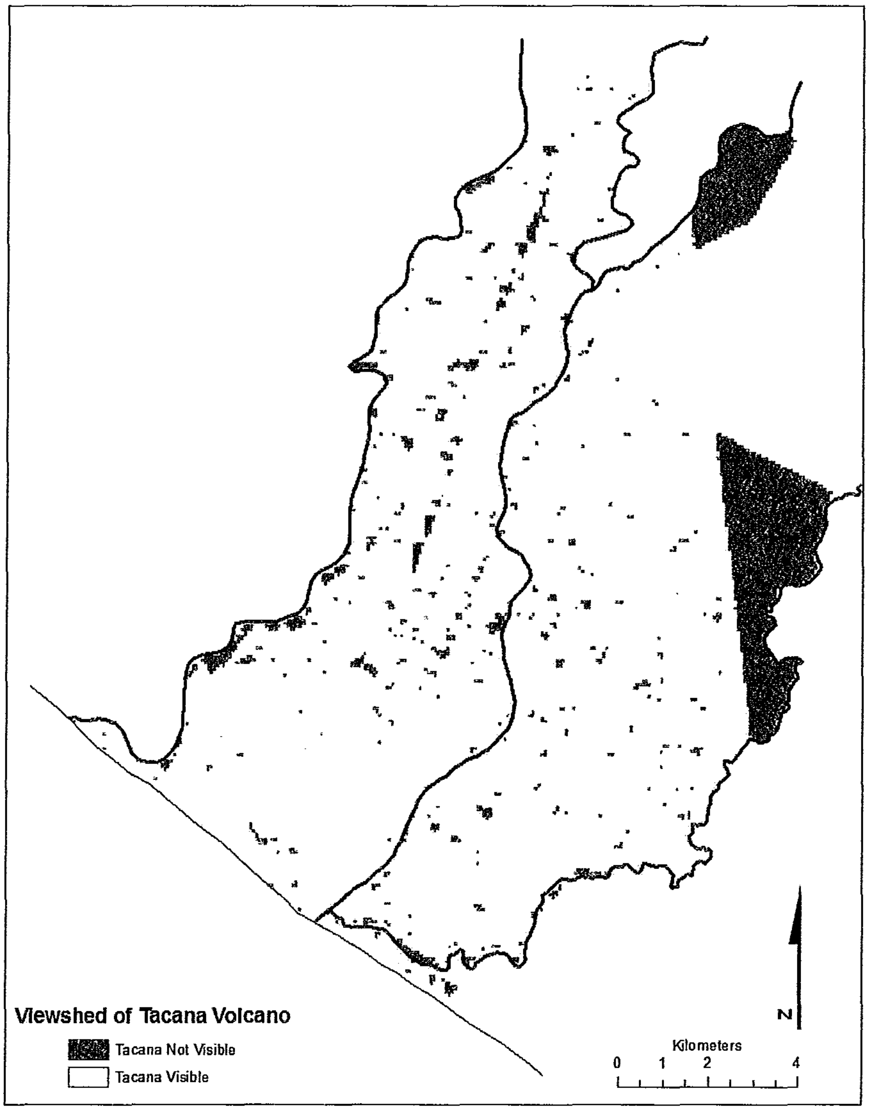

Figure 4-13. Visibility of Tacaná Volcano.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	In Tacana Viewshed	128.72	69	0.0095	0.1207	-0.1509	0.5011	0.1604	0.5155	0.3112	0.378
Late Formative	In Tacana Viewshed	128.72	79	0.0165	0.1129	-0.2800	0.5011	0.2965	0.5137	0.5772	0.282
Mid Formative	In Tacana Viewshed	128.72	54	-0.0397	0.1364	0.4539	0.4097	-0.4937	0.4318	-1.1434	0.126
Cuadros-Jocotal	In Tacana Viewshed	128.72	21	0.0193	0.2184	-0.3375	1.0006	0.3568	1.0241	0.3484	0.364
Locona-Ocos	In Tacana Viewshed	128.72	20	0.0170	0.2238	-0.2909	1.0006	0.3079	1.0253	0.3003	0.382

Table 4-12. Analysis of Selection for Visibility of Tacaná Volcano.

Selection for Visibility of La Blanca Mound One

Mesoamerican temple platforms and pyramids were considered to mimic sacred mountains and embody some of their spiritual power (Brady and Ashmore 1999), so a viewshed calculation and Weights of Evidence analysis was conducted for the viewshed of La Blanca Mound One, a 25-meter high structure constructed in the Middle Formative period (Figure 4-14). No statistically significant associations were found for the Middle Formative or subsequent time periods (Table 4-13).

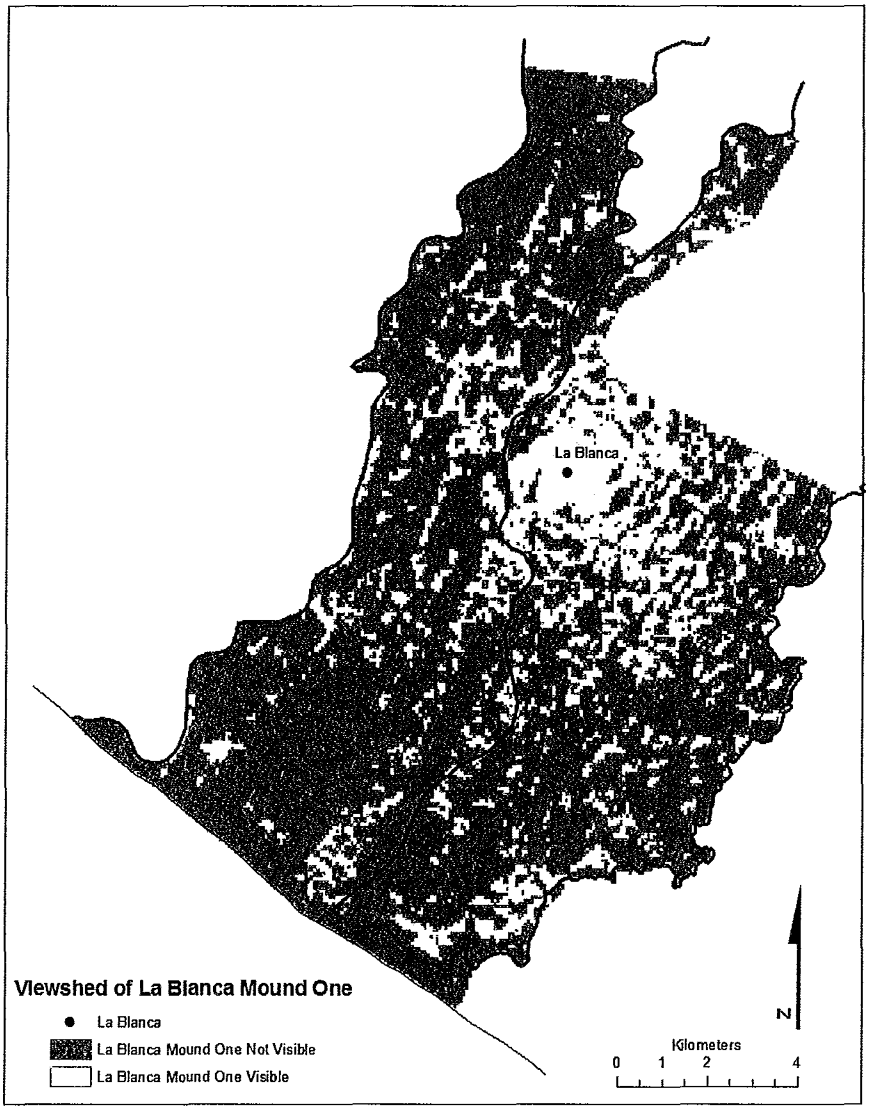

Figure 4-14. Visibility of La Blanca Mound One.

Period	Pattern	Area Sq km	No of Sites *N*	Pos Weight *W+*	St Dev Pos Wt *S(W+)*	Neg Weight *W-*	St Dev Neg Wt *S(W-)*	Contrast *C*	St Dev Contrast *S(C)*	Normalized Contrast *z*	Level of Signif *p*
Classic	In La Blanca Mound 1 Viewshed	26.44	15	0.0663	0.2589	-0.0165	0.1317	0.0828	0.2905	0.2850	0.388
Late Formative	In La Blanca Mound 1 Viewshed	26.44	15	-0.0628	0.2589	0.0144	0.1216	-0.0772	0.2861	-0.2698	0.394
Mid Formative	In La Blanca Mound 1 Viewshed	26.44	9	-0.2497	0.3339	0.0514	0.1404	-0.3011	0.3622	-0.8312	0.203
Cuadros-Jocotal	N/A - Mound 1 Not Constructed Yet	-	-	-	-	-	-	-	-	-	-
Locona-Ocos	N/A - Mound 1 Not Constructed Yet	-	-	-	-	-	-	-	-	-	-

Table 4-13. Analysis of Selection for Visibility of La Blanca Mound One.

Clustering and Dispersion

Another settlement pattern of interest is the possible clustering or dispersion of site locations. Clustering of sites could suggest a defensive strategy or multi-level administrative hierarchy. Dispersion of sites might suggest lack of hierarchy and/or a tendency to maximize the size of foraging territories or agricultural plots.

ArcGIS provides a feature for calculating nearest-neighbor statistics, based on the procedure described by J. Chapman McGrew Jr. and Charles B. Monroe (2000). The straight-line distance from each site to its nearest neighbor is measured, and the mean of all the nearest-neighbor distances is calculated. A cluster index is calculated by dividing this mean by the mean nearest-neighbor distance for a theoretical perfectly random site distribution with the same site density. A cluster index less than 1.0 indicates a clustered pattern where the mean nearest neighbor distance is less than would be expected for a perfectly random distribution. A value of 1.0 would be a perfectly random pattern, and a value larger than 1.0 indicates a dispersed pattern where the mean nearest neighbor distance is greater than expected for a random distribution.

A null hypothesis that sites are randomly distributed can be tested by computing a z statistic as the difference between the sample mean and the random mean, divided by the standard error of the sample mean. As with the Weights of Evidence calculations, the z statistic can be converted to p, the probability of a Type I error in falsely rejecting the null hypothesis, by use of the standard normal density function. The p statistic can then be compared to a threshold level of significance, $p = 0.02$ for the present study.

Table 4-14 shows the results of the nearest-neighbor calculations for the ancient Mesoamerican site distributions in the habitable portion of the study area for each of the five time periods considered. The results show a slightly dispersed pattern (cluster index greater than 1.0) in all time periods, but statistically significant only in the Middle Formative and Locona-Ocos periods.

Time Period	No. of Sites	Cluster Index	Z	p
Late Classic	73	1.1094	1.7882	0.074
Late Formative	83	1.0834	1.4536	0.146
Mid Formative	60	1.1611	2.3879	0.017
Cuadros-Jocotal	22	1.1684	1.5107	0.131
Locona-Ocos	21	1.2801	2.4557	0.014

Table 4-14. Analysis of Clustering of All Sites to Nearest Neighbors.

The nearest-neighbor calculations are based upon the distance from each site to the nearest site of any type or size. Another pattern of interest, however, is potential clustering of small sites to larger sites, as in Ashmore and Willey's (1981) Type C vacant ceremonial center model. The calculations are similar to the nearest-neighbor process, except distances are calculated from each site to the nearest large site rather than nearest neighbor of any size. The mean distance from randomly distributed small sites to the nearest large site is estimated by measuring the distance from each cell in the study area (13,748 cells) to the nearest large site and calculating the mean of all of those distances.

Table 4-15 shows the calculation for potential clustering of single-mound sites around the larger multiple-mound, minor center or major center sites. The results indicate statistically significant slight dispersion during the Middle Formative period.

The pattern during the other time periods is slightly clustered, although statistically significant only in the Locona-Ocos phase.

Time Period	No. of Sites	Cluster Index	Z	p
Late Classic	46	0.84	-1.64	0.101
Late Formative	55	0.93	-0.88	0.377
Mid Formative	50	1.16	2.44	0.015
Cuadros-Jocotal	19	0.87	-1.30	0.194
Locona-Ocos	18	0.72	-2.51	0.012

Table 4-15. Analysis of Clustering of Single Mound Sites to Larger Sites.

Table 4-16 shows the results for clustering of single-mound and multiple-mound sites around minor centers or the major center, when those centers appear after the Early Formative period. Table 4-17 shows the calculation for all of the sites around the major center of La Blanca during its florescence in the Middle Formative. None of the results are statistically significant for either of those cases in any time period.

Time Period	No. of Sites	Cluster Index	Z	p
Late Classic	69	0.8997	-1.6015	0.109
Late Formative	75	0.8964	-1.5287	0.126
Mid Formative	57	1.0841	1.0931	0.274

Table 4-16. Analysis of Clustering of Single and Multiple Mound Sites to Larger Sites.

Time Period	No. of Sites	Cluster Index	Z	p
Middle Formative	59	1.06	1.05	0.29

Table 4-17. Analysis of Clustering to Major Center (La Blanca).

Site Alignments

Supposed alignments of ancient monuments and buildings with landscape features and celestial phenomena are a staple topic of low-budget television archaeology programs. However, there are at least three potential alignment patterns which do have some basis in theory relevant to the present study.

The first is potential alignment of settlements in cardinal directions and quatrefoil arrangements. An ideological system assigning particular gods, natural forces and spiritual powers to the four cardinal directions and to a central vertical *axis mundi* has deep roots in Mesoamerican prehistory (Miller and Taube 1993). The discovery in 2004 at La Blanca of an earthen monument in the shape of a quatrefoil, with a central water feature representing a portal to the underworld, suggests this system was operative in the study area by at least the Middle Formative period (Love 2006; Love and Guernsey 2007). Mounds at the site of El Ujuxte, 12 km from La Blanca, are arranged along a principal axis at 226 degrees azimuth and an intersecting perpendicular secondary axis at 136 degrees (Poe 1997). The site of T'isil in Quintana Roo, Mexico, appears to have been deliberately laid out in a quatrefoil pattern using natural and artificial *cenotes* to mark the cardinal directions and central portal (Fedick 2007). It seems logical to ask whether these types of arrangements may have been carried still further into inter-site alignments in the present study area.

A second type of ritual alignment associated ancient Mesoamerican monuments and buildings with mountains, which were considered to embody generative forces and spiritual power (Brady and Ashmore 1999). For example, the central avenue through the ancient Central Mexican city of Teotihuacan, the Avenue of the Dead, was aligned so as to place the massive Pyramid of the Sun in silhouette against a similarly shaped mountain in the background. The pyramid was thereby associated with the sacred powers of the mountain and, by extension, endowed the city's rulers with that power as well. Love et. al. (2005) report that Mound 1, Mound 3, and a long mound north of Mound 1 at La Blanca are all aligned to 22 degrees east of magnetic north, or 27 degrees east of true north. This alignment is directed almost exactly toward the Tajumulco volcano, which lies at an azimuth of 26.52 degrees east of north from La Blanca. The relevant question for the present study is, again, if these alignments to mountains scale upward from the architectural level to the regional settlement level in the study area.

A third type of potential alignment, common at archaeological sites around the world, arranges monuments and landscape features into sight lines to identify summer and winter solstices for scheduling of agricultural activities. Poe (1997) reports that alignments of this type also occur among the mounds surrounding El Ujuxte.

The numerous sites in the present study area could be conceptually grouped into an almost unlimited number of patterns of the three types described above. However, the usual tools of regression lines and product-moment analysis would be of limited value in this analysis because of the overall geometry of the study area. The area is bounded and divided by rivers into two narrow and roughly rectangular north-south regions, and there is a natural tendency for settlements to line up roughly parallel to rivers, so the overall settlement pattern necessarily has a general north-south orientation.

Consequently, it was thought best to use a simpler analysis which focuses on La Blanca as a likely center of alignment. La Blanca is the largest site in the study area, has several large mounds, and was clearly an important center of ritual activity. Mound One, at 25 meters high, would have dominated the landscape well beyond the Middle Formative period of La Blanca's florescence. The study procedure, therefore, was to measure the azimuth angle from La Blanca to each of all the other sites in the area in each of the time periods considered. These measurements were then compared to the cardinal directions and to the azimuth directions from La Blanca toward Tajumulco, Tacaná, and the points of sunrise and sunset at the summer and winter solstices. A one-degree tolerance was allowed in the comparisons to account for the relative imprecision of the location data in the survey datasets.

No alignments of any of the types discussed above were identified for the Locona-Ocos or Cuadros-Jocotal phases of the Early Formative period, prior to the construction of the La Blanca monuments. Also, no east-west, quatrefoil, or solstice alignments were found for the Middle Formative, Late Formative or Late Classic periods. However, there were possible north-south and mountain alignments during these three periods as shown in Figures 4-15 through 4-17 respectively. It should be noted that the Tacaná volcano lies almost due north of La Blanca at an azimuth of only 2.4 degrees, so it is not practical to distinguish a north-south cardinal alignment from a mountain alignment toward Tacaná.

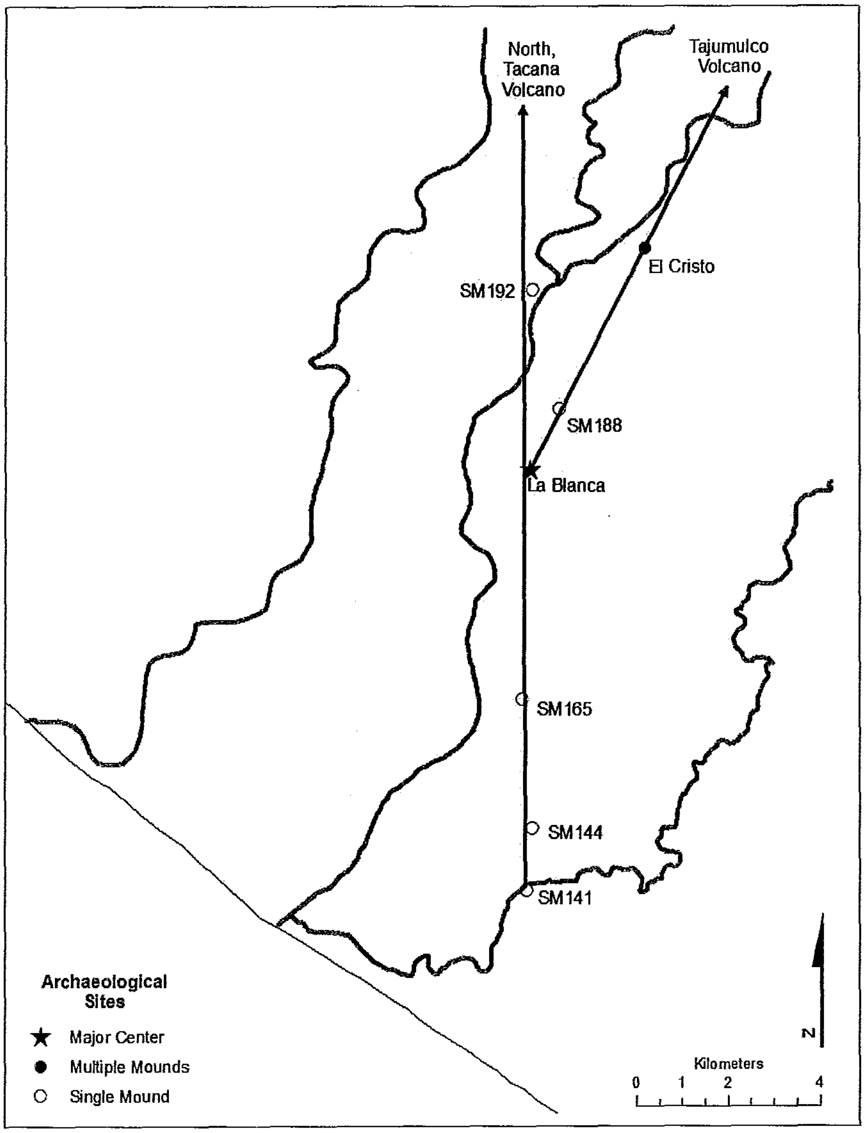

Figure 4-15. Middle Formative Alignments.

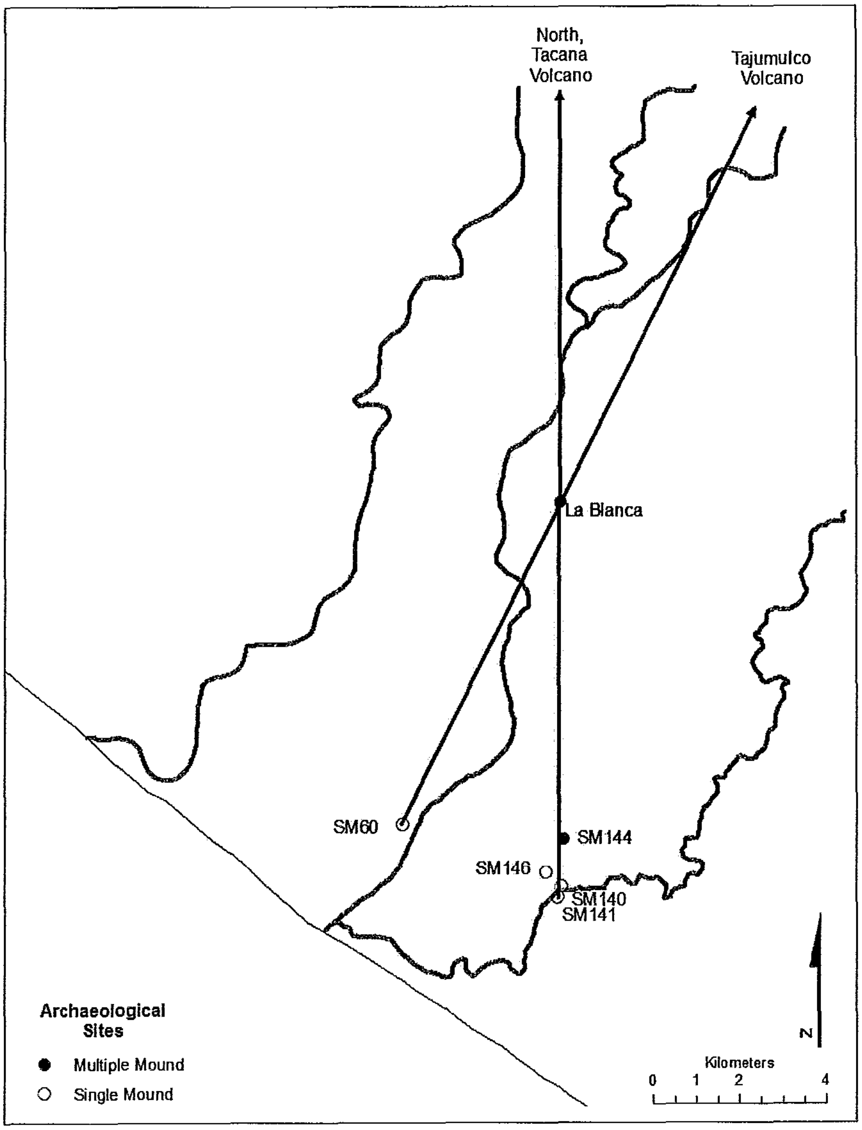

Figure 4-16. Late Formative Alignments.

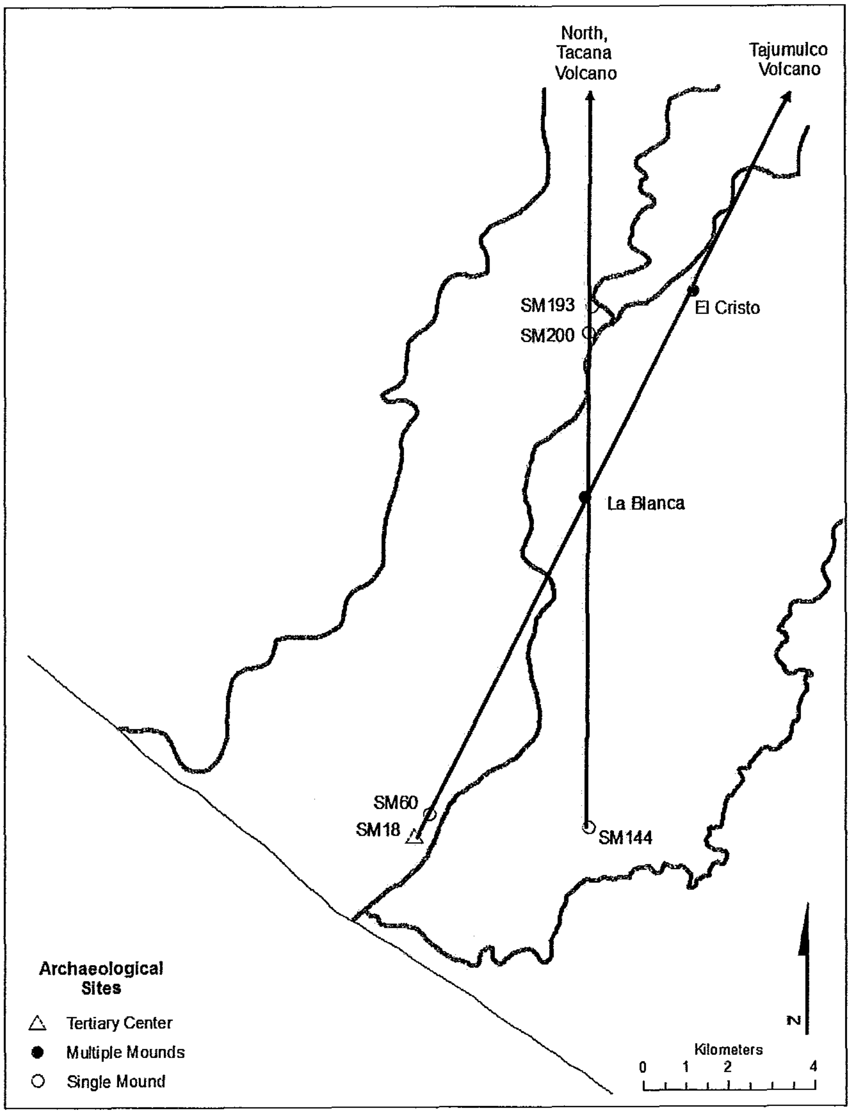

Figure 4-17. Late Classic Alignments.

CHAPTER 5

INTERPRETATIONS AND CONCLUSIONS

Table 5-1 summarizes all of the settlement patterns reported in the previous chapter which were found to be statistically significant, sorted by time period and Weights of Evidence contrast where applicable. Some interesting and unexpected findings emerge from this analysis.

First, the pattern having the strongest apparent effect on settlement locations is preference for a safe distance from the rivers. A few settlements were located on the river banks in all time periods, but the majority apparently preferred to maintain some distance away from the rivers, in the range of about 0.5 to 2.6 km. This pattern is in sharp contrast to the Belize River Valley, for example, where house mounds and minor centers were densely packed along the river banks. A likely reason is that, unlike the Belize Valley, the present study area is a low, mostly flat plain subject to frequent flooding. Maintaining some buffer distance from the rivers would provide at least limited protection from flooding as well as from riverine insects, reptiles and other pests. Another possible interpretation, that flooding may have destroyed evidence of riverbank settlements, is less convincing because the remains of some riverbank settlements with surface artifacts have nevertheless survived from as far back as the Locona-Ocos phase of the Early Formative period.

Another relatively strong pattern was preference for locations in the southern portion of the study area within about 9 km of the shoreline, and closer to the coast during the earlier periods, even though better agricultural conditions are found to the north. A likely explanation is simply that aquatic resources from the ocean and mangrove lagoons were critically important during all time periods, remaining so even after the development of agriculture.

Time Period	Pattern	Weights Contrast C	Cluster Index Z	Level of Significance p
Late Classic	Selection for at Least 2.6 Km from Rivers	1.4620	-	0.002
	Selection for Bucal Soils	0.7662	-	0.001
	Selection for Within 8 Km of Shoreline	0.5982	-	0.010
	Selection for Current Coverage Type 2.1.1 - Principally Cotton	0.5363	-	0.011
	Alignments toward North or Tacana Volcano	-	-	-
	Alignments toward Tajumulco Volcano	-	-	-
	Alignments to Silouette La Blanca Mound One Against Tacana Volcano	-	-	-
	Alignments to Silouette La Blanca Mound One Against Tajumulco Volcano	-	-	-
Late Formative	Selection for Within 9 Km of Shoreline	1.0706	-	0.000
	Selection for Agricultural Productive Capacity Type 5 - Low	1.0221	-	0.000
	Selection for Bucal Soils	0.9686	-	0.000
	Selection for Current Coverage Type 2.1.4 - Corn, Bananas, Pasture	0.7476	-	0.000
	Selection for at Least 0.5 Km from Rivers	0.7350	-	0.009
	Selection for 15 Meters or Less Above Sea Level	0.7000	-	0.009
	Alignments to Silouette La Blanca Mound One Against Tacana Volcano	-	-	-
	Alignments to Silouette La Blanca Mound One Against Tajumulco Volcano	-	-	-
Middle Formative	Dispersion of all Sites from Nearest Neighbors	-	1.1611	0.017
	Dispersion of Single Mound Sites from Larger Sites	-	1.1600	0.015
	Alignments toward North or Tacana Volcano	-	-	-
	Alignments to Silouette La Blanca Mound One Against Tacana Volcano	-	-	-
	Alignments toward Tajumulco Volcano	-	-	-
Cuadros-Jocotal	Selection for Within 5 Km of Shoreline	2.7922	-	0.003
	Selection for at Least 2.6 Km from Rivers	1.9999	-	0.004
	Selection for Within 1 Km of Salt Flats	1.4136	-	0.003
	Selection for Within 1 Km of Mangroves	0.9426	-	0.015
	Selection for Agricultural Productive Capacity Type 9 - Non Arable	0.4585	-	0.003
Locona-Ocos	Selection for at Least 1.7 Km from Rivers	1.2559	-	0.002
	Dispersion of all Sites from Nearest Neighbors	-	1.2801	0.014
	Clustering of Single Mound Sites to Larger Sites	-	0.7200	0.012

Table 5-1. Summary of Spatial Analysis Findings.

Settlement may also have been attracted to the coastal trade routes, and to the salt and plumbate clay trade resources found in southern part of the study area. No statistically significant association was found between the bulk of settlements and the trade resources, but at least one settlement was located adjacent to or in the salt pans during all time periods. Notably these included the site of La Victoria, one of the larger multi-mound sites during the Early Formative Locona-Ocos phase. La Victoria is located near a salt pan, the mangrove lagoons, the ocean and the Rio Naranjo estuary. This location offers some support to the theory of Laura Levi (1996), mentioned in Chapter 2, that larger settlements may be preferentially located in proximity to multiple resource zones because the larger settlements have the population and organizational abilities to exploit multiple types of resources simultaneously.

A somewhat surprising finding was the preference in most periods for areas which are sub-optimal for agriculture, at least by present standards. However, that preference was only moderate, with a Weights of Evidence contrast for soil type selection of no more than about 1.0 (recall that a strong association would be 2.0 or higher). Also, corn, one of the principal crops of ancient Mesoamericans, was being successfully grown in 1982 in the same marginal zones of the survey area. Another important early Mesoamerican crop, manioc, does not require high-quality soils. Overall, the lack of significant preference for high-productivity agricultural resources further supports the conclusion that agriculture may not have been a completely dominant factor in the study area during any of the time periods; foraging may have remained important at all times.

Other negative results of the study are also interesting. The only statistical evidence for clustering of settlements was a relatively weak pattern for clustering of single mound sites to multiple mound sites during the Locona-Ocos phase of the Early Formative. (The cluster index was 0.72 on a scale where 0.0 represents perfectly clustered, co-located sites, and 1.0 represents random site locations.) That pattern is most likely due to the relatively high density of single mound sites in the southern end of the study area close to the marine, mangrove and estuarine resources important for foraging at that time. La Victoria, one of only three multi-mound sites, is located in the same area while the other two multi-mound sites are much farther north. The single mound sites thus appear "clustered" around Victoria. However, during that same phase the pattern for clustering to nearest neighbors, as opposed to nearest large site, was dispersed rather than clustered (index 1.26), and settlement remained generally dispersed throughout the other time periods as well.

The generally dispersed settlement pattern may reflect a desire to maximize the size of agricultural plots and/or foraging territories by maintaining distance from neighbors. The rural population may have also been diversifying their plot locations to minimize the chances of a total crop failure as suggested by Landa (Tozzer 1941). A third hypothesis, that population pressure may have forced the occupation of all available plots regardless of location, is not convincing because total population was never particularly high in the survey area outside the La Blanca site, and in any case the result of filling all available space would more likely have been a random pattern rather than a dispersed pattern. In general, the dispersed result suggests a lack of strong hierarchical control over rural settlement locations. The absence of settlement alignments to solstice directions also hints at the same lack of centralized control over rural agricultural production.

Other results of the settlement study also fail to support a hypothesis of strong centralized control over the region. For example, there is no evidence in the settlement patterns for organized warfare; no evidence of defensive clustering of settlements, preference for defensive locations, or the existence of military buffer zones or defensive architecture The findings with regard to elite control of trade were also negative. There is no evidence in the settlement patterns of elite attempts to restrict access to salt, plumbate clay, or coastal or riverine trade routes. This finding is consistent with the results of other recent research at La Blanca: elites at that site enjoyed a disproportionate share of luxury goods, but did not appear to have exclusive control over access to obsidian (Hoffman 2011), jade (Cogswell Stewart 2011), or fine ceramic vessels (Fauvelle 2011).

If elites had only limited control over trade, rural agricultural production, and military defense, what were the sources of elite power and influence that supported a luxury lifestyle and the command of sufficient labor to build large monuments? One clue in the settlement patterns is the possible alignment of settlements in locations that draw attention to the similarity of elite residences and ritual structures to the presumably sacred (or at least scary) volcanoes in the background. This pattern suggests elite attempts to manipulate ideology as a way of maintaining and exercising power.

In Table 5-2 all of these findings are organized into a format for comparison with the settlement pattern indicators of social complexity shown in Table 2-1 in Chapter 2. The comparison suggests two general conclusions; cycling of social complexity, and weak centralized control of the rural population.

Level of Complexity	Cultural Characteristics	Settlement Pattern Indicators	Time Period: Ocos-Chelra	Quadros-Jocotal	Middle Formative	Late Formative	Late Classic
Family-level group							
	Small-scale foraging	Selection for natural resource zones		√			
	Small-scale horticulture	No selection for agricultural zones	√				
	Low population density	Population less than 1-2 persons per sq km	√	√			
	Family-level social organization	Single and multiple household sites	√	√	√	√	√
	Minimal territoriality and warfare	No defensive clustering, no defensive locations	√	√			
	Minimal political integration	Dispersed settlements	√		√		
	Family-level leadership	No elite residences, no clustering around centers	√	√			
	Family-centered ritual and ceremonialism	No monumental architecture, no sacred alignments	√	√			
Local group							
	Intensified foraging	Selection for multiple resource zones		√		√	√
	Settled agriculture	Selection for agricultural zones		√		√	√
	Intermediate population density	Population 2-20 persons per sq km			√	√	√
	Small groups with common interests	Multi-household sites, minor centers			√	√	√
	Some organized warfare	Defensive locations, clustering, architecture					
	Regional trade	Settlements controlling regional trade resources	√	√	√	√	√
	Local-level leadership	Elite residences, clustering around minor centers					
	Public ritual and ceremonialism	Minor ritual centers, sacred alignments			√	√	√
Regional polity							
	Intensified agriculture	Canals, terraces, field boundaries					
	High population density	Population greater than 20 persons per sq km					
	Institutionalized central leadership	Major centers, cities			√		
	Wars of conquest and expansion	Walls, moats, vacant inter-polity buffer zones					
	Long distance trade	Settlements controlling long-distance trade resources	√	√	√	√	√
	Multi-level administrative hierarchies	Type A, B, C city settlement patterns					
	State religion, "theater states"	Major ritual centers, sacred alignments			√		

Table 5-2. Results of Spatial Analysis of Social Complexity Indicators.

First, as an overall pattern, the level of complexity in the later periods is higher than in the earlier periods, but without a unilinear development of complexity over time. The Locona-Ocos phase closely fits the profile of the Family-Centered Group level with dispersed settlements, small sites, and no marked preferences for particular natural resource or agricultural zones. Some of the characteristics of the Local Group level of complexity developed in the Cuadros-Jocotal phase, including location of settlements closer to preferred natural resource zones such as the mangrove lagoons and beaches, while at the same time showing some evidence of selection for a particular agricultural zone. This development was followed by a sharp increase in social complexity in the Middle Formative period with the appearance of minor centers, the major center of La Blanca, and possible alignments of settlements toward the prominent volcanoes. However, with the decline of La Blanca around 600 B.C. the area reverted back to an agricultural hinterland, possibly part of the El Ujuxte polity which emerged at that time. This situation persisted through the Late Formative until the Early Classic, when the area was abandoned. The area was re-populated in the Late Classic in a pattern similar to the Late Formative, but finally abandoned again in the Postclassic period. The overall trajectory though time was one of cycling rather than unilinear development.

Secondly, Table 5-2 shows that at the peak of social complexity during the florescence of La Blanca in the Middle Formative, settlement patterns do not provide evidence that the community fully reached the level of a regional polity as defined by Johnson and Earle (2000). There is a hierarchy of settlement types suggesting some level of social stratification, but no settlement pattern evidence of significantly intensified agriculture or large-scale military activity. There are minor centers, but no evidence of nucleated clustering around them or around the major center of La Blanca. The general picture instead seems to be of a rural population and urban elite conducting their affairs relatively independently of each other, but over time adopting or developing a common belief system expressed and celebrated at the ritual centers and monuments which remain in evidence today.

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