PROBLEMS WITH EVALUATION OF POPULATION FROM SETTLEMENT DATA: EXAMINATION OF ANCIENT MAYA RESIDENTIAL PATTERNS IN THE TIKAL-YAXHÁ INTERSITE AREA

Anabel Ford
Social Process Research Institute
University of California, Santa Barbara

INTRODUCTION

For quite some time now, scholars have recognized the profusion of ancient Maya house ruins found in the central Maya lowlands. Efforts of the past several decades served to underscore earlier casual observations by accurately documenting the extent of the settlement and the implications for Maya demography. Survey results from the heartland around Tikal indicate residential structure densities from 100 to 200 per sq. km. Clearly, these high structure densities during the Classic Period provide a basis for estimating a high population density, but let us not draw hasty conclusions about the actual population size. We are now at a point where we may interpret structure density patterns and residential unit distinctions which, in turn, furnish part of the basis for considering population estimates. Estimating population size, however, requires a full understanding of residential unit use, distribution, and composition. Without more extensive excavations at residences, especially in the noncentral zones, I do not think we are at the point where we can actually make population estimates.

I will address the problem of population distribution through an examination of the settlement pattern data from the Tikal-Yaxhá intersite area (Ford 1981, 1986). The overview of the Tikal-Yaxhá data will provide a basis for considering the development of Classic Maya settlement and Late Classic settlement distribution and residential unit composition. By examin-

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

ing Classic Period Maya settlement patterns, I will point out distinctions which suggest a complex settlement structure based on the spatial organization of subsistence activities. The pattern in settlement distribution and residential unit composition leads me to weigh two variables regarding residential occupation: contemporaneity and permanence. Because assumptions of contemporaneity and permanence figure critically in demographic reconstructions (*e.g.* Haviland 1970; Rice 1976:265-272; Puleston 1973:171-207), I argue that these factors need to be explicitly evaluated before developing population estimates in the central Maya lowlands.

THE TIKAL-YAXHÁ INTERSITE AREA

The Environment

The Tikal-Yaxhá intersite area is found within the interior core area of the central Maya lowlands (Fig. 1). The core area includes most of the northeast portion of the department of El Petén, Guatemala. The geological base of this area is limestone, however, the region has significant environmental variations. This variability is important in interpreting patterns of ancient Maya settlement. The area is characterized by undulating terrain ranging between 100 and 300 meters above sea level. Except for the lake area to the south, the region lacks surface drainage and includes large seasonally inundated swamps or *bajo* zones interspersed by fertile tracts of well-drained uplands (Simmons *et al.* 1959:563-566). Drainage is from the limestone uplands into the deep acidic swamps (Cowgill and Hutchinson 1963; Laws 1961; Simmons *et al.* 1959:874, 883). These seasonal swamps are the surface water catchments during the six-to-seven month wet season from June to January but become desiccated in the dry season between January to June.

The Tikal-Yaxhá Intersite Project

The Intersite Project research focused on the area between the two major Classic Maya centers of Tikal and Yaxhá because this area promised to be representative of the core area

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

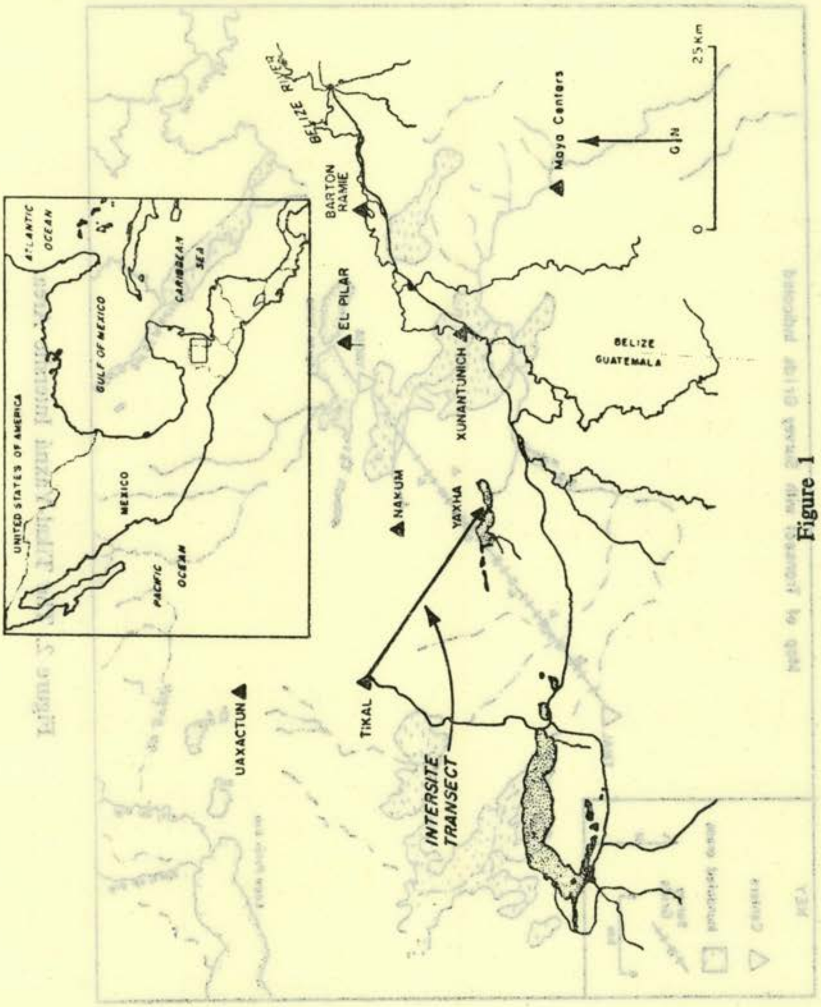

Figure 1

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

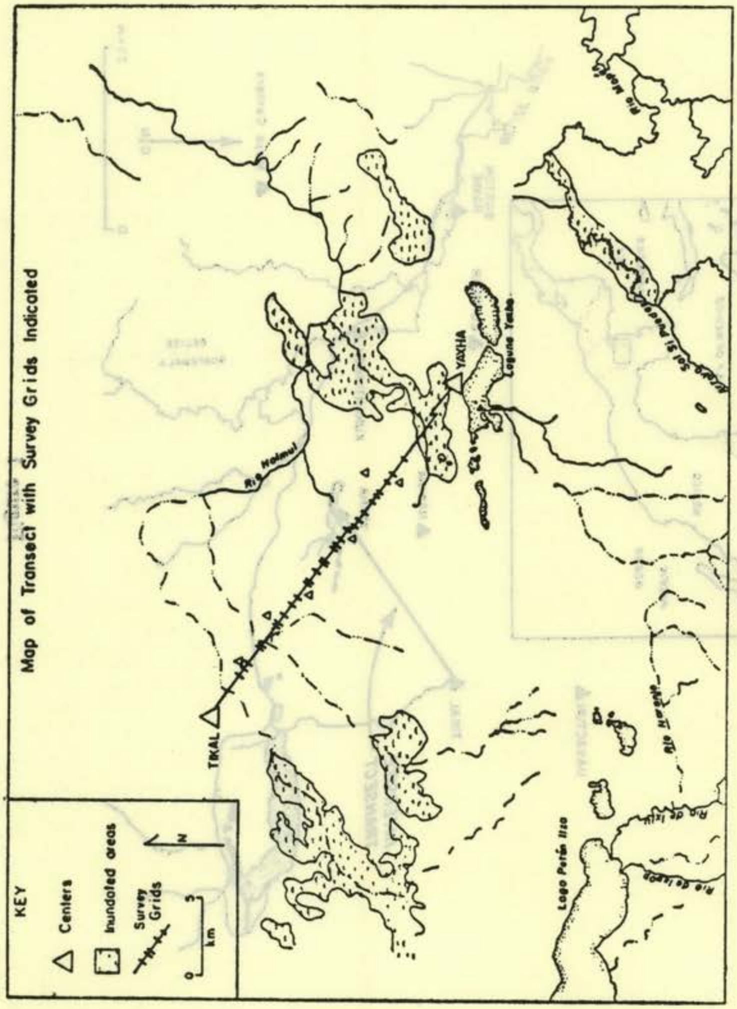

Figure 2. The Tikal-Yaxná Intersite Area.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

rural component (Fig. 2). Prior to the initiation of the Tikal-Yaxhá Intersite Project, settlement studies had been completed in the vicinities of Tikal (Puleston 1973, 1983) and around the lakes of Yaxhá and Sacnab (D. Rice 1976; D. Rice and P. Rice 1980). These studies provided an anchor for the comparative examination of the settlement and chronological patterns of the Tikal-Yaxhá intersite region (Ford 1986).

The fieldwork consisted of three main stages: the establishment of the 28-km-long baseline connecting Tikal and Yaxhá, the settlement survey of 40% of the potentially habitable terrain along the 500-meter-wide transect between the two centers, and the text excavations at 10% of the identified residential units found in the survey (Ford 1986:17-42). Establishment of the 28 km baseline was essential to all subsequent phases of the project (*cf*. Puleston 1983:4). The baseline traversed a straight line between the two centers of Tikal and Yaxhá, crosscutting all major topographic and environmental zones represented in the area. The major environmental zones, forming a mosaic over the region, were represented in the following proportions: uplands 24%, transitional upland-swamp 32% and all seasonally inundated swamp zones 44%.

Three topographic zones were found along the Tikal-Yaxhá baseline (Ford 1986:44-57). The first 14 km from Tikal is charactrized by few areas of relief and includes much of the southern portion of the Bajo de Santa Fe. This zone contains several long stretches of undulating uplands (making up only 16% of the area), but the greater portion of the terrain is either 1) marginal to and transitional between the uplands and swamps (making up 43% of the area) or 2) seasonally inundated swamps (making up 41% of the area). In contrast to the first topographic zone, the second zone, from 14 km to 23 km, displays great relief. Well-drained uplands characterize the majority of the area (58%), upland-swamp ecotones are few (23%), and swamp areas are rare (19%). The third zone runs from 23 km to Yaxhá (28 km). The terrain is almost entirely flat, except for the final half kilometer where the land begins to rise to the center of Yaxhá. This portion of the baseline crosses the large east-west trending Bajo La Justa, north of the center and lake of Yaxhá. Swamps dominate along this por-

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

tion of the baseline (91%), transitional zones occur adjacent tc Yaxhá (8%), and Yaxhá itself is within the uplands.

The survey sample from the Tikal-Yaxhá intersite area was based on a stratified random sample considering variables of vegetation and topography along with distance from Tikal (Ford 1986:28). Careful examination of the survey maps of Puleston (1973, 1983) and D. Rice (1976) provided information indispensable to developing the survey sampling strategy. The Tikal Sustaining Area maps (particularly the region between Tikal and Uaxactún) and the Yaxhá-Sacnab settlement study documented settlement avoidance of seasonally inundated swamp zones (*e.g.*, Puleston 1973:16,92,196; D. Rice 1976:150, 311; see also Ford 1981:64-85). Habitation was recorded in all other zones. To maximize coverage of potentially habitable zones, the Tikal-Yaxhá baseline terrain was initially classed into uplands, transitional upland-swamp, and swamp terrain. All swamp terrain which ocurred along the baseline was excluded from the survey. The remaining baseline terrain of transitional and upland zones was included in the transect area to be sampled.

The defined potentially habitable terrain (uplands and transitional zones) encountered in varying lengths on the baseline were divided into segments for the stratified random sampling procedure (Ford 1986:28-30). Each baseline segment, averaging 225 m, was numbered consecutively, grouped contiguously into two's and three's, and one segment (the width of a survey grid) was selected from each group using the table of random numbers. Each selected grid was surveyed completely, which included recording topography, vegetation and cultural remains. The end result was a representative sample of potentially habitable terrain along a 500-meter-wide transect between Tikal and Yaxhá comparable to the data generated from the Tikal and Yaxhá-Sacnab surveys.

In all, 29 survey grids, including a total of 320 ha (3.2 sq. km) and representing 40% of the potentially habitable terrain along the baseline were surveyed in the course of the project. Twelve of the survey grids (41%) occurred in the well-drained upland areas, and 17 survey grids (59%) fell within the transitional zones. Over 66% of the survey grids (all grids in transitional zones) included portions of swamp zones within their margins (Ford 1986:99-127). Thus, while swamp zones were

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

excluded on the baseline for the grid selection process, swamp zones were not excluded from survey in selected grids and actually comprised 21% (68 ha) of the area covered by the survey grids.

Within each survey grid, all cultural remains were mapped and positioned relative to the baseline. Structures were numbered consecutively and were grouped together in residential units where proximity and orientation dictated (*cf.* Ashmore 1981:45-54). Effort was made to record the most unobtrusive remains, including foundations on the surface. An additional 60 ha were surveyed beyond the grid survey directly from the baseline in upland, transitional, and swamp zones excluded from the sample and all cultural remains within the baseline survey were mapped. Approximately 63% of the baseline survey areas were in swamp zones and no archaeological remains were identified in those zones.

Residential units, rather than individual structures, were the basic level of observation for the excavation phase of the project. Residential units may be solitary or isolated structures distant from any neighbor or may be multi-structure compounds or groups of 2 or more structures in close proximity and sharing ambient space. A 10% stratified random sample of the mapped residential units within the survey grids was selected for the subsurface testing. Residential units were grouped by tens, based on distance from Tikal, and one in ten was selected using the table of random numbers. No deliberate tests were made beyond the immediate environs of a residential unit and excavations were focused on midden rather than structural remains. Middens of 13 residential units were the subject of this testing phase.

Residential unit middens were identified by post hole tests (see Fry 1972) placed around the entire perimeter of the unit, inclusive of all structures. From one to three test pits were excavated at each of the residential units, depending upon the location and number of the middens identified. It was assumed that the identified midden areas were representative of activities occurring at the residential unit as a whole rather than at the nearest structure, as middens were generally few in comparison to the number of structures. Subsurface structural remains were tentatively recorded in two of the testing areas, both located

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

in dense settlement zones around minor centers. These possible constructions were relatively small, simple, single component manifestations located beneath later middens and do not appreciably affect the overall settlement picture.

The primary purpose of the test excavations was to provide a chronology of the settlement in the area. The chronology is based upon comparative ceramic evaluations and is directly correlated with the Tikal material. Residential unit occupations were fixed on the basis of period-diagnostic sherds from the midden associations. There was an average of 28 diagnostic sherds per residential midden and an average of 5 diagnostic pieces per period of occupation at a residential unit. The results of the fieldwork provide a data base comparable to the Tikal Sustaining Area Project (Fry 1969; Puleston 1973) and the Yaxhá-Sacnab Historical Ecology Project (D. Rice and P. Rice 1980).

Comparative Chronology of the Tikal-Yaxhá Area

The chronology of occupation in the Tikal-Yaxhá area adds a new dimension to the developmental reconstructions of settlement patterns of the central lowland Maya (Ford 1986:59-66). Generally speaking, the Tikal-Yaxhá data conform to the overall picture of prehistory in the region, with initial occupation in the Preclassic periods and significant growth by the Late Classic Period (Table 1). Two important divergences from the expected developmental scheme are 1) the drop in occupation of non-central zones in the Early Classic Period as compared to the occupation in the Late Preclassic and Late Classic periods and 2) the sustained, albeit diminished, occupation of the Tikal-Yaxhá intersite area in the Terminal Classic Period.

TABLE 1: RESIDENTIAL OCCUPATION THE TIKAL-YAXHÁ AREA BY CERAMIC PERIOD

	Middle Preclassic Period c.600-300BC	Late Preclassic Period 300BC-250AD	Early Classic Period 250-600AD	Late Classic Period 600-900AD	Terminal Classic Period 900-1000AD
Percent of Occupation	38%	92%	77%	92%	85%

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Reviewing the entire Tikal-Yaxhá sequence in the context of the comparative data from near the Tikal and Yaxhá centers will help provide a perspective on the similarities and differences between these major centers and their intersite area. The earliest occupation in the Tikal-Yaxhá area is in the Middle Preclassic Period, as determined by diagnostic ceramic types of the Mamon/Eb phase. During this period, occupation was concentrated towards the Yaxhá-Sacnab lakes area where settlements were established earlier (D. Rice and P. Rice 1980; D. Rice 1979). This pattern is consistent with the proposal that the interior core area was occupied after the lake and river zones.

Late Preclassic occupation, generally characterized by Chicanel phase ceramics, was markedly different from the previous period. Growth was evident in all areas of the study. Settlement of this period was fairly evenly distributed throughout the uplands (Fry 1969:138-139; D. Rice 1976:233-236; P. Rice 1979:30), with a notable shift in settlement concentration in the Tikal-Yaxhá intersite area towards the vicinities of Tikal and the minor center of El Corozal, within 4 km of Tikal. The rising importance of El Corozal in the Late Preclassic is mirrored at other centers around Tikal (Fry 1969:140; Puleston and Puleston 1972:124). Similar settlement concentrations near emerging centers have been noted around the Lakes Yaxhá and Sacnab (D. Rice and P. Rice 1979:440).

Traditionally, the beginning of the Classic Period has been viewed as one of emphasis and elaboration of centers. In the Tikal area (Culbert 1977; Fry 1969; Puleston 1973) and in the Yaxhá-Sacnab area (D. Rice 1976; D. Rice and P. Rice 1980) general increases settlement occupation have been documented in the Early Classic. Examination of settlement within 14 km of Tikal in the Tikal-Yaxhá area lends support to this interpretation (Table 2). Evidence from the entire area between Tikal and Yaxhá suggests a more complex situation, where Early Classic settlement tended to be focused near centers with the abandonment of non-central areas.

In the Late Classic Period, population growth, as demonstrated by marked increases in occupation densities, is clearly indicated in the Tikal-Yaxhá area as well as in all surrounding areas of the lowlands. Most zones had at least some occupation

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

TABLE 2: RESIDENTIAL OCCUPATION WITHIN 14 KM OF TIKAL AND YAXHÁ

	Middle Preclassic Period	Late Preclassic Period	Early Classic Period	Late Classic Period	Terminal Classic Period
Occupation within 14 km of Tikal	29%	85%	85%	100%	100%
Occupation within 14 km of Yaxhá	50%	100%	66%	83%	66%

in this period. The greatest degree of occupation is in upland areas, especially around centers. There is some use, however, of areas of less relief, particularly in the vicinity of Tikal. Nevertheless, the majority of the zones marginal to swamps continue not to be occupied.

The dramatic Terminal Classic Period decline, interpreted for the whole of the central Maya lowlands, is evident in the Tikal-Yaxhá as well, but not to the same extent. While the utilization of the area significantly decreased, occupation persisted (see Tables 1 and 2). The Terminal Classic settlements were located exclusively on the larger tracts of uplands and around centers in the Tikal-Yaxhá area. This pattern is not unlike the pattern of the Late Preclassic Period.

By Postclassic times, the Tikal-Yaxhá area was apparently abandoned. No excavated material was found to date to this period. However, two untested residential units were recorded in one survey grid (Ford 1986:53-125) within eight kilometers of Yaxhá which were different from other structures recorded in the survey. These structures were simple foundations or courses of faced limestone partially enclosing a rectangular space. Remains of this nature have been dated elsewhere to the Postclassic Period (A. Chase, personal communication; M. Orrego, personal communication; P. Rice, personal communication).

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

TIKAL-YAXHÁ RESIDENTIAL PATTERNS IN THE LATE CLASSIC PERIOD

Environment and Settlement

As has been discussed, the geography of the Tikal-Yaxhá area is characteristic of the northeastern Petén in general. Drainage is from fertile uplands and transitional upland-swamps into large seasonally inundated swamp or *bajo* zones. Although there are no rivers, the Tikal-Yaxhá baseline crosses several small stream beds which have no water in the dry months but have standing water during the height of the rains. The absence of surface water in the dry season makes drinking water a serious problem (*cf*. Haberland 1983; Bullard 1960).

Noticeable variations in settlement densities can be seen among the environmental zones of the surveyed Tikal-Yaxhá area (Table 3). Characteristics of topographic relief and vegetation influence settlement densities. Zones of moderate relief have relatively high settlement densities while other zones generally have low densities. Statistical analyses of these data (Ford 1980, 1981:130-139, 1986:67-78) have demonstrated a correlation between high settlement density and upland zones and between low densities and marginal swamp zones.

TABLE 3: TIKAL-YAXHÁ AREA ENVIRONMENT AND SETTLEMENT COMPARISON

Dominant Environmental Zone	*Structure Density per sq. km*	*Structure per Residential unit*	*Chultun per sq. km*
Moderate Relief* uplands (2375-5025 m)	247	2.7	26
Sharp Relief* uplands (21625-23000 m)	246	3.0	54
Moderate Relief* uplands (14375-16000 m)	171	2.5	21

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Moderate Relief			
transitional	160	1.5	13
(20000-21625 m)			
Sharp Relief			
uplands	112	1.9	5
(16000-20000 m)			
Slight Relief			
transitional	46	1.8	1
(5025-14375 m)			

* Locations of minor centers.

Environmental factors also influence settlement composition (see Table 3). On the average, residential units in areas of slight and sharp relief are composed most often of only one small structure while areas with moderate relief, often corresponding to the location of centers, have large, complex units composed of at least two to three structures (Ford 1986:82-86). Settlement differences among environmental zones in the central Maya lowlands appear to relate to basic status differences among residents. Examination of a standardized labor investment as a reflection of relative wealth is helpful in discerning status distinctions (Arnold and Ford 1980; Ford and Arnold 1982). A distribution of labor ranks can be generated by applying a standard formula of construction labor based on structure volume (Arnold and Ford 1980) and summing the components for multi-structure residential units. Five labor investment groupings (Rank 1 the lowest and Rank 5 the highest) were identified upon the basis of the labor investment distribution at Tikal (Ford and Arnold 1982:439) and the Tikal-Yaxhá area (Ford 1985:84-85). These labor investment wealth ranks can be used to measure status and in combination with other status indicators, such as the elite eastern shrine plaza plan (Becker 1971), to help understand the relative importance of different environmental zones to the ancient Maya.

The same environmental factors that influence settlement density affect the distribution of elite. Major centers such as Tikal contain the highest ranking residential units (Rank 5). Wealth Rank 5 drops out beyond Tikal in the Tikal-Yaxhá, area and only locations of minor centers have elite residential units of

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Rank 4. In uplands outside of centers only residential units of Rank 3 are present (Fig. 3). The Maya appear to have ordered their domain upon the basis of agricultural land and available labor. Consequently, those area with the most extensive tracts of agricultural land, supporting the largest number of settlements, required the greatest amount of administration. Correspondingly smaller tracts of agricultural land, with fewer settlements, had lighter administrative requisites, and the most marginal lands supported so few settlements that they were probably indirectly administed.

Settlement and Chultun Density

Other characteristics associated with residential settlement are also important. Chultunes, bottle-shaped storage cavities excavated into the limestone bedrock (*cf*. Puleston 1971), have been recorded in association with ancient Maya houses of the core area. These chultunes, when present, occur in areas adjacent to and between residential units. Chultun storage units are unlined cavities which do not hold water and have been interpreted as dry storage areas (Puleston 1968:95, 115-116; 1971).

The distribution pattern of the chultun storage facilities is noteworthy. Zones with the highest structure and chultun densities have a distinctly different proportions of structures to chultunes than low settlement and chultun density areas. High density areas around centers have 55% of the structures and 77% of the chultunes, while low density areas marginal to swamps have only 11% of the structures and 2% of the chultunes (Table 4). Hence, zones adjacent to centers have the highest proportion of storage chultunes while zones of slight relief adjacent to swamps have the lowest.

TABLE 4: TERRAIN, SETTLEMENT, AND CHULTUNES IN THE TIKAL-YAXHÁ AREA

Terrain Type	*Proportion of Terrain Covered*	*Structure Density (per sq. km)*	*Chultun Density (per sq. km)*
Well-Drained Terrain			
Adjacent to Centers	20%	221 (55%)	34 (77%)

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Well-Drained Terrain without Centers	21%	136 (34%)	9 (21%)
Poorly Drained Terrain Adjacent to Swamps	38%	46 (11%)	1 (2%)
Undrained Terrain in Swamps	21%	0	0

Structure to chultun relationships become more impressive when one considers the implications for residential access to storage (Table 5). Upland zones with high settlement density average 2 to 3 residential units per chultun compared to low density transitional zones which average 15 residential units per chultun. There was an average density of one chultun in transitional upland-swamps for every 12 chultunes in a comparable area of uplands. Thus, upland residents enjoyed considerable access to storage chultunes, even though there was a greater number of structures. Transitional zones which are marginal to swamps, on the other hand, not only had few structures, but residential access to storage chultunes was severely limited in comparison to that of upland zones.

TABLE 5: CHULTUN AND SETTLEMENT DENSITY IN THE TIKAL-YAXHÁ AREA

Upland Zones Adjacent to Centers	*Transitional Zones Marginal to Swamps*
6 str. per chultun	27 str. per chultun
2 residential units per chultun	15 residential units per chultun

These relationships among settlement density, residential unit composition, and envinronmental zone have implications for our interpretation of subsistence-settlement patterns in the central Maya lowlands. The association among the variables is significant and needs to be explored, as ramifications for reconstructing Maya demography are vast.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

INTERPRETATION OF MAYA SETTLEMENT PATTERN

Influences on Settlement

An understanding of the economic basis of the central lowland Maya is essential to any demographic reconstructions. Both climatic regime of the wet and dry seasons and environmental constraints of terrain are important variables which interact with choice in residential location among the ancient Maya. Environmental conditions of water availability and the locations of swamps and well-drained areas condition settlement patterns. Such links between environment and settlement would be most pronounced among agriculturally based societies such as the Maya.

Ethnographic research on historic and modern lowland Maya settlement has identified a high degree of residential mobility and house abandonment (Redfield and Villa Rojas 1962:225-27; Steggarada 1941:18-19; Wauchope 1938:161). Even permanent villages and towns do not have full occupancy at any one time (Steggarada 1941:19; Wauchope 1938:151-152). This research has revealed that subsistence activities such as field preparation, planting, maintenance, harvest, and storage vary between the dry and wet seasons and residence requirements vary accordingly (Carter 1969; Redfield and Villa Rojas 1962; Villa Rojas 1945; Steggarada 1941). Agricultural field activities are the most demanding in the wet season when the crops are growing and field maintenance is at its peak (Carter 1969:61-70; Redfield and Villa Rojas 1962:83-84; Villa Rojas 1945:78-79; Steggarada 1941:91-129). Agricultural product storage is critical only in the dry months, when the main harvests are over (Steggarada 1941:125). This is also the period when surface water in the core Maya area is scarce and drinking water management would be critical to survival (*cf*. Haberland 1983).

In interpreting ancient Maya settlement patterns, I assume that subsistence practices have significant impact on residential loci. Among societies with agriculturally based economies access and proximity to cultivable land would be important; the more intensive the subsistence practices the more important this would be. Equally important to daily subsistence needs is drinking water. This has great significance in the core area of the Maya, where surface water is absent in most areas during the five

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

or six month dry season except at ancient Maya centers where there were water reservoirs (Bullard 1960; Ford 1986:82; Simmons *et al.* 1959:565). Such constraints on living and working location are reflected ethnographically in settelement patterns and provide the basis of a model of population movement and demographic interpretation.

Ancient Settlement and Agricultural Patterns

In the examination of settlement data for the Tikal-Yaxhá area presented above, concentrations were observed to be consistently focused in upland areas of moderate relief, while zones marginal to swamps were avoided. Uplands are dispersed in large and small tracts within the area, and consequently overall settlement was dispersed. As settlement and subsistence patterns are linked, such an extensive settlement distribution dispersed in all well-drained uplands is most parsimoniously explained in terms of the economic base of the Maya: agriculture. Settlement data document avoidance of *bajos* and their margins while concentrating in uplands and, thus, argue against the swamp or *bajo* cultivation hypothesis. If *bajo* cultivation were practiced, habitable zones most conveniently near to *bajos* should have the greatest settlement densities, but this is not the case. Witness the settlement densities of the zone between 5025 and 14350 m in the Tikal-Yaxhá area. This zone includes large tracts of potentially habitable terrain immediately adjacent to extensive *bajos,* yet the zone exhibits very low settlement densities (see Table 3).

Ancient Maya settlement preference is for well-drained terrain of moderate relief over areas of slight or sharp relief is a pattern which is consistent through the course of prehistory and is in accord with ethnographic studies of lowland Maya farmers. Consequently, these data argue in favor a labor intensive fallowing system of agriculture analogous to the modern Maya practices (Ford 1986:77-78; Puleston 1978; D. Rice and Puleston 1981). This interpretation of a fallowing subsistence base for the ancient Maya bears significantly on interpretations of residential use and contemporaneity in locations of both high settlement density adjacent to centers and locations of low density in the rural areas.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Ancient Settlement and General Subsistence Patterns

It has long been recognized that a disparity exists between the numbers of structures in the Petén and an agricultural regime consistent with a fallowing system, assuming that all were structures were simultaneously occupied. Clearly, one problem involves the issue of residential contemporaneity. It is very probable that not all residential units were occupied at the same time, as no Maya ethnographic cases record full occupancy, whether in towns or smaller settlements (Steggarada 1941:19; Wauchope 1938:151-152). Further, even intensive swidden agricultural practices require some degree of residential mobility due to field rotation. Consequently, if all residential units were not occupied at the same time, population densities cannot be based upon the total structure counts.

The annual cycle in the Maya lowlands, with its distinct half-year wet and dry periods, has great impact on modern-day subsistence activities. The wet season is a period of intense agricultural focus in field planting, maintaining, weeding, and harvesting. It is also the time when the next year's fields are selected and large trees are felled in their preparation. Hence, the bulk of field activities occur between April and February. During this intense work period, residence in field locations is required in addition to the residence in the village (Redfield and Villa Rojas 1962:25-28; Steggarada 1941:124-125). Sometimes these field sites evolve into more permanent *rancherías* (Redfield and Villa Rojas 1962:25). Dry season subsistence activities are mainly focused in kitchen gardens adjacent to the village residences (Carter 1969:100). It is also the time when grains are brought into the village for final storage and consumption.

Parallels may be drawn for the Classic Period Maya based on the modern Maya agricultural cycle. In the central Maya lowlands there is a dichotomy between densely settled areas of moderate relief and lightly settled marginal zones of slight relief. This dichotomy includes settlement density, residential unit composition, accesible storage facilities, and proximity to centers and reservoirs (see Tables 3 and 4). These data suggest a possible settlement split between aggregation around dependable water in the dry season and some degree of dispersal to

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

distant fields in the wet season. This hypothesis can account for the observed variation in settlement densities between uplands with centers and non-central uplands and marginal transitional zones. It is at the centers where dry-storage chultunes are most abundant and accesible, and where reservoirs are located to ensure adequate dry season drinking water supply. The more dispersed zones do not have reliable access to either chultunes or water all the year round.

The pattern of high settlement density and high chultun density around centers may also be seen in the data from the Tikal Sustaining Area Project (Puleston 1983, Fig. 4-7 and 17-19). All upland zones around minor centers with reservoirs have high structure densities and low structure to chultun ratios (c. 5 structures to 1 chultun). This contrasts with zones marginal to swamps, such as found on the North and West Survey Strips, which have low structure densities and high structure to chultun ratios (c. 30 structures to 1 chultun).

These data from the Tikal-Yaxhá area and from the Tikal surveys indicate that dry storage in chultunes was more important in the uplands and adjacent to centers than in the other zones. Grain storage would be most important for the dry season when all the harvests were in and before the first crop of the next season had matured (Villa Rojas 1945; Steggarada 1941). Drinking water would also be critical in the dry season, when all surface water in the core area disappears. All centers have water storage reservoirs, many of which still hold water today. Living in the vicinity of these centers would ensure access to water during the long dry season while living away from these reservoirs would be inconvenient and could jeopardize survival. Combining the data on settlement density, residential unit composition, and chultun density with reservoir access provides a basis for considering a multiple residence pattern where field and center residential units were simultaneously maintained in accord with the annual agricultural cycle of the wet and dry seasons.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

RESIDENTIAL CONTEMPORANEITY AND PERMANENCE IN THE CENTRAL MAYA LOWLANDS

Residential Structure Density and Population Estimates

The core area of the central Maya lowlands is characterized as having high settlement densities (Carr and Hazzard 1960; Fry 1969; Puleston 1973; D. Rice 1976; Ford 1986). Densities at major centers such as Tikal exceed 200 structures per sq. km, and densities in peripheral zones such as the Tikal-Yaxhá area are around 110 structures per sq. km. Traditionally, population estimates have been generated directly from data like these (Haviland 1970; Puleston 1973:190-207; D. Rice 1976:277-285). Raw structure densities have been taken and reduced by the percent of sites with occupation at any one period (95% in the case of Late Classic Tikal or 92% in the case of the Tikal-Yaxhá area), further reduced by an estimate of the percent of non-dwellings (16%) such as kitchens or shrines (*cf.* Haviland 1970) and finally multiplied by an average family size estimate of 5 to 6 persons (*e.g.*, Haviland 1970; Rice 1976:272-277; Puleston 1973:171-185). The results are then taken as a reasonable estimate of population. Thus, for the Tikal center, where the average structure density is 200 per sq. km:

200 × 95% occupation = 190 × 84% dwellings = 159.6 × 5 persons = *798 persons per sq. km*

and the rural Tikal-Yaxhá intersite area with 110 structure per sq. km:

110 × 92% occupation = 101.2 × 84% dwellings = 85.0 × 5 persons = *425 persons per sq. km*

Surprisingly, the lowest of these population estimates—425 persons per sq. km—exceeds published population densities of modern day China, India, and Japan (Boserup 1981:9-11). Even reducing the rural intersite figures to compensate for residential mobility (Haviland 1970:193), 100 persons per sq. km is still considered dense settlement in modern times, comparable to modern Europe or South Asia (Boserup 1981:11). Clearly, these

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

estimates are unreasonable and not conceivable for a preindustrial agrarian economy such as that of the ancient Maya.

This means of generating population estimates for the Maya lowlands includes assumptions about settlement which are not well understood. The issue of contemporaneity is the most fragile part of the equation. There are many problems with the assumption that all structures were occupied at the same time. Modern Maya villages and towns have variable occupancy and modern cities in the US have residential vacancies around 10% (City of Santa Barbara, 1987). Consequently, any estimate of ancient Maya population must seriously consider this issue.

The Function of Residential Structures

Investigations into the nature of residential units and component structure function in the central Maya lowlands has been largely restricted to the vicinity of Tikal. It is upon the data from Tikal that the estimated proportion of *bona fide* houses to residential adjuncts was derived (Haviland 1970:193). We know Tikal was one of the largest centers in the lowlands, over four times the size of neighboring centers such as Uaxactún and Yaxhá (Adams and Jones 1981:402). Moreover, residential units are larger and involve greater labor investment than residential units in the peripheral zones (Arnold and Ford 1980; Ford and Arnold 1982; Ford 1986:83). Given these facts, how representative of all Maya residential units are those at Tikal? Without comparable excavations in the non-central contexts, this is difficult to answer.

Along the same line, are all structures to be counted equally? Are the large residential structure compounds at Tikal the same as small isolated solitary structures in zones marginal to swamps? These two types of residential units appear distinct, and they may actually represent distinctly different aspects of overall settlement pattern. General size variations alone suggest significant differences, but other dimensions are also important. For example, the isolated single-structure units could have been used during the wet season as field houses and the residential compounds as a permanente base mainly for dry season occupancy. Or the large compounds may represent a consolidation of several wet season households of the more peripheral areas. If such

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

were the case, not all structures could be treated equally. All these dimensions affect demographic interpretations.

Implications for the Development of the Ancient Maya

Acknowledging that there may be different uses of Late Classic Period residential units depending on their location, size, and composition, I will turn to an examination of settlement through time. This review assumes that there was continuity in subsistence strategies over the entire development of the Classic Period Maya.

The central lowland Maya area naturally would have been sought by pioneering agriculturalists. Initial populations expanded into the lowland areas with rivers and lakes which were close to both uplands and secure water resources (Voorhies 1982). These locations are on the peripheries of the core area around Tikal. The core area around Tikal was one of the last areas of the lowlands to be settled. At the beginning, adequate land resources (Sanders 1977) could not offset the lack of drinking water, and differential access to drinking water characterized the first occupation of the interior zones. Natural water collection basins occur within the area (Lundell 1937:116) and would have been locations of the early occupation. Access, control, and development of these water resources were critical to survival (*cf.* Haberland 1983) and would have influenced subsequent settlement in the area.

In the Early to Middle Preclassic Period, settlements were well dispersed within the river and lake areas. Evidence from this time period is very limited, suggesting a very dispersed mobile population. With population growth in the river and lakes areas, more interior zones, such as the Tikal-Yaxhá area began to be settled. But even during the initial period of occupation in the Middle Preclassic, the mobile residents of the area focused on the zones nearest to perennial water when compared with more interior zones.

Occupation of the Tikal-Yaxhá area is apparent by the Middle Preclassic Period. Settlements were relatively dispersed and isolated in well-drained upland hilltops, the same zones with the highest settlement densities in the Late Classic Period. The lack of substantial archaeological evidence of settlement attri-

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

butable to this period is best explained by the low densities and high mobility of these early agriculturalists.

Once the Tikal-Yaxhá area was settled, population grew and spread throughout the entire area. By the Late Preclassic, the obstacles which inhibited the earlier settlers were overcome and settlement is found in all upland zones of the interior. While a higher degree of permanence is reflected simply by the volume of refuse attributed to this period when compared to the Middle Preclassic, populations must have continued to be mobile. There is widespread use of the area with some degree of aggregation in upland zones where centers existed in the Late Classic Period. This is most clearly seen in the area around the minor center of El Corozal, in the Tikal-Yaxhá intersite area. These zones were probably locations of permanent water resources which served as settlement *foci* and established the base for centralization in the area.

There is a distinct change in the settlement of the Early Classic Period. Evidence from the Tikal-Yaxhá area suggests nucleation towards centers and a general abandonment of non-central zones. Examination of Tikal's peripheries supports this interpretation. While settlement steadily increases at Tikal (Culbert 1977:53; Culbert and Kosakowsky 1985), the greatest amount of occupation in the sustaining area beyond Tikal is found around minor centers (Fry 1969:68-71) with a concomitant decline of settlement in non-central zones (Fry 1969:148-149). Similar Early Classic settlement concentrations around centers were noted in the Yaxhá-Sacnab lakes area (D. and P. Rice 1980:442-443). Such settlement concentration stands in contrast to the settlement distributions of the earlier Late Preclassic and lates Late Classic periods. Assuming continuity in the agricultural regime, this nucleation around centers may be best explained by reference to external social pressures.

The evidence of continued population growth within the region as a whole would exacerbate competition over land resources. The presence of a threat of overt aggession among local communities over resources would induce population nucleation for protection and defense. Settlements would logically cluster around existing administrative centers, which, in the interior core area, were the location of dry season water supplies. In aggregating, Early Classic populations locating permanently at

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

centers would have sacrificed easy access to fields for safety (*e.g.*, Earle *et al.* 1981:23).

The Early Classic settlement nucleation around centers may be seen to have influenced public construction. Initiation of dated monuments and major architectural undertakings are the hallmarks of the Early Classic (Willey 1974) and originate at the interior core centers of Tikal and Uaxactún (Marcus 1976: 33). Such impressive investments in monumental constructions at centers suggests competition among local hierachies for resources, and recent analysis of inscriptions on Early Classic monuments supports this interpretation (Mathews 1986:31). Also, a suggested defensive earthworks, tentatively dated to the Early Classic Period (Puleston and Callender 1967), was recorded north of Tikal and a similar (undated) feature was recorded 8 km to the southeast in the Tikal-Yaxhá area (Ford 1986:47, 109). These features appear analogous to the clearly defensive earthworks known from Becan (Webster 1976).

In sum, the Early Classic Period appears to represent a time of significant conflict. As growing local and regional populations continued to demand more agricultural land, competition became more acute, creating a need to nucleate for protection. Settlements in non-central zones were apparently the subject of depredation, and ultimately those zones were abandoned for the safety of the centers. While population undoubtedly continued to grow during this period, fueling competition, population increase at the centers was probably more related to population influx from rural zones than *in situ* growth.

Early Classic competition culminated with the Classic Period hiatus (Willey 1974), a brief span of time which lacks monumental displays of stela. The mounting evidence for competition in the Early Classic coupled with the widespread settlement expansion in the following Late Classic Period suggests that the cessation of stela commemoration was a problem of finance. The financial base of the society probably remained the same, but expenditures were taken from the arts and consumed elsewhere and, given the evidence for competition at this time, the increased expenditures were most likely in the realm of defense. An example of similar consequences of military investment is seen in preindustrial Europe. Church building in northern France was interrupted during the Hundred Years' War, and

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

heavy taxes were levied for military pursuits (Allman 1973). When the need for defense had passed, church building resumed where it had left off and, as testimony to the disruption, church steeples initiated in one century were finally completed in another.

Competition among the centers in the Early Classic Period ended, and the area was consolidated into a regional hierarchy most likely centered at Tikal, where there was significant Late Classic building and growth (Adams and Jones 1981). With the competitive constraints limiting settlement to central zones removed, during the Late Classic Period there was a spread back into the non-central areas in greater numbers than before. Indeed, there was more generalized use of all potentially habitable zones than any previous time period (*cf.* Puleston 1973:315). Still, the highest settlement densities continued to be adjacent to centers, especially in the vicinities of Tikal.

The Late Classic Period "*Pax* Maya" permitted the recolonization of the intersite areas and with it a relative decrease in aggregation around centers. Residential units at centers, however, remained distinct from those of the rural zones in this period. The former were larger, more complex, and they had the best access to storage chultunes. These settlements at centers, which had probably served as the single permanent residence in the Early Classic Period, were now the permanent residential base used when seasonal agricultural work was at a low and drinking water needs were at a high. This would explain the distinctions between the settlement of the central and non-central zones.

Terminal Classic demographic changes were most severe at the largest centers such as Tikal, where near abandonment is evidenced (Culbert 1973). Despite the demise of the great center of Tikal, the Tikal-Yaxhá area sustained use into the Terminal Classic Period. This is not entirely surprising (*cf.* Nigh 1981). Certainly, the populations leaving Tikal had to be absorbed elsewhere. It is important to note that other major centers such as Uaxactún (Smith and Gifford 1965) and Yaxhá (D. Rice and P. Rice 1980:437, 446, Op. 1 and 2) continued to be used into the Terminal Classic even though the surrounding areas appeared abandoned. In addition, the minor centers in the vicinity of Tikal are the only areas beyond the major center

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

with evidence of Terminal Classic occupation (Fry 1969:166-171).

The complex picture of the settlement of the Tikal-Yaxhá area suggests the maintenance of a relic elite at the smaller centers, perhaps in an effort to retain some hierarchical control during this period of population decline. These data suggest an organizational shift in the Terminal Classic away from Tikal towards the surrounding centers. This may reflect the devolution of the administrative hierarchy to correspond with the decrease in population. It is possible that the continued use of the Tikal-Yaxhá area is more representative of continued population consolidation in the best agricultural zones. On the other hand, it could represent shifting residential patterns of a very small population over the course of the whole period. Whatever the case, there was no significant occupation of the area in the Postclassic.

CONCLUSION

In this paper, I have attempted to outline distinctions in Late Classic Period settlement patterns which challange the validity of population reconstructions based simply on structure counts. The variations in size and composition of residential units and their access to dry storage facilities appears to relate directly to the subsistence regime of the region. Data on Maya settlement have grown tremendously in the last three decades and have yielded important information on the demographic priorities of the ancient Maya. From these data, we have the ability to determine *relative* settlement densities (and, by inference *relative* population densities) between environmental zones and understand differences among the residential types and areas. Ancient Maya population estimates need to be consider the nature of residential comparability and contemporaneity. These are best understood within the context of the subsistence economy —the use of the landscape by the ancient Maya. We cannot assume that all structures were in use simultaneously and served the same purposes without an adequate data base.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

ACKNOWLEDGEMENTS

The Tikal-Yaxhá research was partially supported by grants from the National Science Foundation and Leakey Foundation. The fieldwork was carried out under the auspices of the Instituto Guatemalteco de Antropología e Historia. Support was also provided by the Parque Nacional Tikal.

BIBLIOGRAPHY

ADAMS, R. E. W. AND C. JONES
1981 Spatial Patterns and Regional Growth Among Classic Maya Cities. *American Antiquity* 46:301-322.

ALLMAN, C. T.
1973 *Society at War: The Experience of England and France during the Hundred Years' War.* Barnes and Noble Books, New York.

ARNOLD, J. E. AND A. FORD
1980 A Statistical Examination of Settlement Patterns at Tikal, Guatemala. *American Antiquity* 45:713-726.

ASHMORE, W.
1981 *Lowland Maya Settlement Patterns,* editor. University of New Mexico Press, Albuquerque.
1981 Some Issues of Method and Theory in Lowland Maya Settlement Archaeology. In *Lowland Maya Settlement Patterns,* edited by W. Ashmore, pp. 37-70. University of New Mexico Press, Albuquerque.

BOSERUP, E.
1981 *Population and Technological Change.* Aldine Publishing Co., Chicago.

BULLARD, W. R.
1960 Maya Settlement Pattern in the Northeastern Petén, Guatemala. *American Antiquity* 25:255-272.

CARR, R. F. AND J. E. HAZZARD
1961 *Map of the Ruins of Tikal, El Petén, Guatemala.* Museum Monographs, Tikal Report No. 11. University of Pennsylvania, Philadelphia.

CARTER, W.
1969 *New Lands and Old Traditions: Kekchi Cultivators in the Guatemalan Lowlands.* American Monograph No. 6. University of Florida Press, Gainesville.

COWGILL, U. M. AND G. E. HUTCHINSON

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

1963 Soil Fertility and the Ancient Maya. *Transaction of the Connecticut Academy of Arts and Science* 42:1-56.

CULBERT, T. P.

1973 *The Classic Maya Collapse,* editor. University of New Mexico Press, Albuquerque.

1977 Early Maya Development at Tikal, Guatemala. In *Origins of Maya Civilization,* pp. 27-44, edited by R. E. W. Adams. University of New Mexico Press, Albuquerque.

CULBERT, T. P. AND L. KOSAKOWSKI

1985 Demography at Tikal. Paper presented at the 50th annual meeting of the Society for American Archaeology, Denver.

EARLE, T. K., T. N. D'ALTROY, C. J. LEBLANC, C. A. HASTORF, AND T. E. LEVINE

1980 Changing Settlement Patterns in the Upper Mantaro Valley, Perú: Preliminary Report on the 1977, 1978, and 1978 Seasons of the Upper Mantaro Archaeological Research Project. *Journal of New World Archaeology,* Vol. 4.

FORD, A.

1981 *Conditions for the Evolution of Complex Societies: The Development of the Central Lowland Maya.* Ph. D. dissertation, Department of Anthropology, University of California, Santa Barbara.

1986 *Population Growth and Social Complexity: An Examination of Settlement and Environment in the Central Maya Lowlands.* Anthropological Research Papers No. 35. Arizona State University, Tempe.

FORD, A. AND J. E. ARNOLD

1982 A Reexamination of Labor Investments at Tikal: A Reply to Haviland and Folan et al. *American Antiquity* 47:713-726.

FRY, R. E.

1969 *Ceramics and Settlement in the Periphery of Tikal, Guatemala.* Ph. D. dissertation, University Microfilms, Ann Arbor.

1972 Manually opperated Post Hole Digger as Sampling Instruments. *American Antiquity* 37:259-261.

GIFFORD, J. C., R. J. SHARER, J. W. BALL, A. F. CHASE, C. A. GIFFORD, M. KIRPATRICK, AND G. H. MYER

1976 *Prehistoric Pottery Analysis and the Ceramics of Barton Ramie in the Belize Valley.* Memoirs, Peabody Mu-

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

seum of Archaeology and Ethnology, Vol. 18. Cambridge University Press, Cambridge.

HABERLAND, W.

1983 To Quench the Thirst: Water and Settlement in Central America and Beyond. In *Prehistoric Settlement Patterns: Essays in honor of Gordon R. Willey,* edited by E. Z. Vogt and R. M. Leventhal, pp. 79-88. University of New Mexico Press and Peabody Museum, Harvard University, Cambridge.

HAVILAND, W. A.

1970 Tikal, Guatemala and Mesoamerican Urbanism. *World Archaeology* 2:186-198.

LAWS, W. D.

1961 Investigations of Swamp Soils from the Tintal and Pinal Associations of Petén, Guatemala. *Wrightia* 2:127-132.

LUNDELL, C. L.

1937 *The Vegetation of Petén.* Carnegie Institute, Publication 478. Washington, D. C.

MARCUS, J.

1976 *Emblem and the State in the Classic Maya Lowlands.* Dumbarton Oaks, Washington, D. C.

MATHEWS, P.

1985 Maya Early Classic Monuments and Inscription. In *A Consideration of the Early Classic Period in the Maya Lowlands,* edited by G. R. Willey and P. Mathews, pp. 5-54. Institute for Mesoamerican Studies, Publication No. 10. State University of New York at Albany.

NIGH, R. B.

1981 Review of Prehispanic Maya Agriculture, edited by P. D. Harrison and B. L. Turner II. *American Antiquity* 46:707-709.

PULESTON, D. E.

1968 *Brosimum Alicastrium as a Subsistence Alternative for the Classic Maya of the Central Southern Lowlands.* M. A. Thesis, University of Pennsylvania. University Microfilms.

1971 An Experimental Approach to the Function of Classic Maya Chultuns. *American Antiquity* 36:322-335.

1973 *Ancient Settlement Patterns and Environment at Tikal, Guatemala: Implication for Subsistence Models.* Ph. D. dissertation, University of Pennsylvania. University Microfilms, Ann Arbor.

1978 Terracing and Raised Fields and Tree Cropping in the

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

Maya Lowlands: A New Perspective on the Geography of Power. In *Prehispanic Maya Agriculture* edited by P. D. Harrison and B. L. Turner II, pp. 235-245. University of New Mexico Press, Albuquerque.

1983 *The Settlement Survey of Tikal.* Tikal Report No. 13. University Museum, Philadelphia.

PULESTON, D. E. and D. W. CALLENDER

1967 Defensive Earthworks at Tikal. *Expedition* 9:40-48.

PULESTON, O. S. AND D. E. PULESTON

1971 Ecological Approach to the Origins of Maya Civilization. *Archaeology* 24:330-337.

1972 A Processual Model for the Rise of Classic Maya Civilization in the Southern Lowlands. *Proceedings of the LX International Congress of the Americanists,* pp. 119-124.

REDFIELD, R. AND A. VILLA ROJAS

1962 *Chan Kom: A Maya Village.* Phoenix Books, University of Chicago Press, Chicago.

RICE, D. S.

1976 *The Historical Ecology of Lakes Yaxhá and Sacnab, El Petén, Guatemala.* Ph. D. dissertation, Pennsylvania State University. University Microfilms, Ann Arbor.

RICE, D. S. AND D. E. PULESTON

1981 Ancient Maya Settlement Patterns in the Petén, Guatemala. In *Lowland Maya Settlement Patterns,* edited by W. Ashmore, pp. 121-156. University of New Mexico Press, Albuquerque.

SANDERS, W. T.

1977 Environmental Heterogeneity and Evolution of Lowland Maya Civilization. In *Origins of Maya Civilization,* edited by R. E. W. Adams, pp. 287-298. University of New Mexico Press, Albuquerque.

SIMMONS, C. S., J. M. TARANO, AND J. H. PINTO Z.

1959 *Clasificación de Reconocimiento de los Suelos de la República de Guatemala.* Ministerio de Agricultura, Instituto Agropecuario Nacional, Guatemala.

SMITH, R. E. AND J. C. GIFFORD

1965 Pottery of the Maya Lowlands. In *Middle American Handbook*, Vol. 2, edited by G. R. Willey, pp. 498-534. University of Texas Press, Austin.

STEGGARADA, M.

1941 *Maya Indians of the Yucatan.* Carnegie Institute Publication No. 531, Washington, D.C.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/

VILLA ROJAS, A.
1945 *The Maya of East Central Quintana Roo*. Carnegie Institute Publication No. 559, Washington, D. C.

VOORHIES, B.
1982 An Ecological Model of the Early Maya of the Central Lowlands. *Maya Subsistence,* edited by K. V. Flannery. Academic Press, New York.

WAUCHOPE, R.
1938 *Modern Maya Houses*. Carnegie Institute, Washington, D. C.

WEBSTER, D. L.
1975 Warfare and the Origin of the State: A Reconsideration. *American Antiquity* 40:464-470.

WILLEY, G. R.
1974 The Classic Maya Hiatus: A 'Rehearsal' for the Collapse? In *Mesoamerican Archaeology: New Approaches,* pp. 417-430, edited by N. Hammond. University of Texas Press, Austin.

Estudios de Cultura Maya. Vol. XVIII, 1991
Instituto de Investigaciones Filológicas/
Centro de Estudios Mayas, UNAM
ISSN 0185-2574
http://www.iifilologicas.unam.mx/estculmaya/