CULTURAL ECOLOGY OF THE MAYA LOWLANDS

By WILLIAM T. SANDERS.
Pennsylvania State University.

PART I

BASIC GEOGRAPHY

This paper will attempt to discuss some of the relationships between environment and culture in the Lowland Maya area. We will attempt to answer the following questions:

1. What are the interactional patterns between the environment and the subsistence system?
2. In what ways is the latter related to population history and settlement patterns?
3. What relationship exists between the subsistence system and the birth and decline of Maya Civilization?

All of the Pre-Iron Age Civilizations in the Old World have evolved in one of two ecological settings. 1. Deserts with exotic rivers for irrigation, 2. Semi-arid coastal plains and interior mountain valleys or plateaus with annual rainfall averaging below 40″ (1000 mms.) concentrated in either the summer or winter. In the New World civilizations evolved in Pre-Hispanic times in two areas: the Andean and Mesoamerican. The Andean Civilization evolved in both of the defined ecological settings with a coastal desert and adjacent highland area of light seasonal rainfall.

In the case of Mesoamerica the ecological setting is more complex but two basic types may be defined. 1) Highland in Central and Southern Mexico and Guatemala with rainfall generally falling below 40″ (1000 mms.). 2) A Lowland area with heavy rainfall and tropical forest along the Gulf Coast. The Pacific Coastal plain is more variable with a great range of rainfall. Several of the most spectacular regional developments occurred in the tropical forested Lowlands.

The Lowland Maya area, as defined here, includes the Peninsula of Yucatan (Campeche, Quintana Roo and Yucatan in Mexico; Peten and Izabal in Guatemala, and British Honduras), the eastern half of Tabasco plus the adjacent foothills in Chiapas and western Honduras.

This huge area of 300,000 $km.^2$ has a fundamental unity in that rainfall is heavy enough to support a tropical forest and that the area of human occupation lies below 800 ms. above sea level. Within this unity, however, a number of distinct ecological provinces must be defined. A large part of this area is occupied by the Peninsula of Yucatan, a huge limestone shelf jutting into the Gulf of Mexico.

Northern Yucatan — the northern half of the Peninsula lacks important elevations (except for the Puuc range but even these do not exceed 300 ms.) and appears from the air as a flat unbroken plain. Actually the surface is extremely uneven with abundant micro-topography. Soil cover is generally scanty with large areas of exposed bedrock (limestone) and soil occurs primarily in the numerous pits. With the exception of a few small lakes in central Quintana Roo around Coba the area lacks surface drainage. The latter characteristic presents one of the most difficult problems for human settlement. In most of the area, however, natural wells or cenotes are abundant and alleviate somewhat the problem.

Rainfall in northern Yucatan is generally lower than that in the rest of the Lowland Maya area. The lowest figures are reported for Progreso on the northwest Coast (20″) (500 mms.) and rainfall increases from northwest to southeast (30″ —750 mm.— in the central part of the state of Yucatan, increasing to 40-50″ —1000-1250 mm.— in the southern and eastern part of the state, Campeche and Quintana Roo.) Rainfall is characteristically concentrated during the summer and early fall with nearly rainless conditions for the rest of the year. The rainfall data over much of this area suggests savanna vegetation whereas in fact it is scrub forest in the drier areas, shifting to zapote jungle in the east and south.

Southern Yucatan —the southern part of the Peninsula has a more varied topography and hydrography. Most of the area is extremely hilly with dome shaped hills interspersed with low swampy "bajos" or "aguadas" with much of the area lying above 100 ms. above sea level. Exceptions to the general picture would be British Honduras where true mountains occur reaching elevations of 800 meters above sea level. A large part of the area is drained by the Rio Usumacinta, one of the major rivers of Mesoamerica in drainage area and annual volume of water. As it flows through hilly terrain there are few floodplains and all are of small size. Soil cover is generally as scanty as in northern Yucatan.

Some area, southwestern Campeche around the Laguna de Terminos and Candelaria Basin, and the department of Izabal in Guatemala, are low flat areas with great tracts of seasonally and permanently flooded land. Annual rainfall over the entire southern part of the Peninsula averages from station to station from 60-80″ (1500-2000 mm.) —rising to 100-150″ (2500-3750 mm.) in the Maya Mountains of British Honduras and foothill areas in the southern part of the Peten. The rainfall is generally as seasonal as in northern Yucatan. With the exception of one large continuous zone of savanna in northern Peten (south of Lake Peten Itza) and scattered savannas in Campeche, all of this area is covered by dense tropical forest.

One of the major problems of Cultural Geography is the origin of the savanna zones in this area of high rainfall. The lack of Classic Maya sites in the Peten savanna area suggests that they are natural in origin but the Campeche savannas are associated with heavy Classic occupation and are presumably the result of agricultural activities.

Tabasco —the ecological characteristics of Tabasco differ strikingly from the rest of the Lowland Maya area. Tabasco is a huge flat coastal plain characterized by deep soils, poor drainage, and a large area of permanently or seasonally inundated terrain. The eastern and central parts of the plain are drained by the Grijalva and lower Usumacinta rivers.

The Grijalva has large stretches of alluvial flood plain which are prize lands for commercial agriculture. Average annual rainfall over the plain from station to station ranges from 60-80″ (1500-2000 mms.). Although the heaviest rains occur during the summer and early autumn there are sufficient rains during the winter for agriculture. Over most of the area the natural vegetation is forest but there are large stretches of grassland, some of which occurs on high, well drained land outside the reach of annual floods and some are "drowned" swamp savannas. Archaeological survey in the Chontalpa suggests that the more elevated savannas are natural since they have a paucity of archaeological sites.

Behind the coastal plain is the foothill zone of the Sierra Madre de Chiapas with hilly broken terrain, rapid flowing and abundant surface drainage, and the heaviest annual rainfall in Mesoamerica. Some stations record an average annual rainfall of 200-250″ (5000-6250 mm.).

AGRICULTURE. MODERN AND ANCIENT

In sharp contrast to the Highland areas of Mesoamerica, the "Tierra Caliente" in general, and the Mayan Lowlands in particular, is characterized by an extremely rich crop assemblage. Although the staple crop is every-where maize, it is supplemented by an extraordinary variety of secondary food and other crops. It should be stressed, however, that most of the secondary food crops are fruits, producing foods for only short periods during the year, and cannot be stored. Two of the root crops could have been important staples (sweet potato and manioc), but they are cultivated today as minor crops and there is no evidence for the Pre-Hispanic periods that suggests a greater importance then.

In spite of the richness of the food complex, Steggerda's studies of the Yucatecan Maya and mine of the Chontalpa indicate that maize products, in the form of pozol and tortillas, make up most of the diet (Steggerda, 1941, Sanders, 1956). Rice is an important secondary staple in the Chontalpa, but is of course a Post-Hispanic crop. Estimates of population for the Pre-Hispanic periods should therefore revolve around the capacity of maize as a food provider.

Although metal was known in the area after the tenth century it was apparently rarely used for basic cutting tools, and the Lowland Maya area remained essentially Neolithic throughout the Pre-Hispanic Period. Today steel axes and machetes are used in clearing the bush. Our analysis of Pre-Hispanic agriculture, then, concerns a people living in a tropical forested environment with an annual grain as a staple, and limited to a Neolithic tool kit. The primary problems for a cultivator in such an environment are: 1) competition of natural vegetation, and 2) exhaustion of soils of low to moderate fertility. The critical points with respect to these two problems may be summarized in the following way. The forest cover tends to result in a relatively high organic content in the soils. Once the forest is cleared, however, the process of organic matter production is sharply curtailed. After clearing, the combination of high temperatures and heavy rainfall produces an extraordinarily rapid growth of weeds, of both the grassy and woody types. The former, especially, are troublesome to a cultivator. The longer the period of cultivation, the more troublesome the problem of weed competition becomes. The high temperature results in the rapid oxidation of soil minerals into soluble particles usable for the plants. This of course is a beneficial process under normal conditions, and along with the natural humidity is responsible for the exuberance of tropical vegetation. Unfortunately, however, the abundant rainfall, especially in areas of poor drainage, results in a process called leaching, whereby such soil minerals are dissolved in the ground water and redeposited well below the depths that plant roots ordinarily penetrate. Once the forest is cleared, and especially if the soil is plowed to control the weeds, not only is the process of leaching hastened, but the normally high organic matter contained in the soil is exposed to the abundant microbic life and destroyed. It is preferable in cultivating most tropical forest areas, then, not to break the soil, and even to permit the natural plant cover to recover enough to provide a cover for the ground.

How then to control competition between domestic and wild plants to the point where the former are favored? The answer is a system of cultivation called variously in the literature slash and burn, milpa, "roza", bush fallowing, nomadic agriculture, and swidden cultivation, and practiced all over the world where tropical forests occur, even in areas where steel cutting tools are used. It has been variously characterized as primitive, wasteful, and destructive; whereas in reality, like nearly all folk agricultural systems, it is one in harmony with the environmental characteristics.

The system involves the following basic steps: 1) The selection of the field; based upon a number of considerations, such as, distance from the settlement, drainage, soil depth, and the kind and exuberance of natural vegetation. 2) The clearing of the bush. Today in Mesoamerica, this is done primarily with a steel machete supplemented by axes. Frequently, economically useful trees are left and trees are felled well above the roots to speed up regrowth. The trash is heaped up in a large number of piles scattered around the field. 3) Burning. A fire trail is cleared around the field as a precaution against spreading and, contrary to many claims, at least in well populated areas, burning is carefully controlled. Piles of trash are then burned as a final clearing operation. The result is an extremely clean field covered by ash. 4) Planting. Fields are never plowed and frequently only a pointed pole, called the "macana" in Tabasco, is used to perforate holes in the ash large enough to insert seeds or young plants. In some parts of the world the soil is hoed. 5) Weeding. A chore of major proportions except in fields where climax forest has been cleared. 6) Harvest.

The same field may be planted only once, or succesively for a period of several years, until declining yields make planting uneconomic and the field is abandoned. The cultivator then shifts to another field. The first field is left fallow for a number of years and then cleared again for another cultivation. The precise number of years in cultivation and years of rest varies considerably according to specific characteristics of vegetation, soil, and demographic pressure. Essentially, however, the system involves cultivating as long as it is economic to continue in terms of labor and production, and resting until the woody plants have achieved dominance over the grassy one. In all areas where the system has been studied, it has been noted that production is normally very high for the first years of cultivation, and declines sharply for each succesive year. The declining yield has been ascribed to either increasing weed competition, soil exhaustion, or both. It is probable that both factors are responsible, but I feel that the former is probably the main factor in most areas, especially where the "macana" is used rather than hoe for planting. With the former, the soil is not turned over at all, and weed regrowth is only partially controlled. The result is that fields are cultivated normally no more than three years, a period I do not feel would affect soil fertility in most areas.

In Africa the hoe is typically used in preparation of the land before planting, enabling a better control over weed growth. Lands are frequently cultivated more than three succesive years and decline of soil fertility probably is a more important factor in the declining production.

It is of interest to note, in connection with the above argument, that, in the experimental milpa maintained by the Carnegie Institution at Chichen Itza in northern Yucatan, they were able to prolong the period of cultivation with relatively high yields by uprooting the weeds instead of cutting them off at ground level, as do the modern Maya with the machete, an alternate method to hoeing them under (Morley, 1946). But, and this is a point of greatest importance for our later arguments, the result was a much heavier invasion of grasses in the final years to the extent that hand weeding could not cope with the problem, and the field had to be abandoned.

In Africa, deep hoeing combined with this system is carried out primarily in the West African savannas, where soils are probably less leached, and the iron hoe permits effective control of grasses. In the Congo forests hoeing is done by women who use a lightweight hoe which does not thoroughly disturb the surface layer and cultivation cycles are typically shorter.

As has been stated, the precise cycling of periods of cultivation and rest varies enormously, even within the Maya Lowlands. A decision to abandon a field and shift to a new location is based on two primary considerations: 1) How much land is available, in other words the size of the area at the disposal of the cultivator. 2) Is it more economic in terms of relationship between labor expended and crop expected to clear new forest or combat weed growth. If land is abundant, and the drop in yield between first and second year milpas is striking (due to exceptionally poor soils or vigorous grass growts), them it would be more economic to clear a new field each year. In Tabasco, in areas of lateric soil, outside of the river flood plains but on flat terrain and with scanty population the fields are frequently planted only one year.

Although documentary data is disappointingly scanty with respect to agricultural practices for the Pre-Hispanic Period, all of it does suggest that slash and burn agriculture based primarily on maize was the dominant system of agriculture for the Lowland Maya area at the time of the Conquest and during 16th Century in general. The data is especially conclusive for northern Yucatan where the demographic decline following the conquest was not as catastrophic as it was on the Gulf Coast Plains, and our data is therefore roughly applicable to the final Pre-Hispanic Period. Several *Relaciones Geograficas de Yucatan* (RGY, 1898-1900) describe the system directly, and general statements about the presence of forest, savannas (probably man-made or possibly referring to scrubby acahual), and milpas from the accounts of the Conquest, and the *Relaciones* provide indirect confirmation. One writer, Ponce, leaves no doubt as to the kind of agriculture practiced by the Yucatecan Maya as the following quote demonstrates:

"It seems impossible that this maize, of which we speak, is able to yield in that province because the Indians sow it among rocks, where it seems there is no moisture whatever, and nevertheless the land is so good and fertile, that without any other tillage, plowing or spading, but with only the timely burning of the bush the land is left so well cultivated by the fire and so well prepared for sowing that, sown thus, it produces very tall and stout stalks and on each of them one, to and even three ears: and the more and better burned the milpa is, the more and better corn it produces because the fire and the ashes from it serve as dung that burns the insects and roots of the weeds, and when the milpa has been recently burned and the maize sown thus and the rains approach (of which the Indians keep careful count), it sprouts quickly and grows with the showers and when the weeds start to grow, they find the maize already up, so that they can not grow well before they are crushed and smothered, and the maize prospers and grows very fast till it reaches full size." (Roys, 1943.)

The main difference between modern Maya milpa agriculture and Pre-Hispanic was probably in the activity of weeding, as I have suggested above. With Neolithic axes, slashing down the weeds at ground level was not practicable, and without effective digging tools the only technique of weeding possible was uprooting by hand. It is probable the period of cultivation and period of rest were both prolonged beyond the normal pattern today. It seems probable also that complete removal of the larger trees was not practiced and they were probably killed by the burning. The primary clearing of the climax or near-climax forest would also presumably be a more arduous task with polished stone axes, thus providing an added incentive to more prolonged cultivation before abandonment of a field. Furthermore, the amount of land that could be cleared for cultivation must have been considerably lower than cleared by the machete-wielding mestizo farmer today, and the surplus, per farmer, considerably less. In the alluvial flood plain in the Chontalpa there are areas of dense population where many farmers hold only six hectares of land. Furthermore, it is an area with 80 inches (2000 mm.) of annual rainfall combined with naturally humid soil conditions. As a result many farmers plant for two to three consecutive years two harvests per year for a total of four to six harversts, and rest the land for only two to six years with a resultant ratio of 1:1 or 1:2. This is made possible by unusually fertile alluvial flood plain soils and extraordinary rapid regrowth of woody plants. More usual in this area, for maximum production, a ratio of one to three is ideal, and on holdings where a 1:1 cycle is maintained the yields are markedly lower. In the Puuc in northern Yucatan, an area of hills and small valleys with deep soil, Steggerda notes in areas at the bases of hills or in the valleys soils can be planted up to six to twelve consecutive years, but these are exceptional areas where soil creep downslope and moderate rainfall produce exceptionally fertile soils.

A characteristic of agriculture in Lowland Mesoamerica in general is the tendency to plant a great variety of crops in a single field, so that the production of maize is only part (although the major part) of the harvest. Typically the farmer plants maize, beans, and squash mixed together in each hole, and in the intervening row between them are planted chilli peppers, tomatoes, yucca, sweet potatoes, jicama, beans, and today Post-Hispanic crops such as cabbages, onions, and melons. A few scattered papaya and banana plants (both of which grow to the size of a small tree) may also be planted. The former is a Pre-Hispanic plant, the latter introduced by the Spaniards.

In much of the Tierra Caliente of Mesoamerica, the meteorological pattern permits planting and harvesting of two crops in the same plot of ground in a single year. It is perhaps this fact that has given the area its fame for productivity. Exaggerated claims of even three to four harvests in some areas have been made, but this usually involves one or two plantings of a special variety of maize that matures in 60 to 90 days and produces a very low yield. Even in two crop areas the yield of the winter crop is usually considerably lower than the summer or main crop, often only half as great. Everywhere there is a principal crop which is grown during the summer, the period of maximum rainfall, and called the milpa. Whereever the winter rains permit, a second tonamil crop is characteristic. Theoretically, in areas of heavy rainfall, planting can be done at any time of the year, but the need for short dry spells to dry out the bush for firing, the behavior of flooding streams, and the need for heavy rainfall at the two critical periods of germination of the seed and tasselling of the plant mean relatively strict timetables for all agricultural activities. In the Lowland Maya area in particular, double cropping is not characteristic. Over nearly the entire Yucatan peninsula, even where rainfall is 60 to 80 inches, there is such a marked concentration in the summer that winter rains are insufficient for an extra crop. In northern Yucatan, Steggerda reports a crop of the sixty day type of maize in late spring in years when rains started a little earlier than average followed by the main milpa, but the yield is very low and the system can hardly be called double cropping. Double cropping is characteristic of the Tabascan plain and foothills of the Sierra Madre de Chiapas, however, where the two major sites of Comalcalco and Palenque are located. I suspect that the southern Peten foothill region just north of the Cuchumatanes Mountains is also a two crop area, as is probably the area around Copan.

Aside from subsistence crops in northern Yucatan, where the population lives primarily in villages today, each house has a relatively large houselot surrounded by a stone wall averaging some 5000 $m.^2$, which is occupied by a fruit orchard with a great variety of crops. In Tabasco where we have a ranchería pattern each house is surrounded by a clearing with a similar fruit orchard.

Along with the houselot orchard one finds frequently banana or plantain groves, in Tabasco near the houselot and in northern Yucatan in the forest at some distance from the house. Characteristically in Tabasco farmers have small cacao or coffee groves near the houselot; in Yucatan, in some villages, the houselot or some other lot within the village area, may be entirely planted in orange trees.

Looking at tropical agriculture as a whole and the problems involved, it would seem that orchard crops involving trees or treelike herbs, such as the banana or papaya, would be an ideal agricultural system, since it involves slow-growing plants that extract much less nutriment from the soil than fast-growing grains, require humid conditions, which are of course typical of the area, and finally, may successfully compete with weeds because of their size. This system of farming is most in harmony with the ecology, since it simply means the replacement of a natural forest of limited food productivity with an artificial forest of great productivity.

In Africa, the densest populations are found in Uganda where plantains are the staple foods and in southern Nigeria where there is a highly developed commercial cacao orchard agriculture. Unfortunately only a few fruits such as the banana or plantain can be used as a staple, and there were none in the Pre-Hispanic agricultural complex, and commercial agriculture is dependent on efficient transportation and a big international market, both of which were lacking in the technological system of the Maya. Exceptions to the latter statement would apply to Maya Lowland areas adjacent to the Highland region where tropical fruits could not be grown and where the Highland market was close by; and in the case of cacao, where the product was a bean and could be dried, stored, and shipped all over Highland Mesoamerica and where great demand as a luxury made its exportation lucrative in spite of the inefficient transportation technology. Cacao, however, is demanding in its ecological requirements, needing welldrained alluvial, humid, riverside soils and an annual rainfall of at least 80 inches (2000 mm.), or in areas of hilly, rapidly draining terrain, a rainfall exceeding 150 inches (3750 mm.) distributed throughout the year. (The prize cacao zones today are in the Pichucalco-Teapa areas, where we have an anual rainfall of 200 inches (5000 mm.) a year.) Cacao also needs limited sunlight. (Even in damp, cloudy environments its dislike of bright sun requires it to be planted in the shade of another tree called the mother-of-cacao.) Within the Lowland Maya area the only area where cacao was a major crop was the Tabascan plain and adjacent foothills of the Chiapas ranges.

A major problem with respect to the history of land use in the Maya Lowlands in Pre-Hispanic times is the possibility of a more intensive system of maize cultivation than slash and burn. Palerm has suggested the possibility of irrigation agriculture or chinampa cultivation in the aguadas or bajos of the Peten (following Cook's argument that these were formerly open lakes that have become silted in through the erosion of nearby slopes) (Palerm 1961). The fact that no system of intensive maize cultivation is practiced today in the Mayan Lowland area would seem to suggest its essential impractibility. However, it should be noted that the population generally is well below its potential, even with slash and burn agriculture, so there is slight demographic pressure. In the Chontalpa area in Tabasco, along the more fertile alluvial strip, there are areas of high population density probably exceeding 50 to 60 per square kilometer and an intensive system of agriculture has not evolved there (although as we have noted a very short cycle of rest is characteristic).

Outside of the Mayan area, but within the Tierra Caliente, plow agriculture is practiced in the areas of low rainfall, with savanna vegetation, in central Veracruz and the Panuco river basin. Palerm reports irrigation agriculture in the former area, especially around Cempoala, for the inmediate Pre-Hispanic period. My own position with respect to such a possibility might be summarized in the following way:

1) Over the great majority of the Mayan Lowlands, the soil characteristic are such that lacking abundant resources of animal fertilizers intensive agriculture would be an extremely unlikely possibility.

2) If fields were continuously cultivated in spite of declining returns, then the intensity of weed competition and labor involved in weeding would reach a point that in terms of declining production a man could not support himself and his family with daily maize requirements. I believe the data from the Chichen Itza experimental station suggests this, and test data on third year milpas gathered by me from Quintana Roo suggests that even in third year milpas hand weeding is so laborious that a farmer could just about support his family.

3) Metal hoes were unavailable to the Maya, which means that the only technique of weed control that could have been used was by hand. The absence of good slashing tools suggests that they did in fact weed in this manner. The result, according to the Chichen experimental milpa, is a definite prolongation of the life of the milpa, but it also apparently reduces the competitive advantage that regrowing woody plants hold over grasses to the point where the latter take over and a regrowth of forest is therefore retarded so that the cycle of rest must be prolonged. The result, in fact, doesn't seem to lead to any greater demographic advantage. One might argue that grasses could have been removed by hand weeding, but here we run into problem two, and the fact that in both the Peten and Tabasco the natural savannas lack evidence of Pre-Historic occupa-

tion argues strongly that grass covered areas are nearly unmanageable with Neolithic technology.

4) In small areas of exceptionally fertile soil, it is conceivable that hand weeding combined with the higher production would permit a system of intensive agriculture that would be economically feasible, especially if it were combined with careful use of organic refuse from corral birds, humans, and composts of vegetal fertilizers. If this were furthermore combined with irrigation in wetter areas to permit extra cropping during the dry season or in dryer areas as a supplement to rainfall for the summer crop, and/or combined with terracing, then the possibility of a system of more intensive agriculture must be admitted. (Irrigation in itself is a soil restoring mechanism since irrigation water contains minerals in solution and frequently fresh soil.) There is to date no acknowledged evidence that this occurred in the most densely settled part of the Maya Lowlands and its cultural heartland (the northern Peten) is precisely the area that lacks the critical ecological characteristics or archeological evidence of intensive agricultural technology. The only example I am aware of, of a system of intensive agriculture based on annual grains in the tropical areas of the world, is in Southern and Eastern Asia where the system of wet rice cultivation involves precisely the complex of traits listed above. It, however, involves a crop which has a much higher caloric production per unit of land than maize and therefore is economically feasible in terms of labor on small parcels of land, is better adapted generally to tropical soil characteristics, and is used in alluvial river bottoms where soils are more fertile and water for irrigation is available or on hillsides where terraces and/or irrigation provide an artificial ecology. Even so, fields are maintained in cultivation only by continuous cultivation and labor, which usually involves the use of draft animals and plows. No area of the Maya Lowlands surveyed yields a picture of such complete manipulation of the soil and water resources that are required in wet rice agriculture.

5) The one good possibility of intensive agriculture in the Maya area would be chinampa agriculture in the bajos of the Peten. Their presence has not yet been demonstrated archaeologically.

6) The settlement pattern picture of the Lowland Maya

suggests strongly that the basic system of grain production was in fact slash and burn.

The only archaeological evidence known to me for a more intensive system of cultivation is a system of terraces described by Thompson for British Honduras (Thompson, 1939). They are apparently limited to high elevations in the Mayan Mountain area and are not located in an area noted for major ceremonial centers, so that the marginal relationship to Maya agriculture as a whole is clear. It is possible that even these terraces were used for slash and burn agriculture and were not continuously cultivated. The development of terracing here might have occurred in response to extreme susceptibility of local soils to erosion.

DEMOGRAPHY. MODERN AND ANCIENT

Documentary Data

Between the time of the arrival of Cortez in 1519 and 1580, there occurred a demographic disaster in Mesoamerica rarely equalled in history. The major cause seems to have been the introduction of a series of foreign diseases of which smallpox, measles, and whooping cough seemed to have been the prime killers in the area as a whole, and malaria may be added to the list for areas below 1600 meters and especially those situated below 800. Three major epidemics are reported, in the 20's, the 40's, and in the 70's. Aside from disease, cultural breakdown, overwork by the encomenderos, and emmigration through slavery seem to have been prime factors. The *Relaciones Geograficas* for areas all over Mesoamerica describe disease as the main factor, except in northern Yucatan, where the resettlement program is considered as the cause. Starting in 1549, the Spanish government forced the Maya residing in small hamlets to move to the old zonal ceremonial centers, or to new town locations, to facilitate conversion and taxation. Between 1549 and 1579 (the latter is the date of the *Relaciones Geograficas)* the process continued, and even the newly formed towns were recombined into larger communities. Although a great demographic decline between 1549 and 1579 is indicated, much of the loss is ascribed to this regroup ing policy. The large communities apparently were difficult to maintain in terms of slash and burn agriculture, and the population either died or fled back into the forests. This is a dramatic demonstration of the difficulty of maintaining large communities with slash and burn agriculture. For the rest of Mexico there is abundant tax data for the period from about 1530 to 1580, enabling us to estimate population size and decline. For the Central Plateau, and areas generally above 1600 meters, the population declined to about one half of the 1519 figure by the 50's, and by 1580 it had declined to one third of the 1519 figure. For the Tierra Caliente of Vera Cruz, the decline was much faster, possibly as low as 10 percent of the 1519 population survived the series of epidemics of the 16 th Century.

In Yucatan, the curve of population decline seems to have been closer to that of the Plateau. The relatively dry northwestern part of the peninsula is freer of malaria today than the Gulf Coast, and its relative isolation presumably were the main factors responsible for this lesser decline. It is of interest to note that the more humid parts of the area that was well settled at the time of the Conquest (northern British Honduras, western Honduras, southwestern Campeche, Tabasco, and Quintana Roo) suffered as heavy a decline as in the general Tierra Caliente of Mesoamerica.

Roys (1951) estimates a population in 1549 (the first tax census) of 57,000 tributaries or 256,200 people in the peninsula of Yucatan proper, excluding the provinces of Uaymil and Chetumal. If we estimate some 50,000 more for this area, the total population would be approximately 300,000.

Vázquez de Espinosa in 1609 estimated 116,600 confesses, or about 180,000 people for the penisula of Yucatan plus Tabasco (Vázquez de Espinosa, 1948). The reduction is almost exactly that suffered on the Mexican Plateau for the same period. We have no figure for the Conquest period of total population, but it certainly was not greater than the latter area, especially when we consider the fact that Yucatan was not conquered until 10 years after the Central Plateau area and missed the epidemics of the 20's completely.

A few figures given by Roys from the 1549 tax lists include estimates of a former population that indicate roughly a decline of no more than one half. Presuming that this is the general reduction figure, the following population estimates and densities for the peninsula are calculated from his data.

(We have included the 1940 census figures as controls.) Another interesting parallel here is that the tax data for the Valley of Mexico for the same period is roughly equivalent to the 1940 rural densities and sizes. Note the correspondence below.

Province	Area km.²	1549	Dens.	1940	Conquest (est.)
		Population Figures for			
Cupul	9000	54,000	(6)	60,000	100,000 (12)
Chakan	1500	15,000	(10)	15,000	30,000 (20)
Cehpech	2400	40,000	(17)	37,000 (excluding Merida)	80,000 (34)
Hocaba	1200	15,000	(12)	15,000	30,000 (25)
Ah Kin Chel	5000	40,000	(8)	38,000	80,000 (16)
Sotuta	2000	15,000	(7.5)	10,000	30,000 (15)
Chikinchel	5000	data incomnlete			70,000
Ahcanul	5000	26,000	(5)	38,000	52,000 (10)
Mani	8000	32,500–60,000		65,000	65,000–120,000 (8–15)
Total	39,100	237,500–265,000		278,000	535,000–592,000

The range of densities for the Conquest run from 10 to 34 per km.², or 25 to 85 persons per square mile, and 5 of the eight provinces range from 15 to 25 persons per km.² The total population varies from 465 to 522,000, excluding Chikinchel. If we apply the average density of the areas for which demographic data is available (14) to the province of Chikinchel the total would be somewhere between 535,000 and 592,000 people. In 1940 the state had 416,378 people, of which 129,026 were urban (Merida and Progreso). The rural population was then 287,352, or nearly exactly the total population in 1549.

Agricultural Production

Steggerda's data on modern milpa production would indicate that an average family of five persons needs 8 hectares of land in cultivation and rest for maintenence, with a ratio of 20 percent in cultivation and 80 percent in various stages of rest (Brainerd, 1954). Theoretically this would permit an overall density of population for the state of Yucatan of approximately 60 persons per km.². Actually, a reasonable density would be considerably below this due to the following conditions: 1) The extreme northwest, probably one quarter of the surface area of the state is too arid for really effective maize cultivation, and yields over a long period are probably no more than half of Steggerda's figures for the Valladolid area. 2) A sizeable percentage of the area is agriculturally unproductive even in the area of generally favorable conditions (i.e., savannas, areas of exceptionally scanty soil, and poor drainage). 3) Even in the favorable areas, drought and crop loss is relatively frequent, which means that larger milpas must be cultivated each year to tide the farmer over the lean years. Taking into consideration the above factors, I believe a maximal density of some thirty per km.^{2} is not unreasonable for a well balanced system of slash and burn agriculture.

The density at the time the Conquest was well below this, but it may have been that high during the Late Classic and early Post-Classic Periods. Steggerda, taking into consideration the factors noted above, estimated a safe population density of some fifty persons per square mile (twenty per km.^{2}), which seems to check well with our estimates (Steggerda, *op. cit.).* The population of the state of Yucatan in the periods following the Pre-Classic may have fluctuated, then, from the Conquest period low of 600,000 to as high as one and a quarter million.

Within the area small zones would conceivably have had densities as high as fifty to sixty per km.^{2} and as low as ten in some of the more unfavorable areas. Agricultural data from the Chontalpa in Tabasco would suggest a demographic potential of at least double the figure for northern Yucatan, and in the more favorable areas near the river flood plain the figure might be increased to three times as high, especially considering the shorter cycles of cultivation, double-cropping, and generally higher yields. The same generalization probably applies to parts of Western Honduras.

For the southern half of the Peninsula of Yucatan, ecological conditions for slash and burn agriculture are probably more favorable than in the north. Annual rainfall in the northern Peten is approximately double that of the central part of the state of Yucatan, and at least fifty percent higher than the eastern and southern portions. Agricultural data from Lundell suggests that the agricultural yield per sown milpa was half again as high as in Yucatan. The Cowgills estimate that agricultural production figures permit demographic calculations of 100 per km.^{2}, with a balanced system of slash and burn agriculture (Lundell, 1937, Cowgill Ms.). However, these figures, like those of Steggerda, must be reduced in terms of large area densities.

In the northern Peten, swampy bajos and savannas occupy nearly half of the land surface, and very steep, rocky slopes would further reduce the percentage of usable land. A maximal population density for the area as a whole, without deleterious effects of the ecology, would probably be somewhere between 40 and 50 per km.^{2}, and especially in more favorable areas the density may have reached or even exceeded the 100 per km.^{2} estimated by the agricultural data.

Archaeological Data

Bullard has recently summarized what archaeological data is available for the northern Peten during the Classic Period. We will quote him in full and discuss his data.

"As part of an attempt to estimate population at Uaxactun, Ricketson laid out a cruciform area in the environs of the ceremonial groups which comprised 2,273.920 sq. m. of which some 953,040 sq. m. were habitable land not occupied by ceremonial ruins (Ricketson and Ricketson, 1937:15-24). Here were found 78 house mounds. Ricketson's map shows that he is counting separate platforms rather than the units of one to four platforms which in this report are called individual houses (Ricketson and Ricketson, 1937, fig. 2). Assuming only 25% of the mounds occupied simultaneously, a minimum figure of 270.83 per square mile was obtained. Ricketson goes on to assume that settlement of this density was uniform over the country and that these population figures would be applicable to the region as a whole.

Even higher estimates could be derived by similar means from data which we accumulated, although these are based on smaller samples. For examples, at Dos Aguadas we made a careful examination of a strip 200 m. wide along 2500 m. of a brecha made for petroleum exploration, an area of 500,000 sq. m. Not quite half of this area (215,000 sq. m.) was surveyed into more or less regularly spaced plots, in which we found 37 house ruins containing a total of 89 separate platform mounds. The remaining parts of the strip are predominantly unoccupied slopes so that the counted ruins, while not the total, represent well over half the total. Taking merely the 89 recorded platforms, we can, on the basis of five persons for each, deriver a maximum figure of about 2300 persons per square mile (890 per sq. km.), or 575 per square mile if it is assumed that only 25% of the mounds were occupied at once. This is over double Ricketson's estimates.

"Such estimates must be regarded with the utmost skepticism. There is, of course, the problem of how many houses may have been occupied at once, and whether all the separate platforms associated with an individual house unit were ordinarily separate family dwellings. More important are the indications brought out by this survey that houses are not scattered evenly over the country, but that they tend to concentrate, according to geography, in some areas at the expense of others. Thus a population estimate based solely on house mound counts for a particular area of ruins is no more representative of the true population per square mile of a region than, to take an extreme case, the population per square mile of Manhattan is representative of New York State.

"The tendency for house ruins to concentrate means that there are tracts of potential farmland between house-ruin areas. Moreover, within house-ruin areas themselves there are usually large stretches of hill-slope which were not built upon and were very likely used crops. Hillside locations are preferred for agriculture by the modern Maya of western British Honduras. According to A. C. S. Wright, former director of the Colony's soil survey, this is because hillside crops in limestone country with clay soils and high and intense rainfall stand a better chance than crops in low-lying land." (Bullard, 1960:366.)

As Bullard indicates, his data applies only to small areas where heavy house clustering was noted by the archaeologists, and in all probability each settlement area utilized a large agricultural hinterland, so that the population density for large areas would be much lower than the figures would indicate. In the Peten, settlements frequently tended to cluster along bajo shores. The neighboring hilly terrain was probably the better agricultural land, and hamlet populations would probably use land at considerable distances from the settlement. Aside from this, I feel that his figures are calculated somewhat too high and should be re-calculated as follows: 1) The figure of

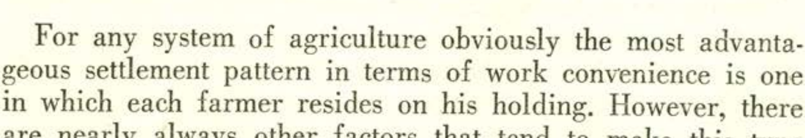
2,273.920 square meters of the Uaxactun survey also includes unproductive bajo, not just ceremonial precinct along with the higher, cultivable land. So for zonal density calculations, the entire figure should be used, not just the 953,040 square meters of estimated productive land. 2) My data from Central Mexico suggests an average of 10 persons per extended family. (Sanders, Ms., 1957.) We know that the Maya had extended families at the time of the Conquest, and the pattern of settlement Bullard describes (to be analized in detail in Part II) of house platform clusters of one to four platforms, probably represents an extended family. The average per house (presumably per nuclear family) should be reduced to probably four (2.5 platforms per cluster on the average). The figure then calculates at 142 per km.^{2}, if all platforms were occupied simultaneously at Uaxactun. Applying the above considerations to Bullard's own data, the density recalculates at 740 per km.^{2}. Both of these densities, especially the latter, are much too high for slash and burn agriculture. The Ricketsons suggest that only one quarter of the house platforms were occupied simultaneously, that estimate being apparently just a guess. (Ricketson-Ricketson, 1937.)

We might here apply our data on rural population movement from Valladolid. We will note below that the small hamlets in modern Valladolid are impermanent settlements, disappearing from one ten-year census to the next. Aside from this, they vary in population upward and downward from census period to census period, and over a twenty to thirty year cycle are frequently reoccupied. The total zonal population density doesn't vary very much, but the location of living sites does. The ancient Maya built their houses on substantial, solid platforms of stone of fair size, and incentives therefore for reoccupying such sites would be even higher. The modern Valladolid hamlet corresponds in size and population very neatly Bullard's house "cluster", a group of five to twelve house groups in an area of four to five hectares. Archaeologically, then, these are the units that presumably would suffer phases of temporary population and abandonment.

Bullard's large zones of 50 to 100 house groups were presumably more stable units, and not abandoned as a whole, although that possibility exists. If we apply our modern Valladolid data, of the 552 hamlet names appearing in censuses running from 1930 to 1950, only 243 were occupied in 1950, on approximately 40%. If we had tax data over long periods, it is probable that this figure would be reduced somewhat, possibly down to Ricketson's 25% estimate (since only a fraction of the 1930 hamlets were reoccupied in 1950). It is possible also that not all the houses within a hamlet were occupied simultaneously, which would further reduce population estimates. Even taking all of the above factors into consideration, it seems clear that small areas in the Peten had population densities either above the safe limits of a balanced system of slash and burn agriculture, or populations close to that maximum estimate.

MODERN SETTLEMENT PATTERNS

The settlement pattern of any given area is the result of multiple factors, and in this paper we will briefly discuss such non-ecological factors as political and religious institutions and their effects. It is maintained here, however, that the primary determinants of rural settlement patterns in a peasant society is the agricultural system practiced. It is further postulated that the agricultural system in such a society is primarily the product of interaction of technology and environment. This, of course, does not mean that secondary factors do not operate throughout the cause and effect relationship. We might diagram our position as indicated below.



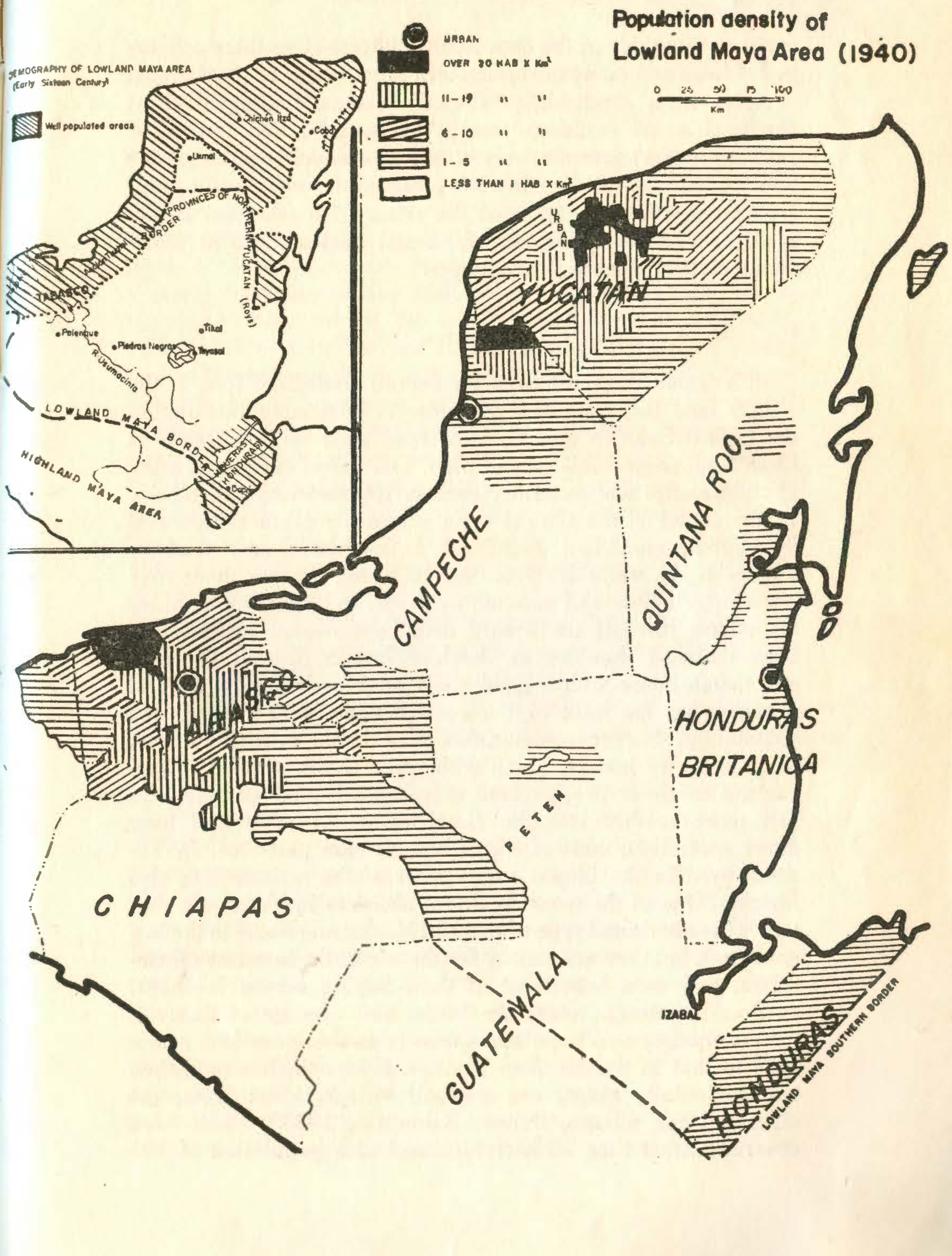
For any system of agriculture obviously the most advantageous settlement pattern in terms of work convenience is one in which each farmer resides on his holding. However, there are nearly always other factors that tend to make this type of settlement pattern a rare one (kinship ties, larger socio-political institutions, warfare, or a specific desire for socialization) so that in most peasant societies farmers live in residential communities exceeding in size the family. From studies completed by the author in the Valley of Mexico, Tabasco, and Yucatan there seems to be a very close correlation between the intensivity of agriculture and the size of the community (Sanders, 1957). Slash and burn agriculture with its need of large areas of land in rest for each area in cultivation would seem to correlate with a completely dispersed settlement pattern or one of small hamlets. We will test the above argument by an examination of the modern settlement pattern of two of the well populated areas within the Maya Lowlands: Tabasco and the state of Yucatan.

Tabasco

The state of Tabasco is divided into 16 "municipios", other than "el centro", where the state capital of Villa Hermosa is located. Each of these "municipios" includes a nucleated center or "cabecera" which is a small urban community of 1500-4000 inhabitants. They are true towns with a primarily non-agricultural population and are religious, commercial, and administrative centers for the "municipios". Approximately 10-15% of the municipal population resides in the "cabecera".

Most of the balance of the population lives in "rancherías", the most important settlement type in Tabasco. It is not really a community since it lacks social integration, has little in-group spirit, and performs few social functions. They are primarily units of administration in the political system of the "municipio". There is generally no center, or if it does exist consists of a pole and thatch church, a school house and a general store or "miscelanea". In cases where such incipient centers occur there may be a slight clustering of a dozen or so houses nearby. Each man builds his home on his agricultural holding, and as the modal holding is from 6-30 hectares of land the result is a very dispersed settlement pattern.

Within our archaeological test area of 300 $km.^2$ in the "municipio" of Huimanguillo are situated one town, one nucleated village, and twelve rancherias. The total population is nearly 12,000 or approximately 40 per $km.^2$. Of this population 8000 must be classed as rural (residing in the village and 12 rancherias), the average "ranchería" composing 2300 hectares and 650 people. Each family has theoretically at its disposal 18 hectares of land. Actually the situation for the small farmer


Population density of
Lowland Maya Area (1940)
URBAN
OVER 20 HAB X Km²
11 – 19
6 – 10
1 – 5
LESS THAN 1 HAB X Km²
Km
DEMOGRAPHY OF LOWLAND MAYA AREA
(Early Sixteen Century)
Well populated areas
Chichen Itza
Coba
Uxmal
PROVINCES OF NORTHERN YUCATAN (Roys)
BORDER
TABASCO
Palenque
Piedras Negras
Tikal
Tayasal
R. Usumacinta
LOWLAND MAYA BORDER
HIGHLAND MAYA AREA
Copan
YUCATAN
URBAN
CAMPECHE
QUINTANA ROO
TABASCO
HONDURAS
BRITANICA
PETEN
CHIAPAS
GUATEMALA
IZABAL
HONDURAS
LOWLAND MAYA SOUTHERN BORDER

is not as favorable as the data would indicate since there are large holdings and many townsmen own large fincas or plantations.

Aside from rancherias; "fincas" (commercial agricultural communities of moderate size), "haciendas", and "ranchos" (cattle ranches) are relatively common settlements although the total population residing in such communities make up a small fraction of the population of the state. Also recorded in the 1940 to 1950 censuses were 50 small nucleated rural settlements called "pueblos" or villages.

Yucatan

In Yucatan the most common overall settlement type is the village, and this type of community is invariably laid out in the typical Spanish grid pattern; even such small villages as Chan Kom possess this overall plan. The streets cross each other at right angles and generally enclose 100 meter square blocks. In the center is the typical open square or plaza surrounded by church, municipal buildings, a few shops and masonry houses of the wealthier families. In small villages there may be no private homes of masonry or shops. In larger communities the streets just off the square may be occupied by masonry houses almost shoulder to shoulder but in general the pole and thatch house with a good sized solar or house lot around it makes up the bulk of the constructions in any Yucatecan community. Larger communities may have, near the plaza, more masonry houses, along with more shops, several restaurants, a movie or two, perhaps even a hotel. Such communities fall more readily into the classification of town and have many specialists, most of whom however are part-time. In Yucatan even in the largest towns most of the artisans are also farmers. One of the most important absences in Yucatecan centers is the aboriginal type of market. Markets do occur in the larger towns, but they are mainly for the use of the townsmen themselves, and even here most of their buying occurs in shops.

Most Yucatecan solars are large, and average at least 50 meters square, and population density is therefore low compared to that in the Mexican Plateau. Kilmartin has published two community maps, one a small village, Chan Kom, the other a large village, Dzitas (Kilmartin, 1933). Chan Kom covered at that time 10 hectares and had a population of 197 people or just about 2000 inhabitants per $km.^2$. Dzitas covered 80 hectares and possessed 1177 inhabitants or about 1500 per $km.^2$. Kantunil Kin (Quintana Roo) studied by the author covers 30 hectares and and had a density of about 1800. In general, my impression is, that these Yucatecan villages adhere much more rigidly to to the Spanish grid pattern than villages in the Valley of Mexico. The basic reason for this less compact settlement here is the tendency of the Yucateco to have a small orchard around his house.

Aside from the village and town, a high percentage of the population also live in the small hamlet type of settlement, called variously in Yucatan the "rancho", "paraje" or in the case of larger ones, the "ranchería". Unlike Tabasco, the houses, although not following any orderly plan, are generally within a few score meters of each other. The settlement may be quite scattered and spread out, but there is no incentive for houses to be very widely spaced as land is not parcelled. The main feature which sets off these communities from the village is the lack of plazas as centers of social orientation. If we were to extract the plaza and associated buildings from the nucleated village, reduce the size to less than 100 inhabitants, and remove the regular grid of the streets we would have the Yucatecan "rancho" or "paraje". These settlements are generally colonies from nearby villages and very impermanent.

Haciendas are common in the central part of the state or were before the Agrarian Reforms. Many place names are still listed as haciendas in the censuses.

For detailed analysis of Yucatecan settlement patterns I've selected the modern Distrito of Valladolid in the eastern part of the state as a test case. The selection of this area is based upon a number of considerations. Firstly, it is an area of slash and burn agriculture carried on by Maya speaking peoples and therefore the data is more pertinent to archaeological problems. The economy of central and northern Yucatan is obviously a recent one based principally on the rise of value of henequen in the international trade market. Secondly, the area, in terms of the ecological system, is well populated. Thirdly, we have excellent studies of the technology and economy of the agricultural system carried out by Carnegie Institution and so can relate our settlement pattern discussion to this data. Finally the ecology is fairly representative of the Peninsula as a whole, certainly much more so than the sub-humid henequen belt or the more fertile Puuc valleys.

The people of Valladolid are undoubtedly the most restless of all modern Yucatecans. The economy is one of almost pure slash and burn subsistence maize cultivation. Lands are divided into "ejidos" which are held and operated in common. This is the so-called "Open Ejido" system in which each community has a large tract of land, is not divided into parcels and each farmer can sow where and as much land as he pleases.

The Distrito has an area of 4000 km.^{2} and a population in 1940 of approximately 37,000 inhabitants or 9 per km.^{2}. It probably has not yet reached its demographic limit but the instability and restlessness of the rural population indicate that the pressure is already strong. The agronomic studies made by the Carnegie staff indicate a probable maximum of from 15-20 per km.^{2}, and some "municipios", such as Chan Kom and Chichimila, seem to be reaching this theoretical maximum. Most of the distrito has been converted to scrub forest by continous clearing and re-clearing for cultivation and in spite of the low density of population it gives one the impression from the air or on the ground of being well populated. The distrito includes the following "municipios":

Municipios	*Area km.²*	*Population 1940*	*Density*	*Population of Cabecera*
Valladolid	943	15,749	18	6,402
Chan Kom	80	1,614	20	270
Tixcacalcupul	325	1,534	5	775
Kaua	154	1,603	7	772
Tinum	291	3,028	9	1,360
Uayma	144	1,225	8	975
Cuncunul	301	922	3	502
Chichimila	182	3,079	17	1,797
Chemax	813	4,103	5	1,573
Temozon	806	4,263	5	1,060
Total	4,039	37,120	9	15,486

The Valladolid district, unlike most of the state, is characterized by having most of its rural population dispersed in small settlements; villages, "ranchos", and "parajes". In most Yucatecan "municipios" especially in the henequen area at least half and more commonly from 3/4 to 7/8 of the population live in a single nucleated village with but a small fraction of its population living in outlying settlements. In Valladolid, the reverse is true, the "municipio cabecera" is often rather small and contains on the average but a third of the population of the "municipio". For example, if we subtract Valladolid (an urban town) from the above totals we find that of the approximately 32,000 rural population in the distrito only 10,000 live in the central villages. Six of the ten rural "municipios" have central villages with under 1,000 inhabitants.

One is reminded of the pattern in the Chontalpa, but the resemblance is only superficial. In Tabasco we have a small city or town as the center of the "municipio" with the rural population scattered in "rancherías" or "ranchos". In Valladolid the "municipio" center is simply a medium or large sized village and the rest of the population live in smaller villages or hamlets. The nucleated community is the basic population unit in the Valladolid district, although usually of very small size.

Several types of these nucleated settlements may be noted. First we have the "paraje" which is simply a clearing in the forest with from 6-12 huts. These settlements are extraordinarily impermanent, often disappearing from one 10-year census to the next. The population usually consists of a number of discontended families who have left their parent village and often stay a few years and then return or move to another village or establish a new "paraje". There is an inherent centrifugal force in Valladolid economy which lies behind this instability. The term "ranchería" is usually used for the larger "parajes" and the term "rancho" theoretically refers to cattle ranches or other permanent agronomic establishments. Actually the latter is often used in place of "paraje". The village is the final settlement type and is invariably laid out in the typical square grid pattern.

Municipio	Below 50	50-100	100-250	250-500	500-1000	1-2000	Over 2000
Valladolid	262	6	7	6	3	1	1
Tixcacalcupul	18	1	3	0	1	0	0
Chan Kom	19	5	3	1	0	0	0
Kaua	15	1	0	0	1	0	0
Tinum	25	5	1	1	1	1	.0
Uayma	14	0	0	0	1	0	0
Cuncunul	9	5	0	0	1	0	0
Tekom	17	3	2	0	2	0	0
Chichimila	42	4	2	0	0	1	0
Chemax	53	6	4	1	0	1	0
Temozon	113	5	2	1	1	1	0
	587	41	24	10	11	5	1

Only six communities in this large area possess populations of over 1000 inhabitants and of these only one may be classified as a true town, the others being large villages. The rest of the population live in small villages and hamlets. Of the total population of the district only 1/3 live in these six large communities and this high percentage is due to the inclusion of the urban town of Valladolid. If we subtract the latter we can say that only about 1/4 of the rural population live in large villages. Approximately 1/2 of the population live in communities with less than 500 people and fully 1/3 in communities of less than 100 inhabitants. The data may be summarized then:

Urban town of Valladolid......	16%	
5 large villages..............	16%	(over 1000 population)
11 medium villages............	18%	(500-1000 population)
34 small villages..............	16%	(100-500 population)
628 hamlets	34%	(below 100 population)

Of special interest is the extraordinary number of what we are calling hamlets, over 600 of them.

I have pointed out a basic restlessness and instability in the demographic pattern of Valladolid, and I present here a special analysis of the "municipio" of Valladolid to illustrate the point. The "municipio" of Valladolid occupies some 95,000 hectares of scrub forest. Within it are one urban town, Valladolid itself, and the twelve villages of Dzitnup, Ebtun, Kanxoc, Pixoy, Popola, Tahmuy, Tesoco, Tikuch, Tixhualahtun, Xocen, Yalcoba and Yalcon. These communities may be considered as the permanent settlements of the "municipio". Only one possesses over 1000 inhabitants, three between 500-1000 and the remaining eight between 100-500. On our community distribution chart above we noted 13 communities falling between the bracket 100-500, but only eight are classified as true "pueblos" or villages, the others are "rancherías". We classified them along with the small villages purely on a scale of population size. Actually there are two important differences between big "rancherías" and small villages: a) the village has a plaza and masonry church both lacking in the "ranchería"; and more important, b) the village or "pueblo" is a permanent settlement, no cases of actual abandonment of a village are known, whereas even large "rancherías" may disappear and appear frequently. These thirteen communities, Valladolid and its 12 satellite "pueblos", are permanent communities and the sources from which colonization proceeds.

A few families from one of these communities or even one family may decide, either because of dissatisfaction in personal relations or more frequently due to lack of nearby land, to cultivate a milpa at a considerable distance from the village in fresher lands. After a few years of experiment he discovers the land to be more productive than the overworked land nearby and will decide to live there for a while. He may be joined by others until the population may reach as high as a hundred or so. Within a period of from 10-30 years, depending on the number of colonists, the land becomes overworked to the same degree as around the mother village and a number of families may return and found a new ranch or "paraje". Often the entire population moves and the spot is abandoned. After 10-20 years the spot may be reoccupied and resettled and the pattern recurs again. The result is that numerous satellite communities are in a constant state of population shift, some are newly founded, some are increasing in population, others decreasing, others being abandoned and others being reoccupied. The whole pattern quite obviously relates to the technique of cultivation and the important fact about it is the presence of a restless shifting rural population with a relatively stable general demographic picture. The latter conclusion is based on the census data. The population of the "municipio" in 1940 was 15,749, in 1950 it rose to 18,225 but most of this growth was due to urban growth in Valladolid. The rural population in 1940 was 9,349, in 1950 it rose to only 10,060, an increase of but 8 percent. Even in the permanent villages actual increase was slight from a total of 5,637 to 5,982, and important for our observations, some villages declined, others grew in population, undoubtedly related to going and coming colonists from the hinterland.

Of those communities which we can class as impermanent the following chart summarizes their demographic history:

Impermanent Communities	*Number of Communities*
Occupied 1940 — still occupied 1950	137
show population increase	82
show population decrease	55
Occupied 1940 — abandoned 1950	132
New Settlements 1950	86
Occupied 1930 — abandoned 1940 and 1950	40
Occupied 1930 — abandoned 1940, reoccupied 1950	20

Today the pressure has reached the point where the Valladolid district population as a whole is beginning to move out into the hinterland of the Quintana Roo-Yucatecan border. Most of the new communities are of the "ranchería-rancho-paraje" type. There are very few cases of foundations of true "pueblos" in the classic Yucatecan sense. This suggests that these smaller units, which we can call hamlets, are the natural settlement type with slash and burn agriculture in this type of environment. I wish also to point out for the archaeologists' benefit that a deep continuous ceramic stratigraphy at a small site in this area does not necessarily indicate a *continuous occupation.* We may have a case of repeated cyclic occupation and abandonment and the periods of such are too short to be detected by the present Maya ceramic stratigraphy.

In the Valladolid area, then, with slash and burn agriculture, we found a pattern of true villages and hamlets rather than "rancherías" as the basic settlement form.

DECLINE OF THE OLD EMPIRE MAYA

Most of the Lowland Maya today is nearly without population. The modern state of Yucatan which occupies the northwestern part of the peninsula, had, in 1950, 516,899 people in an area of 38,508 km.^{2}, with a density of 13.4 per square kilometer. Tabasco, in the same year, with a surface area of 22,800 km.^{2} had 363,501 inhabitants and a density of 16 per km.^{2}. These were the only two well populated areas in 1950 and even in Tabasco and Yucatan the population tends to be concentrated in a fraction of the total area, with much of the land being very thinly populated. The rest of the Lowland Maya area, the state of Campeche and the territory of Quintana Roo in Mexico, the departments of Peten and Izabal in Guatemala, the colony of British Honduras, and the western part of Honduras, an area of approvimately 200,000 km.^{2}, had a population in 1950 of less than 300,000 people or 1.5 per km.^{2}. If urban populations are subtracted, this density would drop to approximately 1.0.

The least densely populated part is a continuous tract of nearly unpopulated forest in the center, including Quintana Roo plus the Peten, with a surface area of 100,000 km.^{2} and a population of only 50,000 people. One could add to this demographic vacuum most of British Honduras and Campeche, since the slightly higher density in those two areas is due to the presence of two sizeable cities on the coast and a small well populated rural hinterland nearby. Of great interest to our arguments presented later is the fact that this huge geographic center of the Maya Lowlands, which is today without population, was the demographic and cultural center during the so-called Old Empire.

Documentary sources for the 16th Century (see Roys summary of the data) present a picture strikingly similar to 1950. At that time a large population lived in the margins or frontiers of the area as it does today. Centers occurred in northwestern Yucatan, Tabasco, and western Honduras, with the heartland of the Old Empire Maya very thinly populated. Thompson has argued that the Spanish sources indicate a sizeable population in the Peten, but Cortez's fifth letter clearly indicates it was a very thinly settled area with small communities widely spaced from each other except for the zone immediate to Lake Peten Itza (where most of the modern population of the Peten are settled today) (Thompson, 1955, Cortez, Colección Atenea). The population of the Peten was certainly not over three to four times the modern figure, and my guess would be about double. This means a density of probably one per square kilometer and possibly two, certainly a very scanty occupation.

British Honduras apparently had a fairly heavy population in the northern coastal strip fronting on the lagoon of Chetumal (where most of the population is located today), but the rest of the colony was nearly unpopulated. Most of interior Quintana Roo and Campeche was sparsely settled, the coastal strips in both areas apparently having sizable populations. The included map summarizes the demographic picture for 1940 and 1519.

This peculiar demographic pattern for the Conquest Period apparently dates from the collapse of the Old Empire Maya civilization, and remains one of the most difficult problems of Maya archaeology today. Some writers, Thompson for example, have argued that the sudden cessation of dated stelae and building activities should not be construed as meaning an abandonment of the central area by the population, but more probably was the result of a revolt of the peasants against the priest-architects and a breakdown of the political control needed for major architectural expression (Thompson, *op. cit.)*. All of the evidence, however, is against such an interpretation. 1) Willey's studies of the Belize valley (Willey Ms., Willey, 1956) and Bullard's settlement pattern studies of the northeastern Peten (Bullard, 1960) indicate that the ceremonial pattern of Maya civilization was not restricted to the elite ruling class, but was a well integrated part of local peasantry life, and small ceremonial structures were apparently built by even small hamlets of 50 to 100 extended families. One would expect, therefor, that even if the major centers were abandoned, the small ones would continue functioning. 2) There is no other area of Mesoamerica where a ceremonial pattern once established was abandoned for an extended period by the local population. 3) Bullard's intensive survey of northeastern Peten reveals little evidence of a Post-Classic occupation except around Lake Peten Itza, where the documentary data suggests a small cluster. It should be stressed here that Bullard's survey included small house clusters and hamlets as well as ceremonial centers. 4) Willey's equally careful survey of the Belize valley revealed very scanty occupation for the Post-Classic Period. We have a major problem here in the field of cultural ecology.

During the period from the 6th to the 10th Century the Maya Lowland area was one of the most densely populated parts of Mesoamerica, and the demographic center was precisely in that part of the area which since that period has been extremely thinly settled. The demographic profile for the Maya heartland is perhaps unique in the history of civilizations. The area was apparently settled by slash and burn farmers during the Middle Pre-Classic (Mamom), was well populated in Late Pre-Classic times (Chicanel) as the presence of large platform mounds testifies, and during the Classic Period witnessed a spectacular population explosion that resulted in a denser population than any part of Mesoamerica except certain Highland regions where intensive agriculture was practiced (the Meseta Central and the Valley of Oaxaca).

Within a century after the period of maximum population all evidence indicates a sudden decline, perhaps to the level of the Mamom Period, which decline persisted until the 16th Century. Since then malaria and other Spanish-introduced diseases have delivered a final coup de grace, and the area has been nearly without population since that date. The only comparable demographic disaster in the history of Mesoamerica known to me is that of the 16th Century along the Gulf and Pacific Coastal plains.

In all parts of the world where civilizations have developed, the normal growth pattern shows a period of formulation, elaboration, and decline. But in these other areas, following the declines, new civilizations replace the old and go through similar cycles. This is true because the so-called breakdown does not involve the peasant class that provided labor and food resources to build it, and the new civilization is built upon the same peasant base as the older one. In the Maya area we have apparently a collapse of both levels of the civilization, the elite and the peasant —and without peasants no new civilization can evolve.

The major problem involves the factors that produced this amazing demographic catastrophe. A number of possibilities have been suggested: 1) epidemic diseases, 2) warfare, 3) revolt, 4) earthquakes, 5) climatic changes, 6) reduction of water supply, and 7) agricultural failure.

The possibilities of number 1) seem to me extremely unlikely. There is, of course, the 16th Century parallel, but this was due to foreign diseases for which the native population had no acquired immunity and the main killer here seems to have been malaria, since the most disastrous decline occurred in areas below 800 meters above sea level. I know of no case where the collapse of a civilization or a complete demographic depression of this type occurred based upon endemic disease. Furthermore, why only the Maya heartland? Why not the Gulf Coast and Pacific Coastal areas as well?

(2) and (3). (3) is strongly favored by Thompson *(op. cit.)*, but involves the idea that only the upper level of the population was destroyed and forced to abandon the area, but that there was no major decline of the peasant population. However, all archaeological evidence is in support of the total population decline, and furthermore, it seems unlikely that no rennaissance of some kind would have occurred over a period of 500 years if the peasant population remained. Aside from that, a simple Mesoamerican civilization with some limited architectural expression would have continued, as we have previously argued.

The possibility of a massive peasant revolt, intra-city-state war, or foreign invasion causing as complete a population decline as the archaeological data suggests seems to me very improbable.

4) Earthquakes. There is no geological evidence of this, no parallels known to me, or any other natural disasters of this kind which have caused the collapse of a civilization spread over such a large area. Furthermore, at no point in our history of the civilizations of Higland Guatemala do we have such a collapse, and this area is in the major earthquake belt of Mesoamerica.

5) Climatic changes. There is no real evidence of any major shift in climate, but this remains as a possibility. Huntington has suggested that an *increase* of rainfall during the final phase of Maya civilization was the cause. In terms of the system of agriculture practiced this would have aided rather than have been detrimental to the peasant population. Certainly the increase would have not surpassed the present-day rainfall of Tabasco, and this is one of the major areas for which we have evidence of a significant Post-Classic population. It seems extremely improbable that the rainfall during the Old Empire period was *low* enough to encourage the development of an irrigation system of intensive agriculture and there is no archaeological evidence for this, as we have noted. Finally, the fact that there was no major population decline on the three frontiers of the Maya heartland, in Tabasco, northern Yucatan, and western Honduras where the rainfall ranges from 20 to 100 inches of annual raifall, suggests that climate was not involved as a major factor. One would have to postulate a major climatic change only in the middle of the Maya area, which seems meteorologically fantastic to me.

6) The reduction of water supply. This explanation has been offered previously, but more vigorously defended recently by the Cowgills (Cowgill and Cowgill, ms.). The argument, briefly, is that in the northern Peten during the Classic Period there was a chain of lakes and today they are sediment and vegetation-choked swamps which dry out completely during the long dry season. The argument is based on the fact that water supply is a major determinant to permanent settlement in the northern Peten today, Cook's support of the silting hypothesis, the fact that the small Post-Classic population in the Peten was

clustered around Lake Peten Itza (a reflection of a former more general pattern of settlement), the evidence of large cisterns and water reservoirs at Tikal and Uaxactun indicating a water shortage, and the extraordinary abundance of small artificial cisterns associated with little Classic hamlets all over the Puuc area. It seems probable that the silting of the lakes and a decline of water supply was one important factor in the northeastern Peten area and probably interior southern Campeche and Quintana Roo, but it can hardly explain the demographic collapse of the population of the Usamacinta Basin, the Belize River valley, and the headwater area around Palenque and Bonampak in Chiapas. Furthermore, the case of the Puuc tends to make the argument untenable. If the Maya had successfully met the problem by collecting rainwater in cisterns why then was that area finally abandoned?

7) Agricultural failure. This position was first detailed by O. F. Cook and was strongly favored by Morley (1946). The argument runs as follows: Under the usual demographic conditions found with slash and burn agriculture (generally ranging from 10 to 50 persons per km^2), the system is ecologically sound with a well balanced pattern of land in production, acahual in various stages of succession, and climax or near-climax forests. As Maya civilization developed, the population reached such a density that the neatly balanced pattern was disturbed and rest phases were shortened and cultivation phases extended to the point that grasses (the major enemy of milpa cultivation as we have noted) over centuries of short cycling gradually assumed dominance over the regenerating forests to the degree that huge areas of the Maya Lowlands were converted to savannnas, extensive milpa cultivation became impossible, and the population immigrated to the less densely populated frontier. A second process would be soil erosion. Normally erosion is a minor problem in an area of slash and burn agriculture, even with relatively steep slopes, because of the vigorous regrowth of natural vegetation. Cook argues that continued burning over a long period of cultivation, however, had tended to destroy the soil, and this facilitated erosion. (Cook 1921) (Actually the soil cover over the peninsula is rather scanty anyway, and I have seen areas in Quintana Roo where escaped milpa fires have actually burned away the scanty soil cover.) Soils were washed down the slopes into

the lakes, silting them in and leaving the slope with even a scantier soil cover.

Objections have been raised to this position, and they may be summarized as follows: (1) The system is practiced all over the Tierra Caliente of Mesoamerica today, and in no area is there evidence of this savannazation process. (2) Northern Yucatan was densely populated during the Classic (at the time Morley wrote *The Ancient Maya* it was supposed that northern Yucatan was almost without population during the Classic and that the Old Empire Maya from the Peten populated the area after the decline of the Classic Period), and yet it was not abandoned and still supports a large population. (3) Evidence today of areas in Tabasco and Yucatan where cattle growers *plant* grasses for pasturage in forest areas — and if abandoned the forest always returns. (4) The fact that the oldest and youngest dates in the initial series were found at Tikal, indicating a long continous occupation throughout the entire Classic Period. The argument here is that if savannazation does occur, the area around Tikal, where the earliest occupation aparently occurred, should have been abandoned well before (perhaps several centuries before) the abandonment of younger centers like those in the Usumacinta valley or at Copan, yet all of these centers were abandoned simultaneously or within a few decades of each other according to the evidence from the cessation of dated monuments. (5) Lundell's Carnegie-sponsored study of the Peten revealed that soils in hilly, sloping terrain in the Peninsula because of their mineralogical characteristics (high calcium content) are not easily susceptible to grass formation, and that only the deep clay soils of the bajos seem to be readily susceptible to such a process (Lundell 1937). Especially, he feels, northern Yucatecan soils are not susceptible to savanna formation. We have noted previously the fact that climatically speaking most of northern Yucatan should have a natural savanna vegetation, whereas the natural cover is scrub forest. (6) The supposed lack of evidence of this process in the Old World.

Personally, I strongly support the Cook hypotheses and will attempt to answer some of the arguments presented above.

With respect to the first argument, this is true but it is an extremely deceptive argument. We have noted that with modern population densities, the system is a neatly balanced one, and there are very few areas in the Tierra Caliente of Mesoamerica today where population density even approaches the potential of a balanced system of slash and burn agriculture, as a glance at our population density map demostrates. The Tierra Caliente is still primarily a frontier region in Mesoamerica today, demographically speaking. In northern Yucatan, for example, the rural population densities for slash and burn agriculture rarely exceed 22 per square kilometer, and over most of the state it is well below ten (1950 census). In Tabasco, the only other part of the Maya Lowlands today that has a respectable population, 13 municipal densities range from 3 to 30. One "municipio", El Central, records 40, but the high density here is due to the fact that the state capital Villa Hermosa, is located here. Two "municipios", Paraiso and Comalcalco, record densities of 35 and 80 respectively per km^2, but these are areas of a highly developed commercial economy based upon cacao rather than subsistence maize cultivation (census 1950). In Vera Cruz, in the "municipios" where slash and burn agriculture is practiced, we have population densities all within the range of a well balanced system of cultivation and fallowing.

It is true that within the demographic units used in my analysis there are small areas of very heavy population. For example, in our tests area for settlement pattern analysis in Tabasco, in the "municipio" of Huimanguillo, the population density for the entire "municipio" was only 7, but half the population live in a riverine strip, 10 kilometers wide and 30 kilometers long with a population density of 37 persons per km^2. Within this relatively large strip there are small areas where the population density probably exceeds 50. However, this small strip of well populated land is surrounded by a vast, almost unused forest and as Conklin (1957) has pointed out plant seeds are blown in from relatively great distances, so that a reservoir of plant seeds is always near and available for reforestation. The study of the Cowgills at Peten Itza I find very unconvincing because they have not considered this fact. Their area of heavy settlement is even smaller than our Chontalpa test strip and is surrounded by an even greater reservoir of forest.

In the case of the savannazation of the Peten during the Classic, we are postulating a large area of at least 50,000 km^2 where perhaps one third to one quarter of the land was in cultivation, and in the core area of northeastern Peten perhaps an even higher percentage, and where population densities may have exceeded 100 per km^2 over the area as a whole, and possibly reaching as high as 200 in the center. Furthermore, this huge heartland was surrounded on all sides by areas of slash and burn cultivation with substantial populations, so that the total reduction of forests may have been far in advance of any situation in Mesoamerica today.

2) Although the old Morley hypothesis of a scanty population in northern Yucatan for the Classic Period is no longer tenable, no careful zonal surveys have been made and we really have no idea as to the population density. However, what evidence we do have, suggests strongly that it never reached the density of the southern areas. For example, the only major sites in the areas of dense Post-Classic population, for the Classic Period, are Dzibilchaltun and Chichen Itza, and the latter was much smaller than the Peten and Usumacinta centers (at least one half of the buildings are of the Toltec Period). Cobá, in northeastern Quintana Roo, was a major center, but this is an area of relatively scanty Post-Classic population. The only part of northern Yucatan which undoubtedly had as dense a Classic population as the Peten was the Puuc, where four major sites, Uxmal, Sayil, Kabah, and Labna are located along a line with a total length of only 50 kilometers. Although the area was within the Conquest Period province of Mani, a glance at Roys's map demonstrates that all of the Post-Classic communities were located north of the range whereas the area to the south, where the Classic population was concentrated, was practically depopulated. In summary, for the areas of northern Yucatan which had a relatively large population in the Post-Classic, Colonial and Modern Periods, there is no evidence of a Classic population of the density of the core area, and it is probable that the population of this northern Yucatecan area has always been well below the limits of a well balanced system of slash and burn agriculture.

3) This objection is answered in my previous discussion of the relationship of the size of cleared to forest land.

4) In reply to objection (4), this assumes a picture of regional or local political autonomy in which the growth of each center is a highly local phenomenon. The greater size of Tikal compared to all other Maya centers, makes this extremely im-

probable. That Tikal was larger than other Maya centers was undoubtedly due to its greater political importance. This means that labor for construction and foodstuffs to support the elite residential class residing therewas probably drawn from a much larger area than the immediate hinterland. Therefore, its longevity doesn't necessarily have anything to do with local ecological history. By the Tenth Century the situation in the immediate rural hinterland of Tikal may have been exceedingly unfavorable for agriculture, possibly even by the end of the Tzakol Period. The continuation of its function as a major center would be related to its being traditionally the center of the expansion of Maya civilization from this core (all recent evidence suggests that Maya civilization did develop locally in this area), and the expansion may well relate to increasing demographic pressure and decline of agricultural potential at home. What is needed here is a more intensive survey of farming hamlets to follow up Bullard's study to see whether the decline of population may have started earlier here than elsewhere. (In other words, how many of the farming hamlets were occupied during both of the Tzakol and Tepeu phases.) Willey's study of the Belize valley shows a maximum population at the end of the Classic, which is precisely what one would expect towards the peripheries of the heartland (Willey, *op. cit.*).

5) The findings of Lundell actually tend to strenghthen our arguments. The northern Peten and northern Yucatecan areas were much more heavily settled during the Classic Period than any other part of Tierra Caliente. Modern agricultural studies tend to show that the Maya heartland is considerably less productive than the Vera Cruz-Tabascan Plain where more dependable and abundant rainfall permits double cropping, reduces crop failure, and permits commercial tropical fruit agriculture. The question arises, then, as to why the Peten and northern Yucatan areas were selected by the Pre-Hispanic population for settlement above nearby more favorable areas. The lesser susceptibility of the soils to savannazation may well have been the incentive that attracted a subsistence slash and burn agricultural population in Pre-Hispanic times. Only extreme demographic pressure would apparently result in the savannazation of the Peten. As we shall demonstrate shortly, there is evidence that this was the case. The fact that the area is a forest today

is hardly a strong counterargument. It has had 1000 years to recuperate from a demographic disaster of the 10th Century, and as we have seen, the disturbance of the regeneration by man has been slight.

6) In general, areas of slash and burn cultivation in the Old World are correlated with low population densities so that we are faced with the same problems with respect to studies of the effect of short cycling over large areas for long periods. In small areas in parts of West Africa we do find high densities but the agricultural system practiced there involves iron hoes and thorough preparation of the soil before planting. We have previously noted the significance of hoeing of the soil over simple dibble stick planting in terms of weed control.

Over large portions of Indonesia where dibble planting is characteristic Pelzer (1945) describes large areas of savanna succession resulting from slash and burn agriculture and indicates that where population densities exceed 50 per $km.^2$ such succession does occur. The precise figure would presumably vary with local meteorological and soil conditions.

Conklin, in an intensive study of a small area on Mindoro Island in the Philippines, makes the following comments about savanna sucession:

"In a forest region such as Yagaw, wind-blown seeds of grasses and various weeds take root easily in the exposed soil of a new clearing. Only by repeated knife weeding are such plant pests controlled during the growing period of the major annual crops. By the end of the main rice harvest, however, perennial bush and tree crops have begun to mature, and natural reforestation by air —and animal— borne seed from the adjacent uncut jungle, and by the resprouting of stumps and limbs of felled or pollarded trees, usually follows. As tree growth increases, grasses as well as other light-seeking herbaceous weeds are gradually shaded out.

"The speed with which these grasses disappear is partly determined by the location of the swidden with respect to certain features of the immediate physical and natural environment. Hilltop and ridge sites remain maximally exposed to light, wind-borne, hairy-glumed grass seed while reseeding from forest stands, the nearest of which are at lower elevations, is minimal. Similar deterrents to rapid reforestation obtain where a site is bordered only by other new swiddens or grassland instead of by secondary or climax forest vegetation. As a general rule, a swidden located on a slope facing into the prevailing winds during the drier post-grain-harvest months is favored over one located on a leeward slope where dry season rainfall is much reduced and where the consequently longer periods of soil exposure encourage the spread of *Imperata* and wild *Saccharum*. The Yagaw area as a whole tilds toward the east, the direction from which the rain-bearing hot season winds blow.

"Where climatic and terrain conditions are ideal for swidden agriculture, a single firing of cut jungle does not —by itsef— start a succession to grassland. However, repeated firing of the same site during the followand succesive years, for recultivation or by accident, may kill many of the coppicing stumps and young tree seedlings, and discourage the growth of broad-leafed shade-providing shrubs, while favoring the spread of erect grasses (especially *Imperata)* whose extensive stoloniferous rhizomes and deep roots are left uninjured. If allowed to continue, these underground parts form a dense sod matting 10 to 15 cm. thick, the deeper rhizomes of which may extend down to 30 cm. below the ground level. This results in an extremely persistent weed source which cannot be controlled effectively except by the use of permanent-field agricultural soil-turning techniques. Even if the weed situation could be kept under control, grassland associations lack sufficient ligneous growth to provide the ash cover desired for swidden cropping. The Hanunóo never attempt to clear a new swidden at a site largely covered by grasses.

"The Hanunóo recognize that some trees kile salibanghang *(Bauhinia malabarica)*, barunāsi' *(Antidesma ghaesembilla)*, and tūlung (Ficus nota) have root systems well enough developed to withstand repeated grass fires. But the main process known to the Hanunóo by which woody species can replace grassland is intensive grazing and browsing. Cattle give the forest a fresh start by keeping down the choking grass and by scattering the undigested seeds of pioneer trees they have eaten. These trees include not only the fire resistant species just mentioned, but also such types as 'ambabalud *(Neonauclea formicaria)*, 'anudla' *(Pipturus* sp.), kūpang *(Parkia javanica)*, and maslākut *(Acalypha amentacea)*. In a number of neighboring areas swiddens are being cleared today for the first time in this century in forests which, as a result of continued and intensive cattle raising, now cover what was extensive grassland 25 to 30 years ago. As one Hanunóo stated succinctly, "bāka lang ti magda'ug sa kūgun" (only cattle can conquer cogon).

"If we assume that agricultural clearance of forested islands originally proceeded from coastal regions to interior regions, from lower to higher elevations, it is quite probable that cleared ridges were the first sites of grassland development because they lacked adjacent, higher forest margins from which reseeding could take place. This occurred more rapidly in areas (such as western Mindoro) where there was a prolonged dry season during which the winds, having lost most of their moisture on the eastern, windward slopes of the island, helped to carry seed from the exposed ridges to lower land that had recently been cleared. Thus, the chances for expansion of grassland seawards were great. On the other side, where hot-season rain-bearing winds blew in from the sea, most of the air-borne grass seed originating on the lower, exposed ridges ended up in uncleared primary forest where it could not survive.

"This process probably continued slowly until it was halted at higher elevations by the increase in quantity and distribution of rainfall and the concomitant loss of any differential effect of a "dry" season. Only the deep or sheltered valleys and unusual terrain features broke the pattern which eventually left long dry season leeward slopes and ridges of most islands *Imperata* covered, and allowed short dry season windward slopes to remain relatively well forested.

"Within this broad pattern of floral succession associated with primitive techniques of pioneer forest clearance, further local changes in landscape have resulted from different types of shifting cultivation. As we have noted above, features of these systems which favor the expansion of grassland areas are:

1) Use of ridges and hilltops as swidden sites,
2) Simultaneous clearance of many adjacent sites,
3) Escape fires,
4) Repeated grass burning for hunting purposes,
5) Successive plantings of grain crops —for more than two years— in the same swidden,
6) Lack of intercropping;

while features which help to decrease or reverse the succession to grassland include:

1) Associated cattle grazing,
2) Dispersal of swiddens,
3) Extensive intercropping,
4) Avoidance of exposed ridges as swidden sites,
5) Use of fire breaks in swidden burning,
6) Annual grass burning for grazing and cutting purposes,
7) Only one or two plantings of major grain crops per swidden cycle (Conklin, 1959).*

* The bibliography will appear at the end of the second part of this study which will be published in the next volume of "Estudios de Cultura Maya".