BROSIMUM ALICASTRUM AS A SUBSISTENCE ALTERNATIVE FOR THE CLASSIC MAYA OF THE CENTRAL SOUTHERN LOWLANDS

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PREFACE

The ramon survey was carried out at Tikal, in Guatemala, in 1967 as one aspect of the Tikal Sustaining Area Project directed by Dr. William A. Haviland of the University of Vermont. The author was field director of this project. The necessary funds were supplied by a generous grant from the National Science Foundation (GS-1409).

The ramon survey was based on a settlement survey carried out by the author under the auspices of the Tikal Project in 1965. In this settlement survey a strip 500 meters wide extending 12 kilometers south from the center of Tikal was mapped. Further survey work in 1966 produced strip maps extending north, east, and west. This work also was sponsored by the Tikal Project which was under the direction of Dr. William R. Coe, with George Guillemin as field director.

ACKNOWLEDGEMENTS

Let it be said at the outset that this thesis represents a joint effort, no small part of which is the result of work carried out by my brother, Peter Puleston, of Adelphi Suffolk College. In 1967, as a participant in the Tikal Sustaining Area Project, he carried out the bulk of the field work with the assistance of Elias Contreras, who was also instrumental to many aspects of the work. Dr. William A. Haviland, associate professor at the University of Vermont, who introduced me to Maya archaeology in 1961 through the Tikal "Housemound" Project has been of primary assistance and great influence at all stages of the present project. I also wish to acknowledge the depth of my indebtedness to Dr. William R. Coe, who in various roles as instructor, advisor, and research director of the Tikal Project has been a constant source of guidance and stimulus in dealing with the problems pertaining directly to this work as well as through the example he has provided by his own work.

It is with great pleasure that I acknowledge the inestimable value of the opinions, criticism, and information I have received from the following persons who took the time to read earlier drafts of this thesis: Dr. Hans M. Gregerson of the School of National Resources at the University of Michigan; John S. Lea, editor, Smithsonian Institution; Dr. Cyrus L. Lundell, Director of the Texas Research Foundation; Dr. Ruben Reina, Professor of Anthropology of the University of Pennsylvania; Dr. Linton Satterthwaite, Professor Emeritus of Anthropology at the University of Pennsylvania; and Dr. J. Eric S. Thompson.

I also would like to acknowledge the guidance, criticism, and often vital information I have received from Dr. Moises Behar, Director of the Instituto de Nutricion de Centro America y Panama in Guatemala; Bennet Bronson of the University of Pennsylvania; Dr. Carl W. Cambell, associate horticulturist at the University of Florida Sub-Tropical Experiment Station; Dr. Michael D. Coe of Yale University; Dr. A. O. Dahl, Professor of Botany at the University of Penna.; Dr. John M. Fought, Assistant Professor of Linguistics at the University of Pennsylvania; Dr. Francis Johnston, Assistant Professor of Anthropology, University of Pennsylvania; Dr. C. Glen King, President of the International Union of Nutritional Sciences; Dr. John M. Longyear III, Professor of Anthropology at Colgate University; Dr. George L. NcNew, Managing Director of the Boyce Thompson Institute of Plant Research Inc.; Dr. Robert Netting, Assistant Professor of Anthropology at the University of Pennsylvania; Dr. Gerald Olson, Assistant Professor of Soil Science in Resource Development at Cornell University; Dr. Paul B. Pearson, President of the Nutrition Foundation Inc.; and Dr. John Popenoe, Director of the Fairchild

Tropical Gardens in Miami Florida. Special thanks are also extended to my sister, Sally Puleston, for photographs of specimens of Brosimum alicastrum used in the study of growth rates; James Stokes for the excellent job he did in inking the survey maps; Rafael Morales Fernandez, Director of the Tikal National Park, who so generously placed at out disposal mules and other Tikal National Park facilities without which many of our undertakings would have been impossible; and the Instituto de Antropologia e Historia de Guatemala, through which the former director, Carlos Samoyoa Chinchilla and Lic. Luis Lujan Muñoz made the present project possible.

Finally, it is with considerable gratitude the author wishes to acknowledge the support he received from the other members of the Tikal Sustaining Area Project, not only for their suggestions and assistance in jobs like counting ramon nuts, but also for information from their own projects which were carried out in conjunction with the survey. The less well-defined but even greater debt to the Tikal Project as a whole cannot be underestimated.

It should be made clear that though many of the above persons have offered valuable assistance to the author, and even encouragement, the present thesis does not necessarily reflect any agreement on their part with the views and opinions expressed here. The author takes full responsibility for any omissions, misquotations, or other errors which may occur here.

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INTRODUCTION

The limitations, difficulties and even liabilities of slash-and-burn agriculture have all been points of contention in discussions of subsistence theory. They have played an important and also controversial role in discussions of Classic Maya subsistence, for which slash and burn agriculture is supposed to have been practiced on a large scale in the rainforests of the southern Lowlands. Toynbee's hypothesis of stimulus and response as a basis for the development of civilizations has been suggested as an explanation of the early blossoming of Olmec civilization in the face of the subsistence challenges of the lowlands (M.D. Coe 1962:71). Meggers (1954) felt that the challenge was too great, and that, once established, Maya civilization was doomed to gradual decline, at least in the Maya Lowlands. Many have attributed a more dramatic collapse to some form of agricultural failure. Most of these hypotheses ascribe this failure to the ultimate liabilities of large scale slash-and-burn cultivation of maize in the rainforest environment (O.F. Cook 1909, 1921; Cooke 1931; Morley 1935; Steggarda 1941). Lately, as we have become more aware of the true dimensions of the achievements of the Classic Maya in time as well as space, such theories have become less popular. Willey and Sabloff (1967) now provide evidence for the role of external factors in the collapse of Classic Maya civilization, though they still feel the subsistence balance was "precarious." As (W. R. Coe 1957) has intimated, however, it is time we recognized the massive accomplishments of the Maya for what they are -- the remains of a civilization formula that worked, and worked well, rather than one that failed.

How then are we to deal with the obvious limitations of slash-and-burn cultivation? A new perspective on the full extent of the inconsistencies here has recently been presented by Reina (1967). Apparently without the benefits of irrigation and chinampa horticulture as practiced in the Mexican highlands (Palerm 1955), seasonal flooding such as occurs in the Chontalpa region (Sanders 1962), or the exceptional soils of the Olmec area (Drucker and Heizer 1960), the Classic Maya of the southern Lowlands still produced a viable civilization of over a thousand years duration. How did they do it?

Though we have long recognized the architectural achievements of the "ceremonial centers" of the Maya as the result of a substantial investment of labor, this has been rationalized by assuming that the indicated manpower was broadly dispersed. A recent survey by Bullard (1960) seemed to support this picture, indicating, as Sanders (1962) points out, "...a surprising lack of correspondence of house clusters to major ceremonial complexes." It is only recently with the data from more intensive surveys at Tikal (Carr and Hazard 1961;

Haviland and Puleston n.d.), Seibal (unpublished data), and Barton Ramie (Willey et al. 1965) that we have really been forced to realize the density of the population that probably once occupied this whole area. The impossibility of the situation in terms of the productiveness of slash-and-burn techniques was recognized by Ricketson and Ricketson (1937:15-24). On the basis of the Uaxactun housemound survey, they calculated a potential population density of about 1000 people/sq. mi.; in terms of the agricultural system attributed to the Maya, such a figure was considered preposterous. Accordingly, they reduced to 25% the number of houses they assumed to be occupied contemporaneously. Sanders (1962:99) performed similar operations on the Dos Aguadas and Barton Ramie data (1963:210) in an attempt to bring the data into line with the ssumption by suggesting reductions of up to 75% in the number of mounds assumed to be occupied at any one time. With no feasible alternative to slash-and-burn cultivation of maize, he had no choice. Though this dependence on maize is one of the oldest and most hallowed building blocks for our reconstructions of Classic Maya culture and civilization, it must be recognized that it is still only an assumption based on very little proof. To date this proof has been primarily inferential, in spite of the fact that a few corn cob fragments have been found at Tikal and Uaxactun; but half a dozen corn cob fragments hardly form the subsistence base of a civilization. New data seems to be continually forcing us to revise population estimates upwards (Haviland et al. 1968:93). In the face of this trend and the known limitations of slash-and-burn agriculture, any subsistence alternatives should receive full attention.

Part of the problem, of course, has been a lack of alternatives (Sanders 1962). Bronson (1966), however, has broken the interpretive logjam with a succinct and convincing case for Classic Maya utilization of several extraordinarily productive root crops. The case for a second alternative is to be presented here.

More than thirty years ago, scientists began to recognize dense concentrations of a fruit-producing tree known as the ramon (*Brosimum alicastrum* Sw. fig. 1) around the abandoned ruins of many famous Lowland Maya sites. This striking distribution suggested that the trees represented relic populations of a tree actually cultivated by the Maya. Though it has been known that the fruit of this tree provides a dense carbohydrate staple that is used by the Maya today when other food sources fail, this interesting tree has not received further attention until the present project was initiated, under the sponsorship of the National Science Foundation.

DESCRIPTION OF THE RAMON

In respect to general unfamiliarity with this tree and the importance of certain aspects of its morphology and distribution, a description is included here as a preface to the body of the paper.

The Family Moraceae:

Brosimum alicastrum Sw. belongs to the family Moraceae. As a member of this interesting family, it is closely related to the breadfruit of the Pacific, (Artocarpus communis Forst.); the mulberry trees; the famous jakfruit, Artocarpus integra (Thunb.) Mirr., which produces one of the largest fruits in the world with weights of up to 80 lbs. reportedly for a single fruit (Chandler 1958:343); and the figs of the genus Ficus which, according to Lemée (1929-43), comprise one of 14 largest flowering plant genera in the world. Humboldt's famous "cow tree," Brosimum utile, (H.B.K.) Pittier, which produces astonishing milk-like sap which is entirely potable and was formerly used in the diet of plantation labor (Humboldt 1819 II:106). Attempts have been made since 1836 to introduce this tree into India as an alternative to cows as a source of "milk" (Biswas 1950: 197). Only recently, however, have attempts to grow the tree met with any success (Chatterjee 1950:116). Controversy still surrounds the nutritive value of this "milk," (Pittier 1918:104).

Figure 1: Illustration of leaves and fruit of the ramon Brosimum alicastrum Sw. (Descourtilz 1821-33: plate 534)

Habitat:

The ramon (Brosimum alicastrum) is a large tree restricted to the lowland forests of Mesoamerica though under special conditions it does occur in drier highland areas and certain parts of the Caribbean. As will be indicated in the survey data, it appears to flourish on well-drained habitats, though it also occurs in swampy areas. In areas of greater exposure it prefers shady canyons and barrancas. The high calcium content of the leaves and fruit (INCAP-ICNND 1961:23,71) suggest that it is well adapted to the limestone-derived lithosols and calcimorphic rendzina soils which characterize the southern Maya Lowlands (Stevens 1964).

Morphology:

Fully mature specimens of B. alicastrum may be as high as 30-35 meters with the trunk more than a meter in diameter. The dense crown spreads out well into the third story of the high forest community. The bark which is basically grey, varies considerably between individuals. This appears to be largely a function of age. Old trees tend to have a dark-brown scaley bark which is often covered with lichens. Younger trees are smooth to the touch with golden-yellow colors around the buttresses and lower trunk. The buttresses on larger trees are tall and thick extending out as much as two meters from the trunk at ground level. During the rainy season, from May to December, a cut in the side of the tree produces a copious flow of milky, white sap. The wood is whitish-yellow. The leaves are bright green, short-petiolate, elliptical-oblong in shape, and glabrous. Their thickness gives a characteristic density to the appearance of the foliage.

The single inconspicuous female flower and the numerous inconspicuous male flowers are all attached to the fleshy globose receptacle which encloses the cotyledonous seed (fig. 2). The male flowers, which are reduced to single stemans, produce the pollen. They are separated from each other by fleshy peltate bracts which cover the surface of the receptacle. The female flower, immersed in the center of the receptacle, exerts its single style with two characteristic stigmatose branches. The lack of a corolla, suggests that the flowers are pollinated entirely by wind.

Some confusion has surrounded the monoecious status of the flower. Swartz (1797 I:18) set the tone with his apparently faulty observation that female flowers grow on distinct trees, thereby suggesting that the trees were entirely dioecious. Probably he had been misled by the fact that the female flower sometimes emerges from the involucre before the male flowers. This mechanism, called dichogamy (Chandler 1950:46) is also employed by the avocado, and is a means of assuming

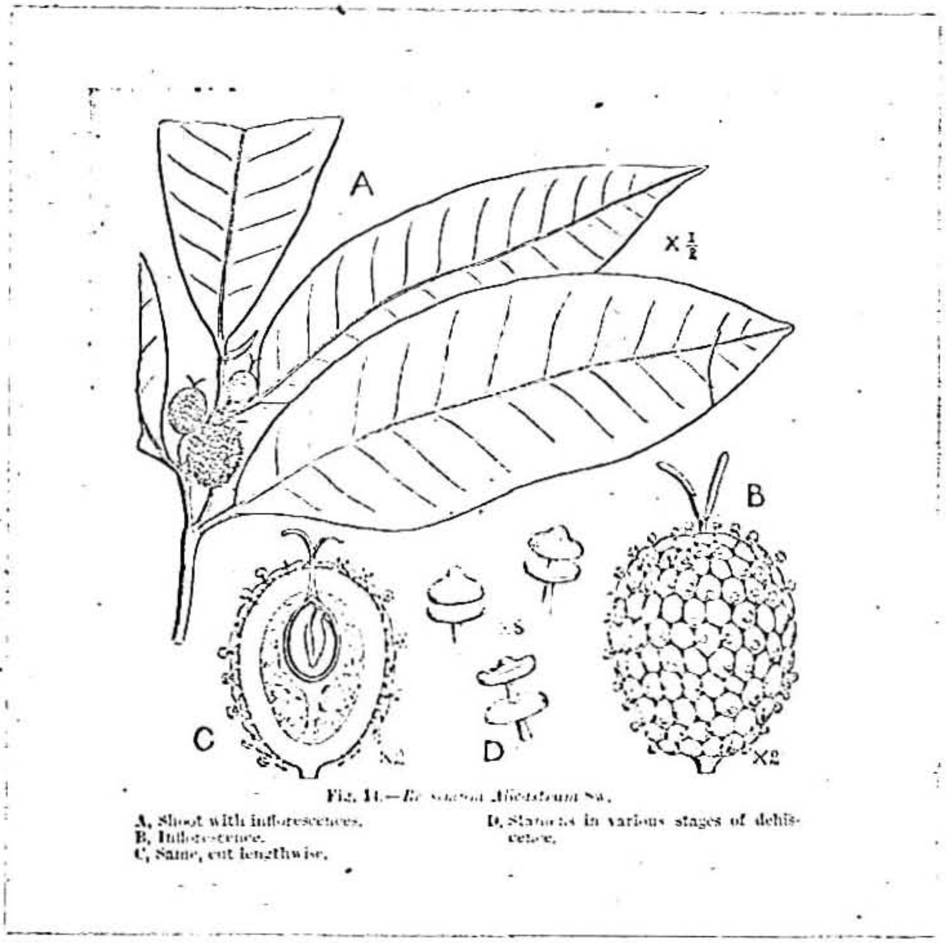

Figure 2: Details of the fruit and flowers of Brosimum alicastrum: (from Fawcett and Rendle 1914:46)

some degree of cross-pollination between trees. Grisebach (1864:152), who noted that both male and female flowers occur on the same fruit of the same tree, possibly was taking his observations from fruits on which the female flowers had become senile when he noted that the flowers were monoecious or "dioecious by abortion." It is now generally conceded that the "flowers (i.e. trees) are monoecious or rarely dioecious" (Bailey 1914:579). Lundell (personal communication) reports that the specimens he has in the Texas Research Foundation collections are all apparently monoecious.

The edible fruits, consisting of the fleshy receptacle and the enclosed cotyledonous seed, arise singly from the axils of the leaves. They are characteristically yellow in color but also can be orange or red. The diameter of the globose fruit varies from 1.5 to 2.5 cms. in diameter. The small size is more typical of specimens observed at Tikal. The fleshy receptacle is about 0.2 cm. in thickness. In terms of weight Tikal specimens averaged 1.5 g. for the receptacle and 3.0 g. for the seed.

Fruiting:

Twice a year, according to local information at Tikal, the ramon trees bear fruit. The first fall, in the dry season can begin as early as February or as late as April. The second comes in the wet season in August. We did not observe this second fall, but Gonzalez (1939: 221) notes that the tree fruits in October and November in Campeche. A normal fall lasts five or six weeks.

Varieties:

Local woodsmen of the Peten claim to be able to distinguish three varieties of ramon on the basis of fruit size and color and differences in the shapes and sizes of leaves. These varieties were called "ramon blanco," "ramon amarillo," and "ramon rojo." Though attempts were made to distinguish these varieties in our survey, the absence of fruits and the obscurity of the leaf distinctions made many of the identifications rather arbitrary. Evidence in support of the reality of these varieties is provided by Martinez (1959b) who reports that three varieties known as "*ox* blanco," "*ox* colorado," and "el de hoja ancha" are found in Tabasco. He also suggests that these varieties occur in Quintana Roo when he writes, "el *ox* colorado de Quintana Roo es menos apreciado que el blanco."

Growth Rate:

Though it is generally known that *Brosimum alicastrum* is fast-growing, little in the way of specific data is available. For lack of reliable data on trees growing in Central America, the following fragments have been collected from data on plantings in experimental gardens in the United States and Puerto Rico. It is possible that growth rates for trees growing in the Maya Lowlands will be found to be quite different. Britton and Wilson (1926:343) report that a specimen planted in 1920 at the Experimental Station at Mayagüez, Puerto Rico had reached a height of 3 meters by 1926, and "appeared vigorous." By 1929 this same specimen had reached a height of 5 meters (Britton and Wilson 1930:570). A tree planted in 1939 at the Fairchild Tropical Gardens in Florida is now (January 1968) about 12.5 meters high as determined from a photograph taken by Sally Puleston. Another tree planted in 1913 at the U. S. Plant Introduction Station at Coconut Grove in Florida was over 15 meters high in 1945. These data are plotted on the accompanying graph (fig. 3). A vertical growth rate of a little under 0.5 meters/year is suggested. Presumably a tree could reach a maximum of 30-35 meters in 65 years. Hopefully, further data on growth rates can be collected in Tikal or Uaxactun in the near future. Information on how long the trees live is not available.

Related Species:

There are perhaps two dozen valid species for the genus Brosimum, though 48 names for the genus are listed in Gray's Herbarium Index. All of these species are

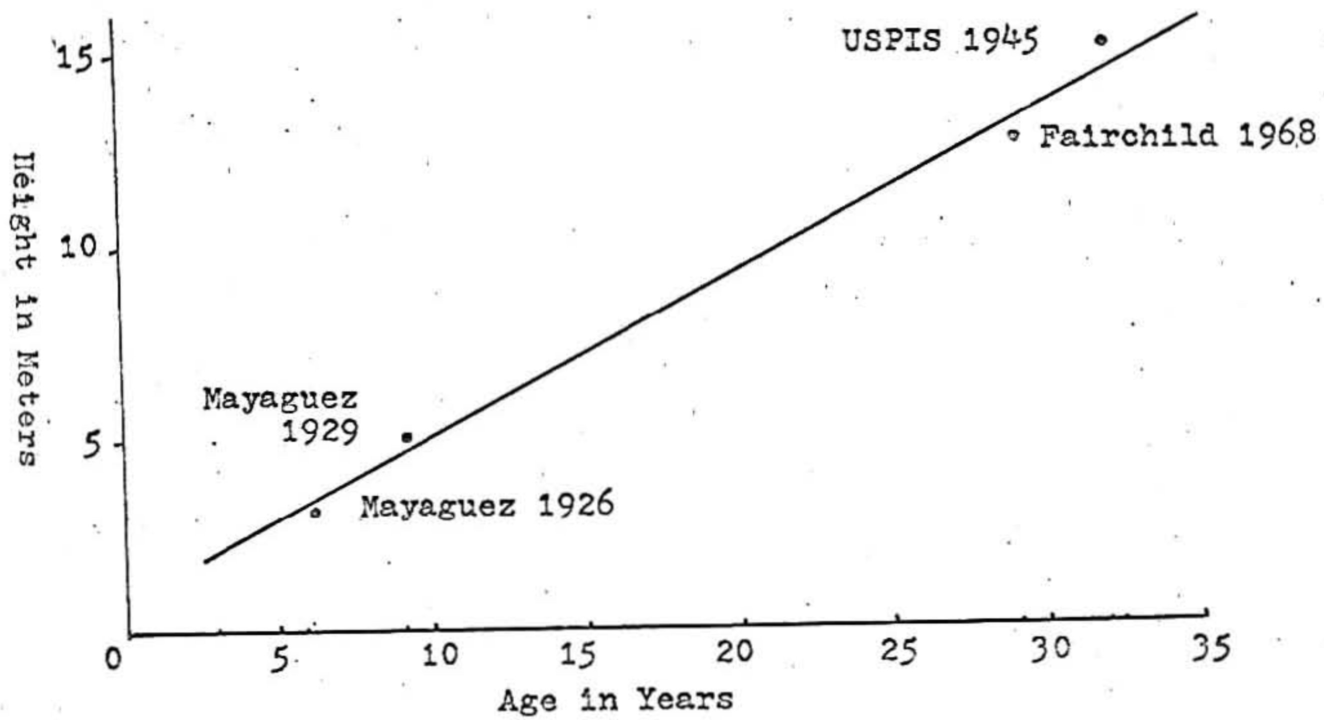

Figure 3: A graph of height and age records for Brosimum alicastrum.

native to the New World. The range of the genus extends from Mexico south through Central America into South America where various species occur in Venezuela, the Guianas, Brazil, Colombia, Peru, Ecuador, and Paraguay. In the Caribbean, representatives of the genus seem to be limited to Jamaica, Cuba, and Trinidad. Three species B. conzattii Standl., B. costaricanum Liebm., and B. terrabanum Pittier, are similar enough to B. alicastrum Sw. to possibly be con-specific. The lack of distinction between B. terrabanum and B. alicastrum is indicated by Record and Hess (1943:380) and Standley (1937:380). Record and Hess further suggest that B. costaricanum is no more than a variety of B. alicastrum. The most recent assessment of the genus is that of Pittier (1918) and it is badly out of date. Standley (1946:15) remarks, however, that "...because of lack of abundant fertile specimens...the species of Brosimum still are imperfectly known and their classification is not altogether satisfactory." In spite of these difficulties, an up-to-date review of the genus is badly needed.

For our purposes here it is sufficient to note that B. costaricanum and B. terrabanum, produce edible fruits similar to those of B. alicastrum. B. conzattii, which occurs in a localized area of Oaxaca (Standley 1919:20), can probably be included in this category though information on the edibility of the fruits is lacking.

Distribution:

The map (fig. 4) indicates the general distribution of the four species mentioned above. In Jamaica, where only *B. alicastrum* occurs, it is most abundant in the central parishes. The tree is sparingly represented in Cuba (Record and Hess 1943). In drier areas as on the Nicoya Peninsula of Costa Rica, in certain parts of Chiapas, and in the drainage areas of the Papaloapan and Balsas, the tree is most common in barrancas where it possibly represents the remnants of a former forest vegetation which has since been removed by man as a result of his agricultural activities.

Standley and Steyermark (1946:13) provide the following information on the distribution of the tree in Guatemala:

> "Moist or wet forest, ascending to about 1,000 meters but mostly at 300 meters or less; Peten, Alta Verapaz; Izabal; Escuintla: Guatemala (valley of Rio Motagua); Retalhuleu; Quiche; Huehuetenango; Baja Verapaz."

THE TIKAL RAMON SURVEY

Introduction:

For many years botanists and archaeologists working in the Peten have been aware of the fact that the ramon tree tends to dominate the high forest community around long-abandoned Maya ruins. Lundell (1938:41)

Figure 4: Map of Central America and of the Caribbean showing the approximate distribution of the main edible species of "ramon," <u>Brosimum alicastrum</u>, <u>Brosimum terrabanum</u>, and <u>Brosimum costaricanum</u>.

reported that he had "...found ramon groves (ramonales) covering the sites of every Old Empire ruin [he had] visited in Peten and Campeche." Thompson (1930:185) observed, "...it is remarkable what large numbers of [ramon trees] are to be found growing in the immediate vicinity of every group of ruins."

O. F. Cook (1935:615) states that the abundance of this tree on Maya ruins has been largely responsible for many of the archaeological discoveries made in the Maya area over the last half century, presumably because the trees brought man with their mules to the ruin areas.

Going back into the literature it is interesting to note that Father Avendaño, often quoted as possibly the first "white-man" to see Tikal, notes unwittingly the general association of the tree with ruin areas in 1696 (Means 1917:167). Avendaño's account is of further interest because it also indicates his awareness of it as a source of food, saying nothing of the value of a bit of earthy philosophy:

> "...but it is wonderful that though these forests in which we traveled for two days and the three preceding ones, consist of an infinite number of <u>sapote</u> and <u>ramon</u> trees, we did not find in them all a bit to eat,...Seeing their sterility, I said, 'They appeared in every respect like those of Gilboa.'
>
> "With so few comforts and so great affliction, our strength went on diminishing very quickly, knowing for truth the proverb, which the Biscayans, my fellow countrymen, say: 'It is the guts which carry and support the legs and not the legs, the

> guts.' Among these high hills which we passed over, there is a variety of old buildings, excepting some in which I recognized apartments[1], and though they were very high and my strength was little, I climbed up them (though with trouble)." (Means 1917:167)

Subsequent observations on this association have been scattered. Ruppert and Denison (1943:3) write "most archaeological sites are covered with a heavy stand of ramon..." They specifically note the occurence of the tree at Rio Bec. Thompson notes its prevalence in the area of San José (Thompson 1939:3), and Maya sites in general (Thompson 1963:236). Maya Archaeol. Willey et al. (1965:23) report that it is one of the dominants at Barton Ramie. It occurs abundantly at Kinal (Graham 1967: 33). Photographed at Calakmul by Morley (Lundell 1937, Plate 3, fig 1,2.) poss. "Ramon-tree island" as name of town (Scholes & Roys 1948: 387)

Purpose:

Initially the objective of this study was to test quantitatively the reality of this relationship between ramon trees and Maya ruins. Assuming that the relationship could be demonstrated, we, of course, intended to go on to the question of why? More specifically, what was the evidence for the ramons being relic populations of trees actually cultivated by the Maya? Again, assuming that this could be demonstrated, we would gain valuable

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[1] Could these "apartments," which Avendano excludes from his category "old buildings," be references to evidence he found for contemporary occupation? Such a conclusion would not be inconsistent with the nature of "post-classic occupation debris" found at Classic sites such as Tikal and Uaxactun

insights into Classic Maya ethnography as well as a powerful tool for dealing with problems relating to Classic Maya subsistence and the interpretation of settlement patterns.

Treating separately for the moment the aims of archaeology and ecology, the value of the study can be considered to be twofold. First, for the archaeologist, it represents an opportunity to clarify the picture of Maya subsistence and land-use in areas beyond the reach of conventional techniques. Second, for the ecologist, it offers a rare chance to study the persistence of ecological changes brought about by man in an area left all but totally undisturbed for almost a thousand years. The significance of this was noted by Bartlett (1935:18):

> "If this supposition regarding ramon should be supported by future investigations, it will afford additional support for the supposition that the plant associations of the Peten forest were determined largely by human agency centuries ago."

Methods and Materials:

In early planning sessions we had intended to compare separate plots in 1) areas known to have been inhabited, 2) areas believed to have been uninhabited, and 3) areas transitional between these two. In view of the magnitude of Tikal and the complexity of settlement patterns around it, it was decided that these separate plots might be inadequate for clear proof of the relationship even if it did exist. Assuming that the relationship could be proven, we were concerned with finding a way of dealing with the logical contingencies which would inevitably follow. In view of the variety of settlement patterns at Tikal (Carr and Hazard 1961), we decided that it would be important to know with what kinds of settlement ramons are most numerously associated; in what situations might there be exceptions to the association of ramons and settlement; and in what ways distribution might have been changed by ecological developments subsequent to Maya abandonment.

In an effort to deal more comprehensively with the specific problem chosen, we decided it would be best to study the ramon in one continuous transect that would extend from one extreme of Maya settlement density to the other. By this means subtle but significant changes might become evident which would otherwise be missed. Clearly, such a transect would have to be a long one and in fact it turned out to be 12 kilometers long before it was completed.

As to the problem of where exactly to run the transect, the decision was greatly simplified by the fact that we were limited to areas in which settlement density was known. The main site map of Central Tikal, covering an area of 16 sq. km. was insufficient, however, for our purposes.

With the exception of inhospitable bajo swamps of escoba (Crysophila argentea Bartlett) the area the published map covers must have supported fairly dense settlement, estimated by Haviland (1966:32) to be minimally 10,000-11,000 people for the mapped area. This density can be seen on a reduced version of the Tikal site map (fig. 5). The apparently vacant areas between the indicated house platforms of the peripheral areas were hardly large enough to test validly the ramon-settlement association for at least three reasons. First, of all, low house platforms, invisible without excavations, had already been demonstrated to exist in tested vacant areas. Second, the dispersal rate of ramons, slow as it might be, could well have altered significant distributions over such small "vacant" areas and over such a long period of time even if these areas really were uninhabited. On the basis of the rapidity of the tree's growth a succession of at least 50 generations since abandonment is calculated. We consider a generation to be the length of time between the falling of the seed and the time at which the tree reaches maximum breadth and begins to produce maximum amounts of fruit, a period of time which is estimated to be about 20 years. The third reason was that, if in fact the trees were planted in kitchen gardens, these areas may have been used for that purpose, thereby eliminating them as controls for testing the hypothesis.

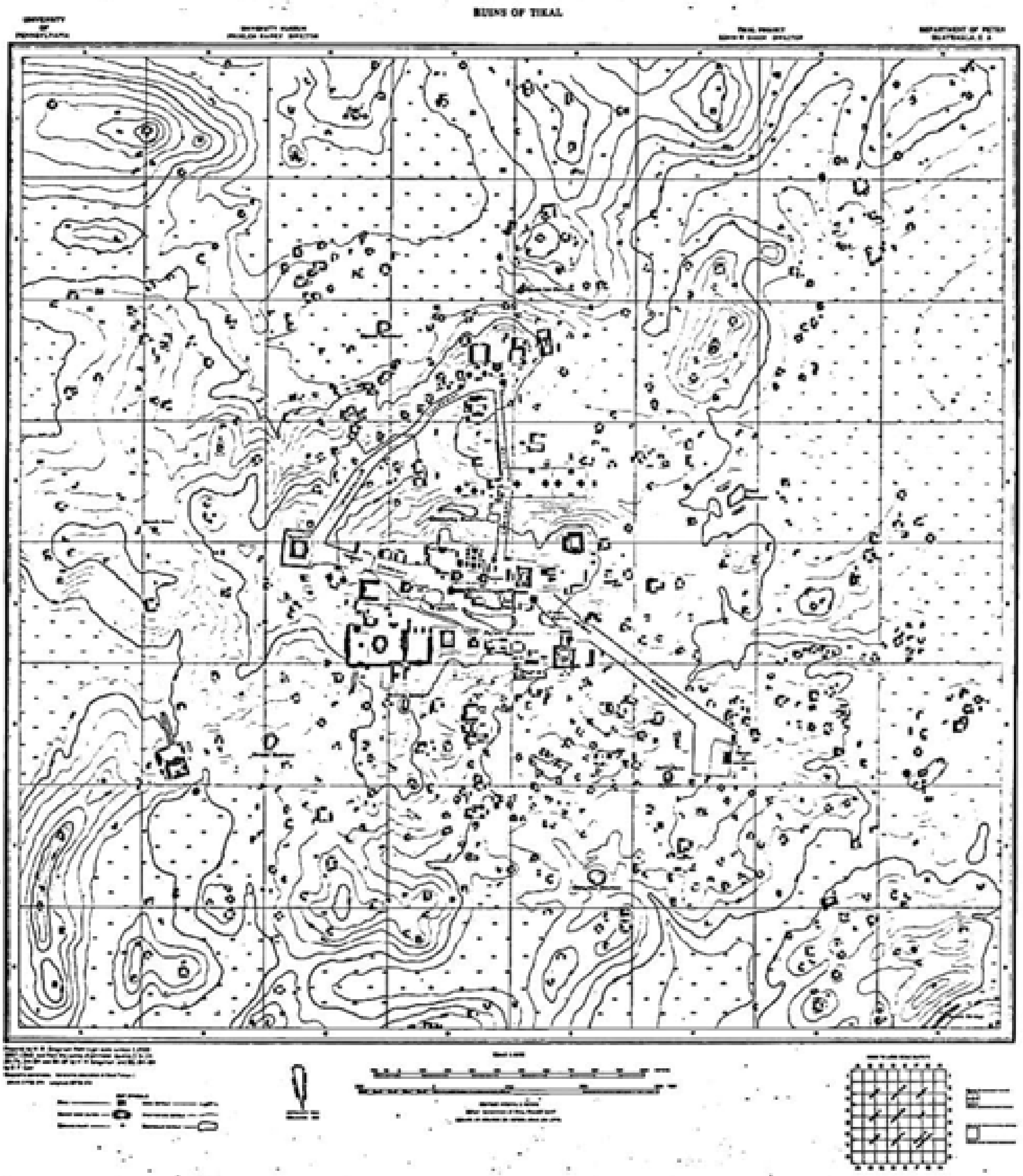


Figure 5: Map of the central 16 square kilometers of Tikal (From Carr and Hazard 1961).

Clearly, we had to have much larger vacant areas on good high ground as far from the center of Tikal as possible.

Fortunately, the recently completed settlement survey strips extending 12 km. north, south, east and west from the center of Tikal, provided an opportunity to meet those needs. The strips, ½ km. wide, begin in the center of Tikal and extend well beyond the limits of the formerly heavily settled area around Tikal (fig. 6). The strips were oriented to survey trails or <u>brechas</u> laid by FYDEP in 1964 in the delimitation of the Tikal National Park.

Of the four strips the south one was chosen for a number of reasons. The most important of these was that it presented the largest number of significant combinations of the three variables we could control: terrain elevation, settlement density, and distance from Tikal. The first two of these variables were less well controlled on the other strips. To the north and west, terrain descended rather continously, eliminating the possibility of testing areas of low settlement density on high ground, which is apparently favored by the tree in situations far from Tikal. To the east the strip descends into logwood swamps characterized by the <u>tinto</u> (<u>Haematoxylin campechianum</u> L.) where the ramon does not occur, apparently because of the unfavorability of this habitat for it. The east strip,

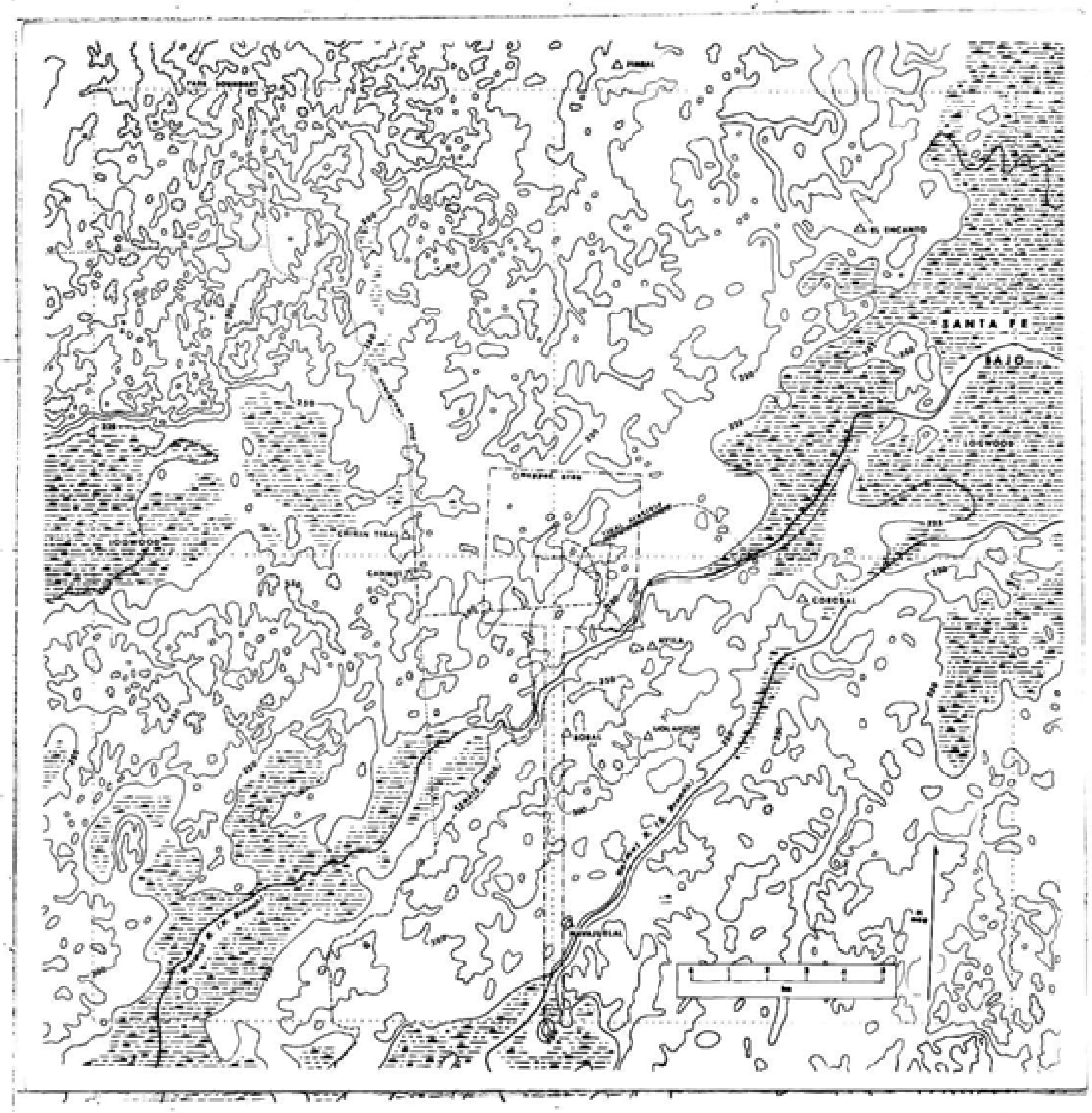


Figure 6: Map of the Tikal National Park showing the locations and orientations of the sustaining area survey strips (From Haviland and Puleston, n.d.)

as well as including sections of logwood, presented another problem relating to the second variable mentioned above. Near the east end, there is a sizeable settlement, possibly linked to the unassessed and apparently positive relationship between settlement and logwood swamp. This situation eliminated the possibility of testing areas of low settlement density on high ground far from Tikal.

Another reason for selecting the south strip was that a number of other studies were being carried out on this strip. These other surveys included a ceramic test-pitting program whihhcovered a randomly selected sample of one-third of all the plaza groups on the strip; a study of soil samples collected in 1967, presently being investigated by Dr. Gerald Olson at Cornell University; and the more complete excavation of about a dozen residential sites and the "satellite" site Navajuelal, excavated by Ernestine Greene (Ph. D. thesis, n.d.).

Before actual mapping of ramons could begin, points of reference to be used in mapping, had to be laid down. For this purpose wooden stakes were placed every 25 meters along the central survey trail or <u>brecha</u> of the mapped strip. On each stake, was written with felt pen, its distance in meters from the center of Tikal. The stakes were laid with a 30 meter K & E cloth tape which was stretched horizontally between the stations. A three-man team was sufficient for this job, two were able to carry out the actual staking, measuring, and marking, leaving the other free to go ahead clearing the trail and continue cutting new stakes.

The techniques employed for mapping the trees were similar to those used on the 500 meter wide settlement transect mapped in 1965 (Haviland and Puleston, n.d.). The ramon survey strip was trimmed to a width of 100 meters for several reasons; 1) because it was felt that 100 meters were sufficient to provide a comparatively representative transect, ramons being somewhat more abundant than house platforms; and 2) the extra time necessary to map a wider strip would have made it impossible to complete the full 12 kilometers in the time available. On the other hand a strip narrower than 100 meters would probably have been insufficient for the following reasons: (1) The hypothetical associations of ramons and settlement made it necessary to include a minimally representative sample of house platforms in the ramon survey, which a line transect or other narrow transect would not have provided, and (2) since areas of minimal ramon density were of special interest in this study, it would be important to get representative samples where they might be very scarce, even though 100 meters might have been more than was necessary where ramon density was high.

Materials used for mapping included a full set of the south strip settlement survey maps, mounted on a clipboard, a field notebook, a Brunton compass, red and black pencils, a felt tip marker, and a small plastic ruler. The actual location and mapping of the trees was carried out with the assistance of two experienced local woodsmen. Small areas were searched systematically, one at a time. Once a tree was discovered it was located from the brecha with the compass. Distances were paced from the 25 meter stakes to points on the brecha perpendicularly east or west of the tree and then to the tree itself, or vice-versa. Where a number of trees occurred together, the location of the first tree was used as a base point to map in others in the vicinity. The plotting of the relationship of trees to house platforms, when they occurred together always received special attention. When, as occasionally happened, mound groups were found to be inaccurately located by a few meters, the trees were plotted to show their relationship to the mounds rather than their actual positions.

The position of each tree was marked on the maps with a red pencil. Each tree was given a number which was recorded in the field notebook with other data, as well as on the map. The number was also placed on the tree itself by making a small blaze and painting it on with the felt tip pen. This was done to prevent the possibility of remapping and also to facilitate relocation. After numbering, a rough shoulder-level diameter of the tree was taken and recorded. A superficial search was made in the forest litter for ramon nuts to determine whether or not the tree was producing fruit. The determination of whether the tree was of the "blanco," "rojo," or "amarillo," variety, as judged by our informant, Elias Contreras, was made and also recorded.

All trees with a diameter of two or more inches were thus mapped and recorded. Small trees were disregarded because of the difficulty involved in finding and recording them all, and because most of them would probably never reach maturity.

Review of the Survey Data:

A cursory glance at the radial strip maps (fig. 7) and the accompanying graph (fig. 8) reveals a [illegible]iking correlation between settlement and the density of ramon. Elevation and drainage only locally affect the overall patterns. A closer examination of the evidence follows.

0.0-1.0 km.: Following the strip map, the survey begins at the center of the Great Plaza of Tikal. For the first 125 meters of the survey the number of ramons indicated on the map and graph are probably somewhat below the actual figure. In the process of clearing, excavation, and reconstruction, many ramons were cut down in the area of the Great Plaza and Central Acropolis. Fortunately, in a good part of this area stumps still remained at the time of the survey, which could be identified and counted.

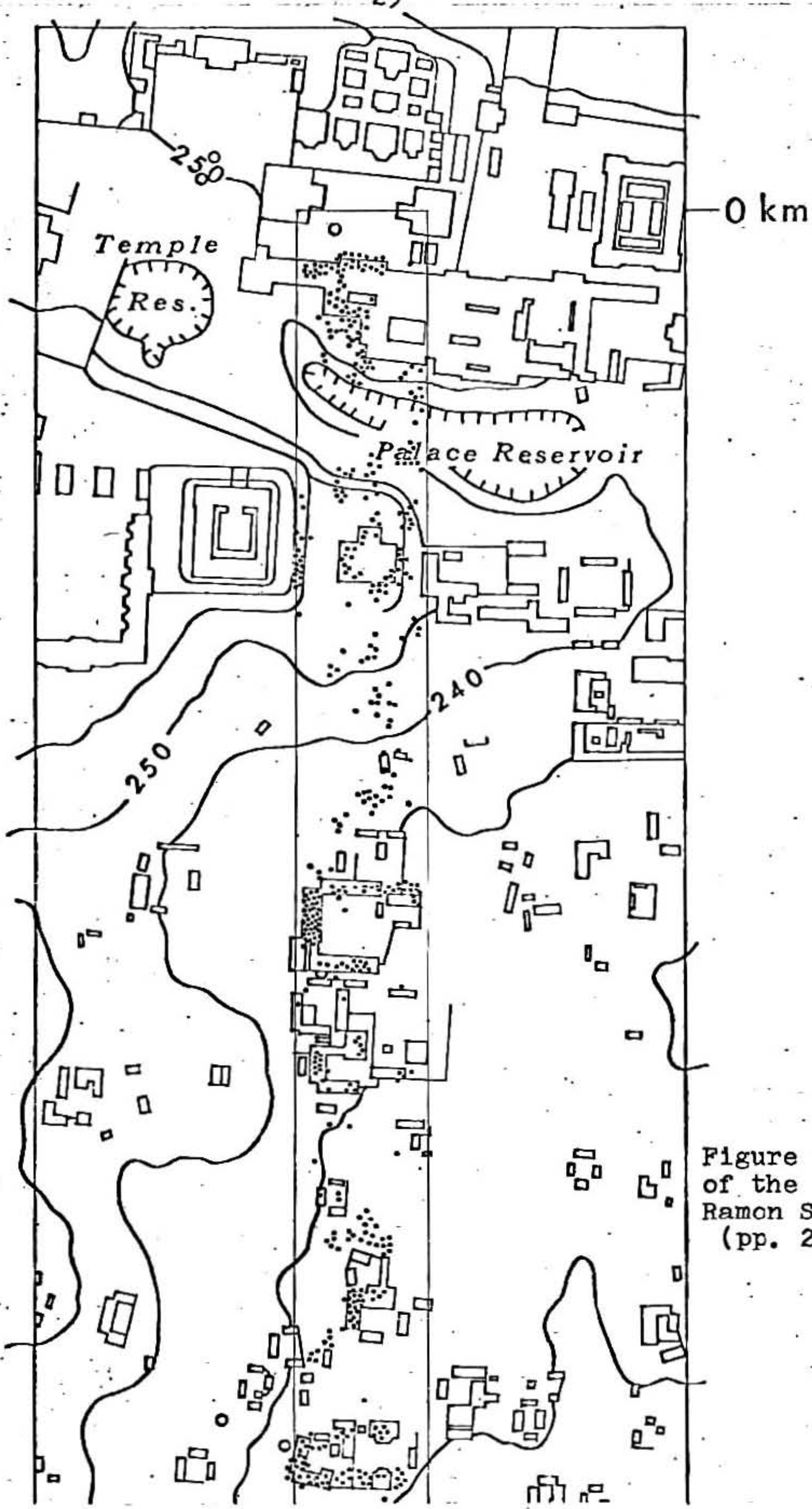
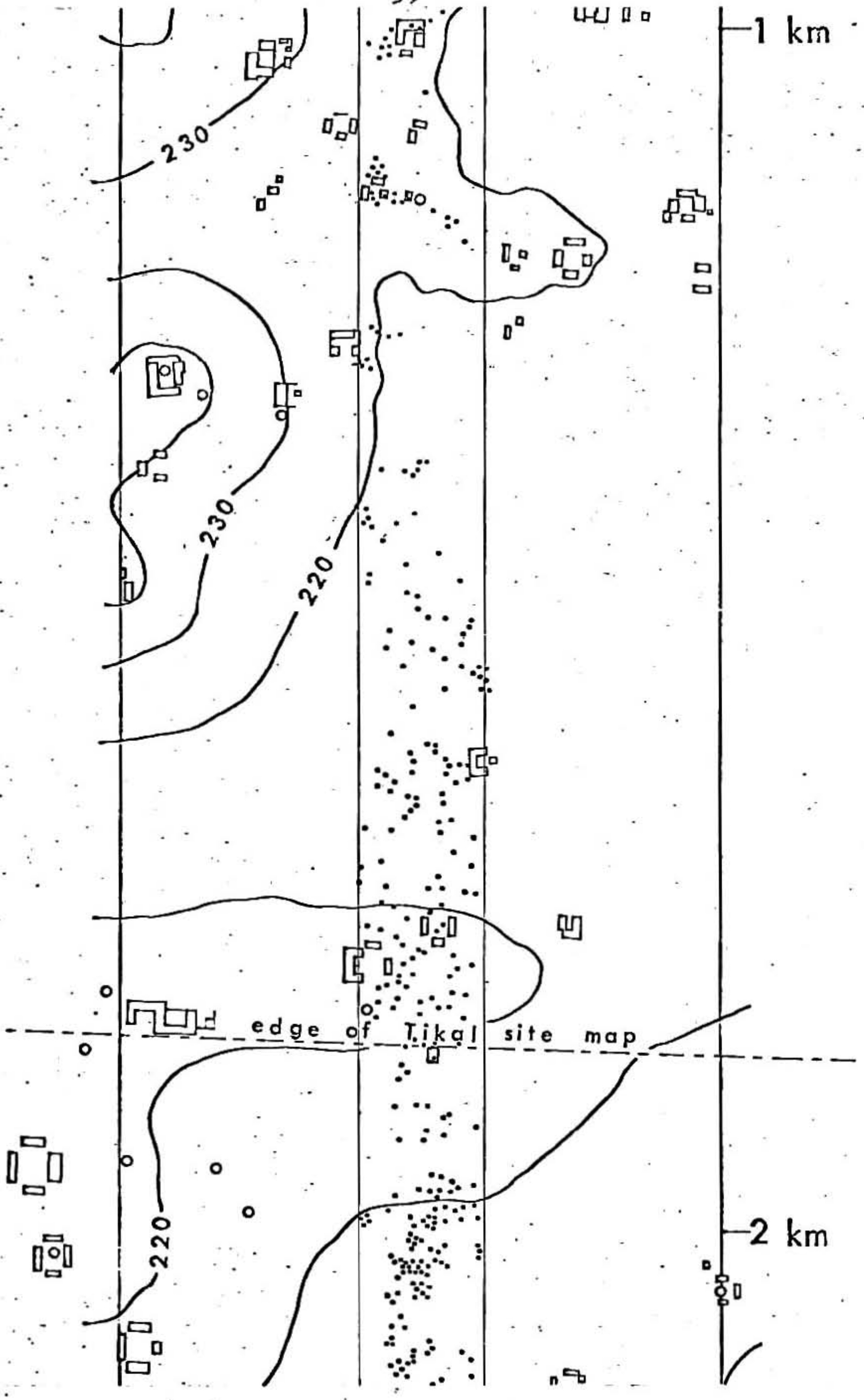
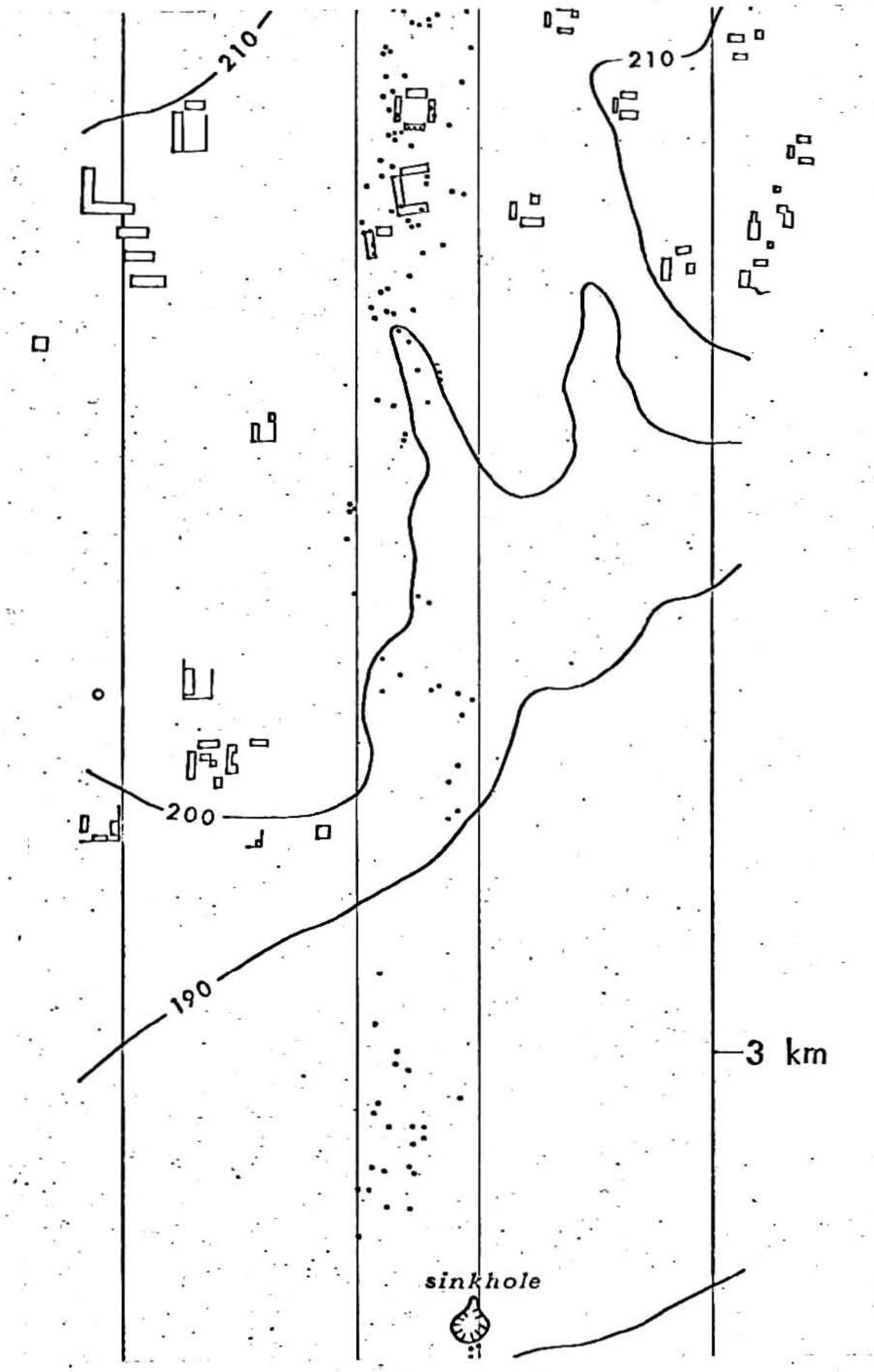
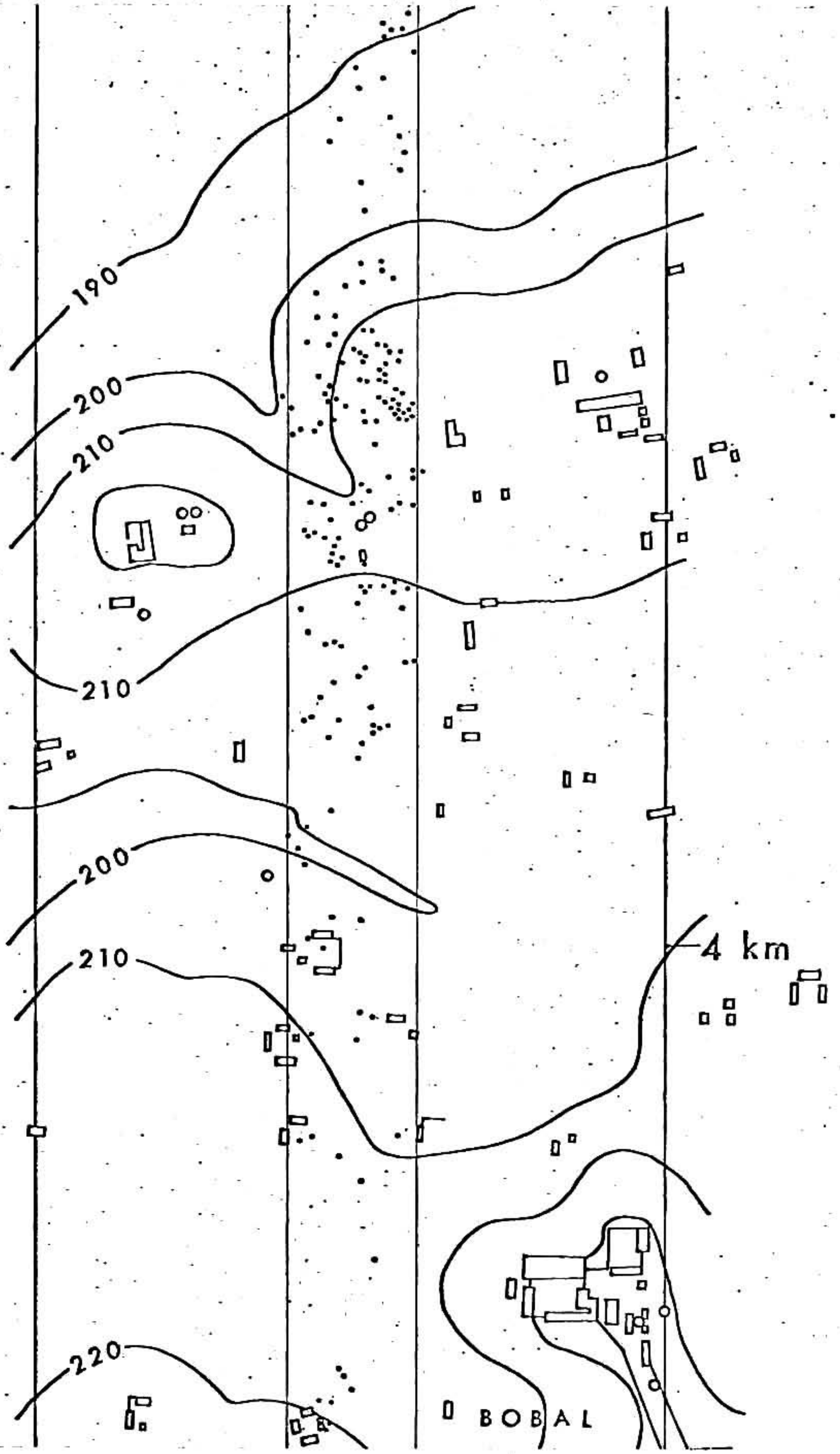
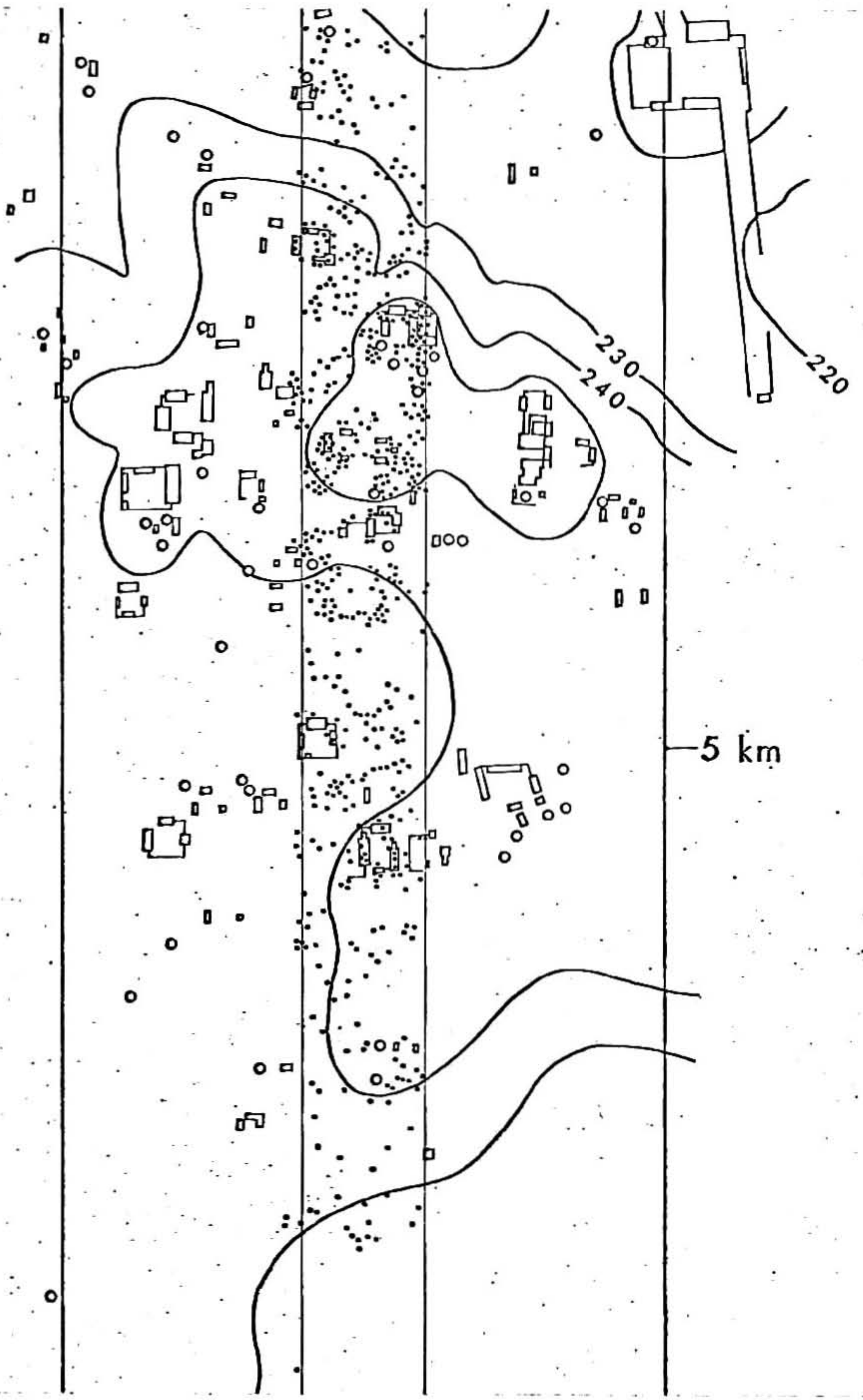


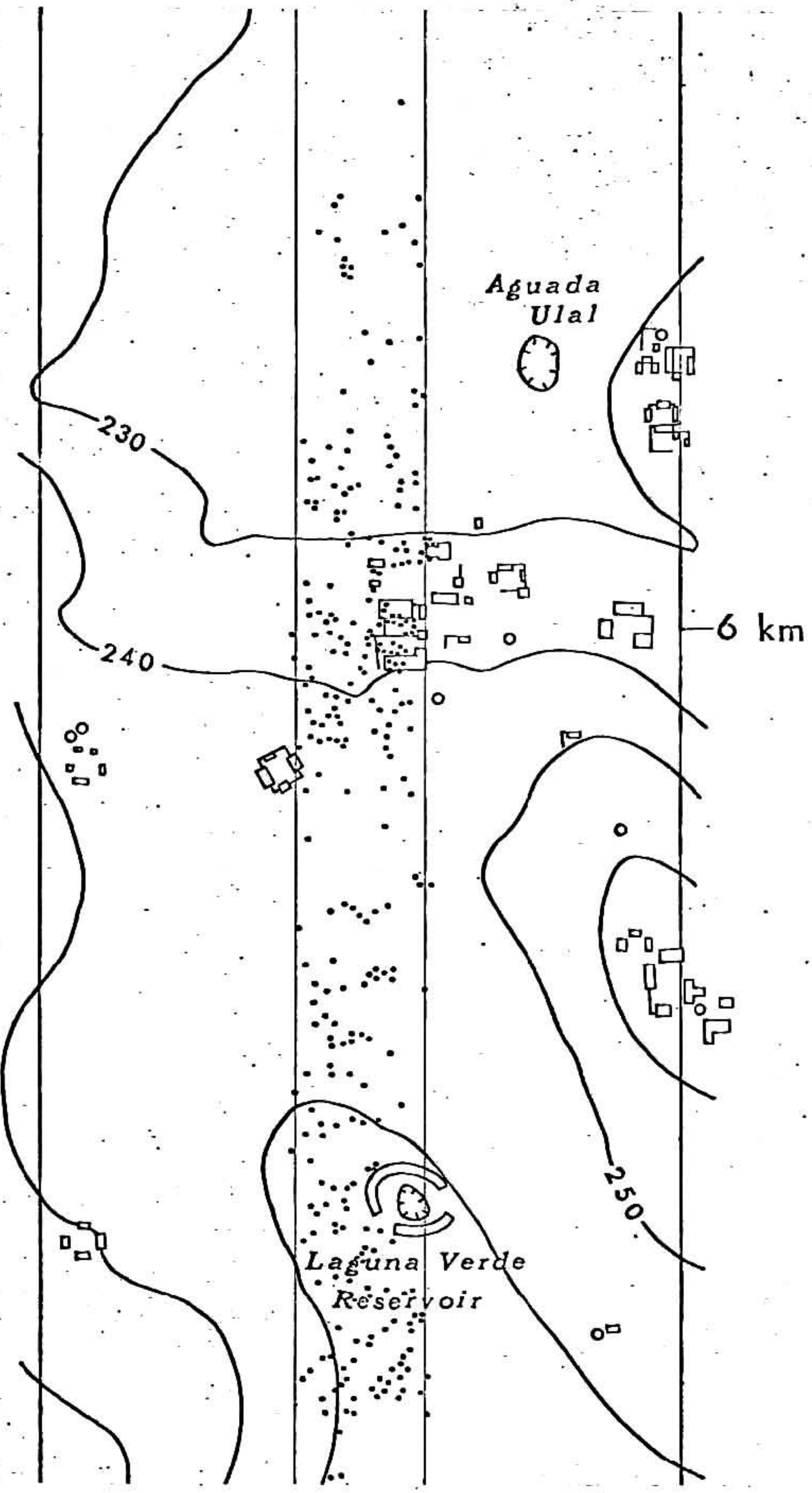
Figure 7: Maps of the Tikal Ramon Survey. (pp. 29-39)

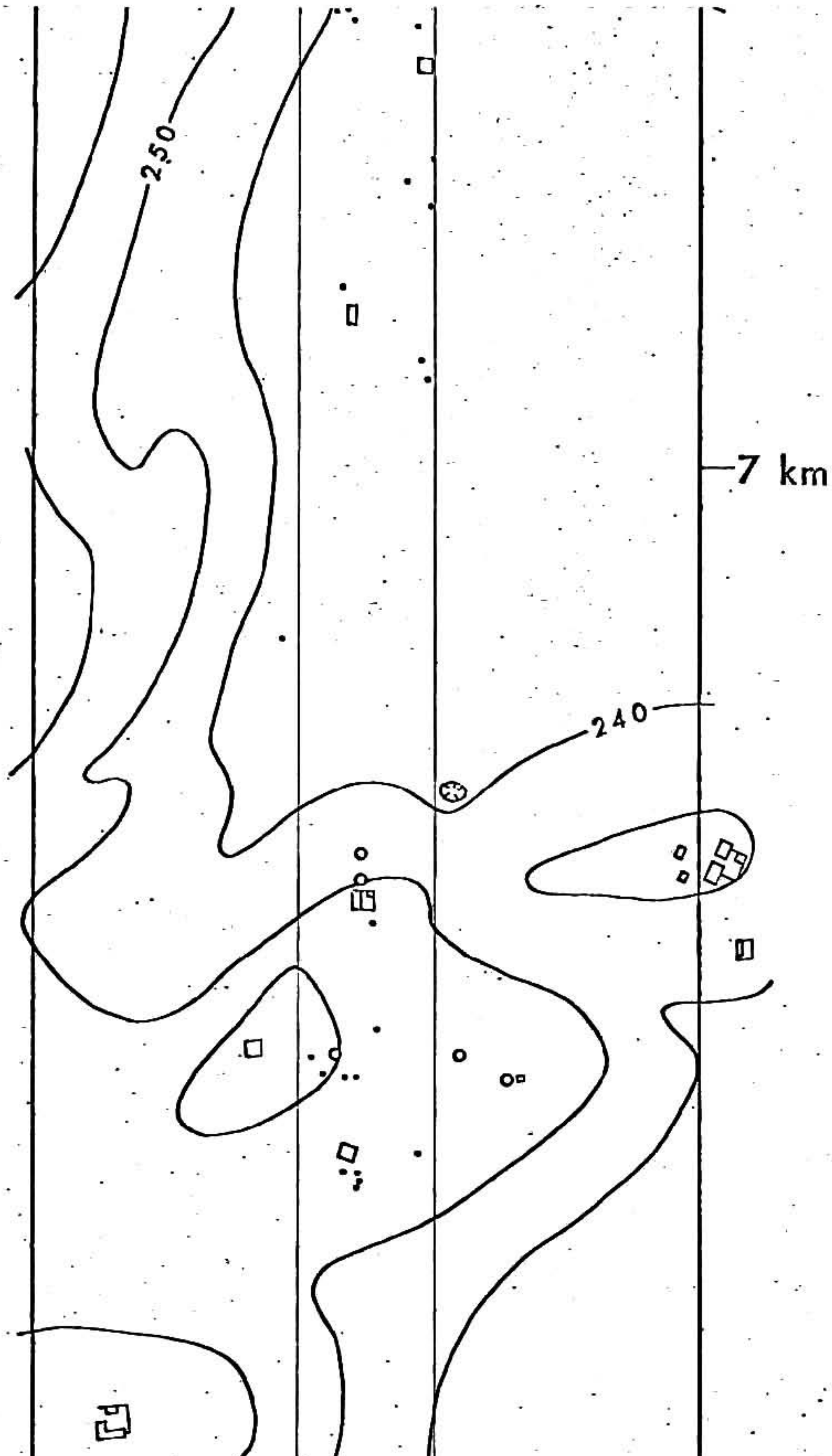

1 km
230
230
220
220
edge of Tikal site map
2 km

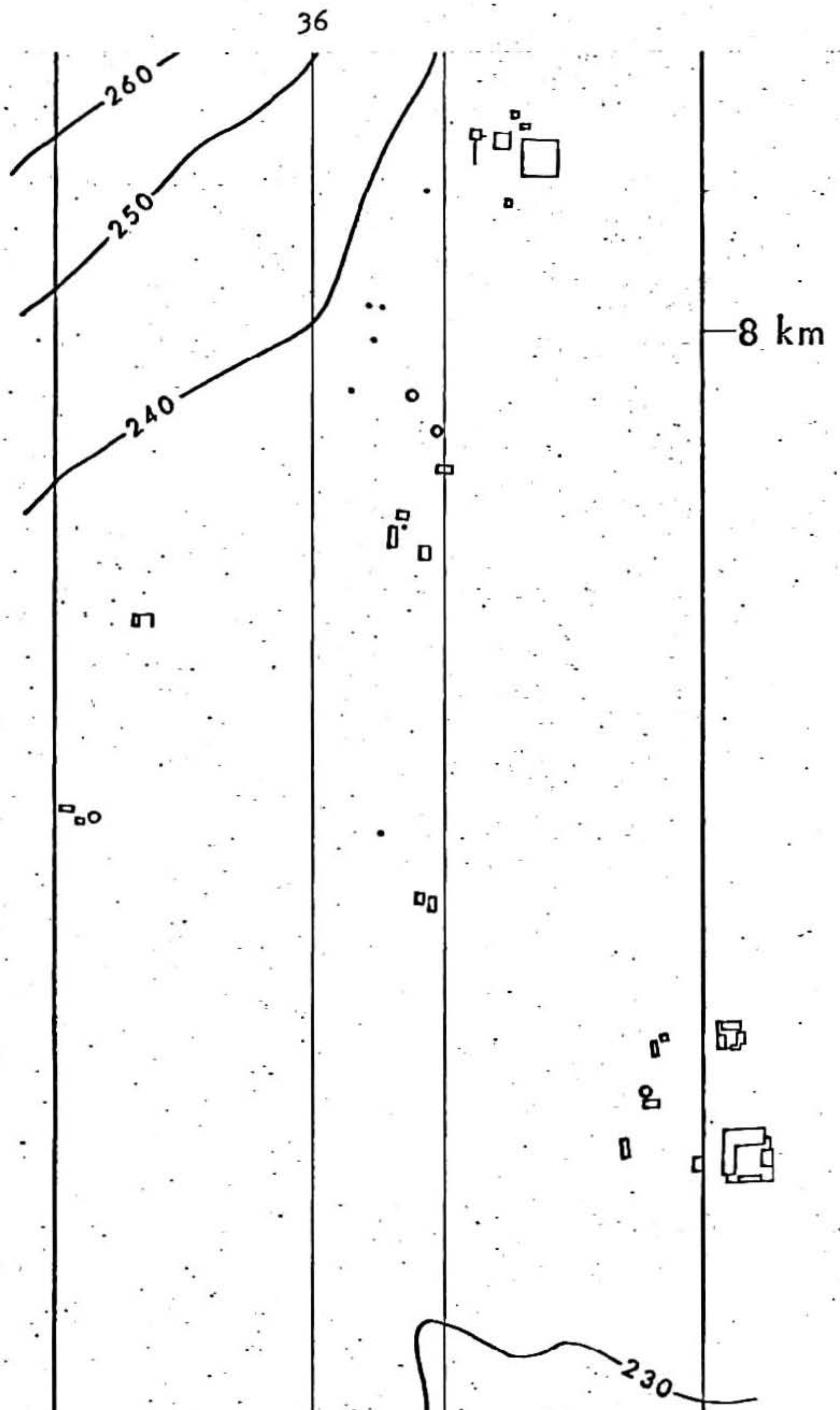

210
210
200
190
3 km
sinkhole

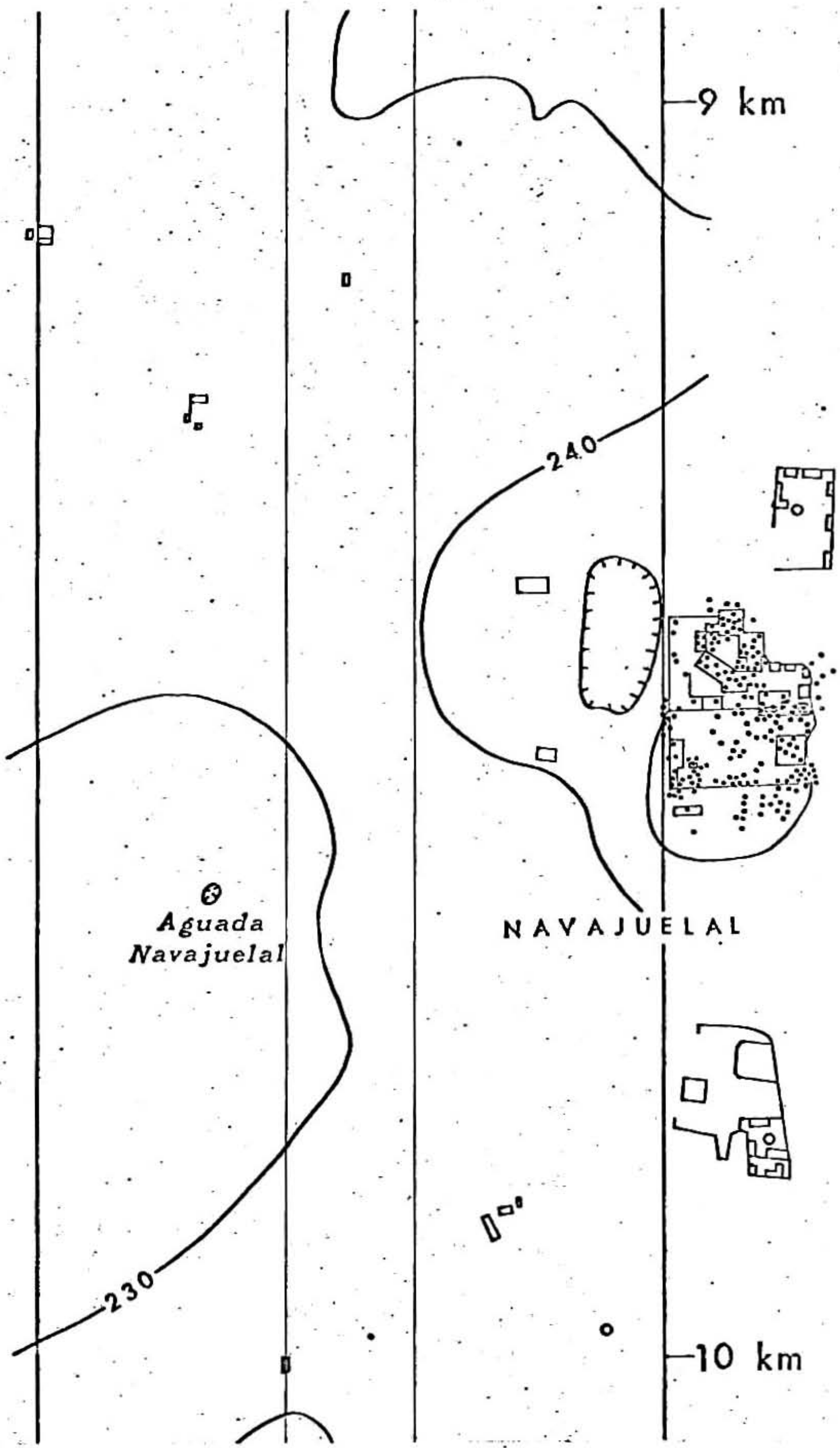

190
200
210
210
200
210
220
4 km
BOBAL

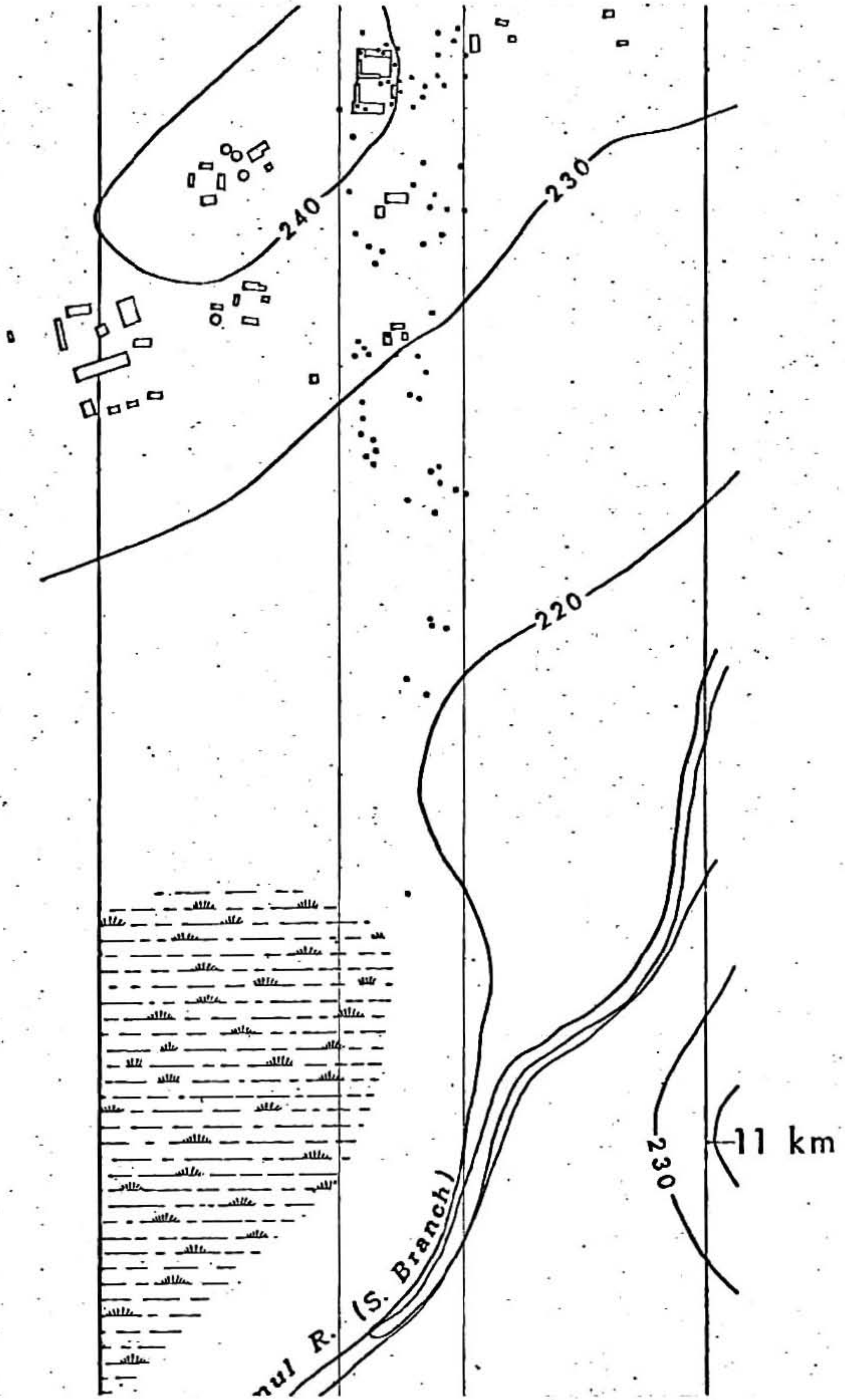

230
240
220
5 km

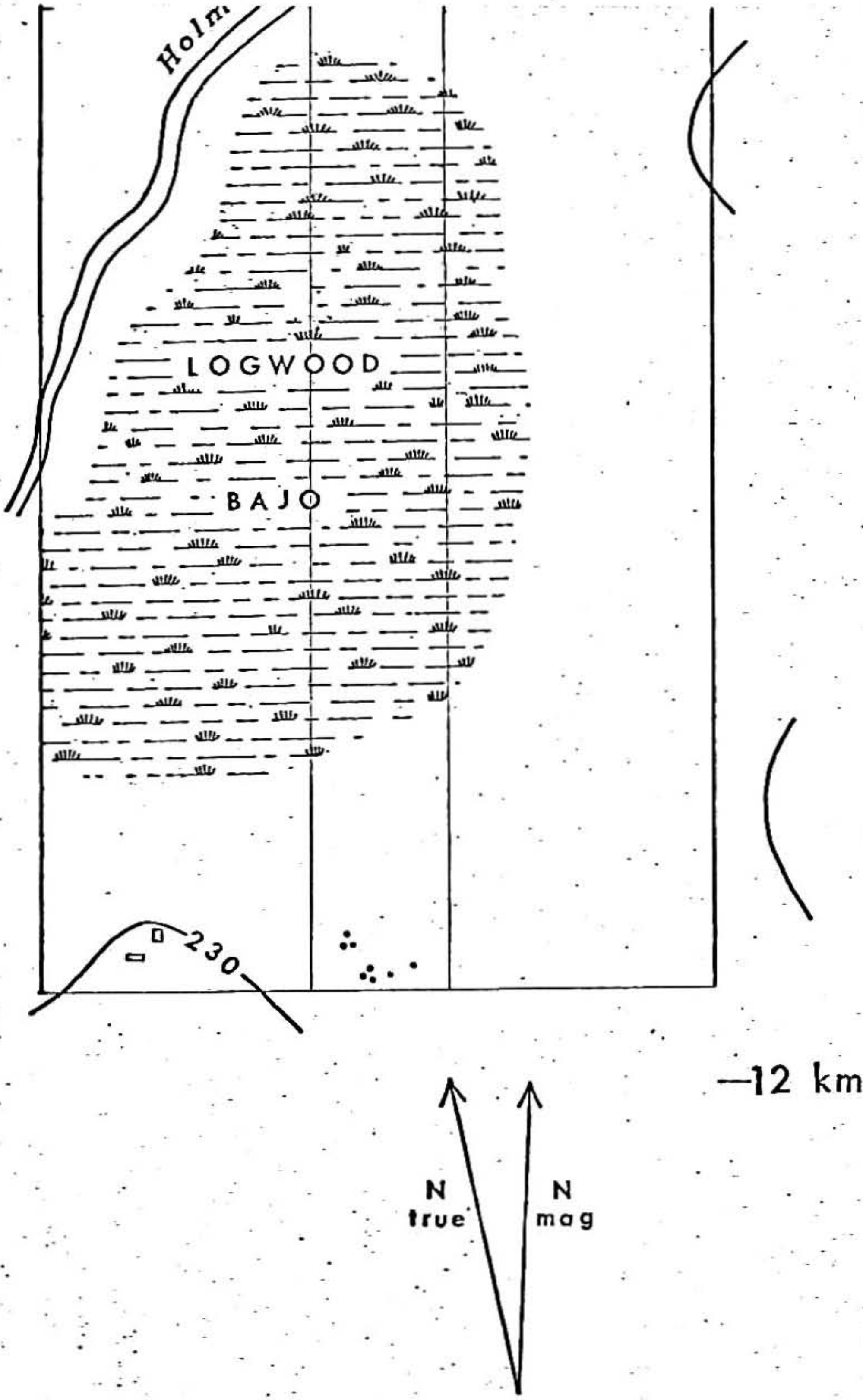

Aguada
Ulal
230
240
6 km
250
Laguna Verde
Reservoir


250
7 km
240


36
260
250
240
8 km
230


9 km
240
230
Aguada
Navajuelal
NAVAJUELAL
10 km


240
230
220
230
11 km
...aul R. (S. Branch)


Holm
LOGWOOD
BAJO
230
—12 km
N
true
N
mag

Copy

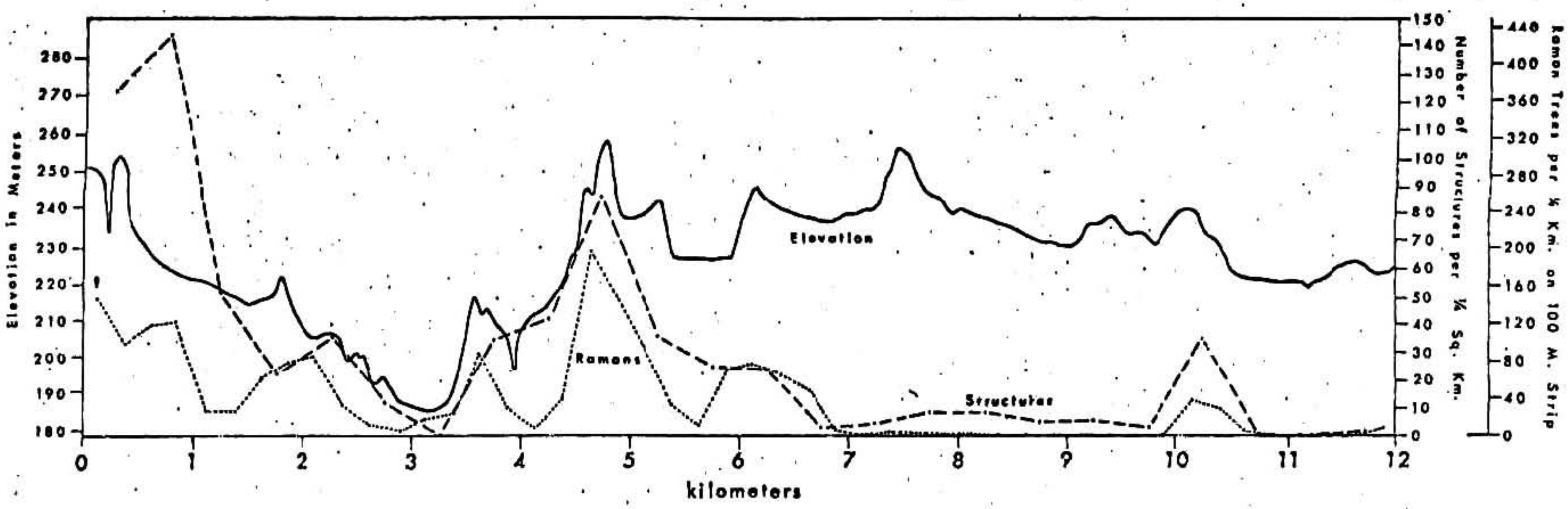


Figure 8: A graphic demonstration of the relation between numbers of structures, ramon trees, and altitude on the south strip. Altitudes down the center of the strip, determined by transit, are indicated by the solid line;; structures within the 500 meter wide strip , by the broken line; and ramon trees within the 100 meter wide strip, by the dotted line. The dropoff in structure density, which begins at 5 km., was actually greater in Late Classic times than indicated by the graph, for not all structures beyond this point were in use at that time. A relationship between structure density and ramons seems to be clearly demonstrated. There is little correlation between altitude and the density of structures or ramons beyond 6 km.

Where possible, this information was supplementd by information taken from earlier photographs. The high density of ramons here is equaled only by the peak at 5 km. In all probability this concentration cannot be attributed to groves which stood in Maya times. Archaeological investigation indicates that the plazas, courts, and alleyways between the many palaces and temples were paved with heavy plaster floors offering little opportunity for any sort of vegetation. It cannot be categorically stated that single large trees were not planted in the centers of these courtyards where the floors are most destroyed, but at present there is only evidence against such a possibility. Most of the ramons in this area are, or rather were, growing up on the tops and along the sides of the collapsed buildings. Evidently this is because of the unique and highly favorable conditions they offer the tree which seems to do quite well in well-drained situations.

For these reasons, it seems likely that the large numbers of trees which occur in this area represent an incursion which has taken place since the abandonment of the site by the Maya. This incursion was probably made possible by large reservoirs of the ramon in surrounding areas, the advance of which may have been implemented by the activities of bats, as will be discussed later.

Continuing south on the strip, below the Central Acropolis in the Palace Reservoir, comparatively few ramons occur. Perhaps this is due to the instability of the steep sides of the reservoir where few large trees of any kind are able to maintain a hold. It seems unlikely that ramons grew here in Maya times either, unless conditions were very different.

Up on the other side of the reservoir, around Temple V, and the South Acropolis to the west, ramons become more numerous again. The dip in the graph at this point is somewhat misleading since it is due to the relatively few ramons found on the long downhill slope behind Temple V. Here again lack of stability for larger trees may be responsible as there are many ramons in the general area.

Beyond this hillslope, further south, the density of ramons increases dramatically. We are now outside the ceremonial nucleus of public architecture, but large "palaces" and palace-complexes still dominate the settlement scene. As in the Central Acropolis, great numbers of the trees occupy the tops and sides of the larger mounds though many also grow in surrounding areas that are quite level. The trees occur less and less frequently on the mounds as we move away from the larger collapsed palaces so typical of the area right around the ceremonial nucleus.

Beyond this area a drop in ramon density is accompanied by a drop in the size of mounds, if not in their frequency. Since most ramons within this area are occupying positions on the collapse, the difference in number of ramons may actually be a function of the available structure-collapse habitat rather than densities of the tree in Maya times.

1.0-2.0 km.: In the half kilometer following 1 km., there is a real drop in mound density matched by an accompanying drop in ramon density, which is clearly visible on the graph (fig. 8). Both have probably been influenced by semi-bajo (swamp) conditions, apparently almost as unfavorable for ramons as it must have been for Maya settlement. A little further south, a slight knoll with some mounds on it has a slightly higher density of the fruit tree. Here, as before, this may be due to a difference in present conditions as well as a difference in Maya times. At 2 km. a large stand of ramons unassociated with any visible house remains is enigmatic. The possibility that it is made up of the descendents of a grove that existed a thousand years ago is suggested, but would probably be impossible to demonstrate.

2.0-4.3 km.: From this point on, the density of ramons decreases steadily with settlement as one descends into the swampy bottom of the north branch of the Holmul (fig. 6).

At the lowest point near the sinkhole, various species of vines, jimba (Guadua sp.) and the pita (Aechmea magdalenae André), this latter used for making string, become the dominants. The ramon is completely absent. On the steep ascent immediately south of the sinkhole, ramons begin to appear again, though not in large numbers until the top of the hill is reached. From a little beyond 3.5 km. to 4.3 km. ramon density remains low in spite of scattered settlement. Actually, the ramon survey strip, though it passes through an area of settlement, includes only one mound between these points, missing all the main groups. If we searched, perhaps greater densities of the tree would be found off the 100 meter strip in closer association with the mound groups. However, from 4.0 km. to 4.2 km. the scarcity of ramon trees seems to be attributable to another factor. Here a dense grove of manax (Pseudolmedia spuria Sw.) predominates over all other species. This tree bears large quantities of a delicious cherry-like fruit which has a fall that follows the first fall of the ramon. This fruit is highly appreciated by the local people who have the disturbing propensity to fell the trees solely for the fruit. The density of manax trees in this area is unique in our experience. The grove quite possibly represents another relic of Maya arboriculture, but further study would be necessary to bear this out.

It is interesting to note the proximity of this grove of delicate fruit trees to the minor ceremonial center of Bobal. The extent east and west of the grove is not known.

4.3-5.5 km.: Moving up the hill, ramon density increases significantly with settlement. At this point it is worth comparing the density of ramon and settlement on this high ridge-top with their densities on the ridge-top at 7.5 km.

The high density of ramons on this ridge is particularly important to the hypothesis, as here, in spite of the small size of the mounds, there are many more ramons than in Central Tikal where the collapsed platforms, palaces, and temples are much more massive. This comparison is important evidence in support of the supposition that the distribution and density of ramons 1000 years ago has more influence on their present distribution and density than subsequent changes in ecological conditions.

This heavy concentration continues down to the edge of the bajo which begins at about 5.5 km. The graph is somewhat misleading here as it indicate a drop in ramons which is not matched by settlement density. In actuality, as can be seen on the detailed map, settlement does not occur in the bajo at all. This discrepancy is an artifact in as much as on the graph ramons were calculated as "trees per ¼ km." on the 100 m. wide survey strip while settlement was calculated as "mounds per ½ km." on the larger 500 m. wide strip. This bajo, moreover, is ecologically unusual for the Tikal area. It comprises a community dominated by the corozo palm (Orbignya cohune Mart.) and is locally referred to as a corozal. Various products of this beautiful palm are used by the Maya today. From the meat of the nut a fine cooking oil is extracted; the great 30-foot fronds are used extensively for thatching; and the heart of the tree produces a delicious salad though it is rarely eaten for the obvious reason that the tree must be destroyed to secure it. It may well be that this community dates back to Maya times and was used by the Maya in these ways. The possibility that this stand of trees was introduced might be suggested by the comparative scarcity of the species in the Tikal area. The corozo is much more common further east in western British Honduras and on the upper drainage of the Usumacinta where rainfall is heavier. At Seibal, the tree occurs as a dominant on the high ground of the ruin area. For a discussion of man's role in the distribution of this species see Johanssen (1957).

5.5-6.6 km.: Continuing on the strip, a few ramons do occur in the southern half of the corozal but they quickly become even more numerous on the hillslope below the house groups nearer the top at 6.0 km. Although mounds continue to occur off to the sides of the strip beyond this point, they do not occur on the 100 m. wide ramon survey strip. In light of this, it is odd that their frequency continues high out to about 6.5 km. It is perhaps noteworthy, though, that they were all comparatively small trees and presumably young. On this basis it might be suggested that these ramons around the Laguna Verde Reservoir represent a recent incursion. Another possibility, however, is that the softness of the soil simply makes it an area unfavorable for larger trees which are infrequent in the area.

<u>6.6-10.0 km.</u>: From 6.6 km. on out to 10.0 km. ramons are practically non-existent. From 6.6 km. to 7.0 km. the Laguna Verde bajo continues, but from 7.0 km. to 10.0 km. typical high forest situations, as found near Central Tikal, seem to predominate, the one major difference being the lack of ramons. The survey strip does pass over a few mounds, however, between these points. This leaves us with the problem of explaining why ramons do not occur with greater frequency around them. Two explanations can be offered, one ecological, the other archaeological. From the ecological standpoint it can be suggested that there were too few ramons there in Maya times to allow the species to establish dominance. From the archaeological standpoint it is interesting to

that the mounds which were excavated in this area all appear to have been built and occupied in Early Classic times. This includes Structures S[illegible]-382, SW(S)-157, SW(S)-159 SE(S)-393, and SE(S)-394, all of which were excavated fairly completely. Where ramons occur with some frequency, in all other areas on the survey strip, Late Classic structures predominate. Thus, there appears to have been an abandonment of the area in Late Classic times. This may be part of a postulated move towards a more urban situation at this time in Tikal. It is not inconceivable that ramon trees which might have stood around these structures in Early Classic times were cut down in Late Classic times to make room for expanding milpas.

<u>10.0-10.5 km.:</u> At 10.0 km., where Late Classic settlement apparently continued, ramon density increases with settlement density in a most dramatic fashion. The structures in this area are apparently associated with the satellite site, Navajuelal, on the edge of the Holmul (S. branch) and a segment of the tintal or logwood bajo.

Ramon trees on the main Navajuelal platform were also plotted, not only because they were being cut down to make way for the excavations of Ernestine Greene but because they were so numerous. The main platforms of Navajuelal, like those in Central Tikal, were covered with heavy plaster floors, so it is assumed that the ramons moved up onto the collapsed construction from the surrounding area. The lack of ramon trees on the survey strip oppo ite Navajuelal as compared to their prevalence in the area of mounds again suggests, though does not prove, their association with structures rather than their cultivation in plantations.

<u>10.5-12.0 km.</u>: Further south, ramon density declines as the survey strip drops into a logwood bajo. Here, the trees completely disappear. At the [illegible]y end of the *brecha* a few ramons occur at the base of a large hill. Informal reconnaissance indicates that more structures are located further up the hill, off the map.

<u>The Correlation:</u>

In order to evaluate statistically the validity of the correlation indicated by the graph (fig. 8) the standard product moment correlation formula (Snedecor and Cochran 1967:180) was used to test the relationship. This formula is as follows:

$$\text{relationship} = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{\left(\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right)\left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)}}$$

The following values taken from half kilometer lengths of the survey strips, were used:

TABLE I: Values used in the product moment correlation formula.

PAIRS	x (No. of ramons on 100m strip)	y (No. of structures on 500m strip)
0.0 - 0.5	±315*	148
0.5 - 1.0	245	137
1.0 - 1.5	60	33
1.5 - 2.0	146	22
2.0 - 2.5	128	35
2.5 - 3.0	20	10
3.0 - 3.5	46	0
3.5 - 4.0	86	35
4.0 - 4.5	57	43
4.5 - 5.0	356	88
5.0 - 5.5	135	37
5.5 - 6.0	88	26
6.0 - 6.5	149	26
6.5 - 7.0	57	3
7.0 - 7.5	6	6
7.5 - 8.0	8	9
8.0 - 8.5	3	9
8.5 - 9.0	0	5
9.0 - 9.5	0	6
9.5 -10.0	1	4
10.0 -10.5	65	35
10.5 -11.0	6	0
11.0 -11.5	0	0
11.5 -12.0	8	2
24 pairs	1985	739

These data produce the following values for the formula:

$$\Sigma x = 1985$$
$$\Sigma y = 739$$
$$\Sigma x^2 = 396,301$$
$$\Sigma y^2 = 60,343$$
$$\Sigma xy = 141,804$$
$$(\Sigma x)^2 = 3{,}940{,}225$$
$$(\Sigma y)^2 = 546{,}121$$
$$n = 24$$

*Though only 248 trees were actually counted here, 67 were added on the basis of photographs and comparative estimates.

With these values r=0.86, which with 24 pairs is significant at the 0.01 level (Fisher and Yates 1948, Table VI). Thus the chances for the ramon-settlement correlation being the result of random chance are less than 1 out of 100.

Discussion:

This astonishingly high correlation between settlement and ramon trees is remarkably independent of elevation and slope and is a statistical fact that demands explanation.

Jones (1942:65) offers three main explanations for the association of divergent vegetation with archaeological sites:

1. "Enrichment of the soil by former occupation, resulting in more vigorous vegetation on the site."
2. "Physical and chemical alteration of the soil resulting in qualitative floral differences."
3. "A concentration of economic plants during occupation and a persistence of these to the present."

The facts that the ramon is cultivated by the Maya today for the leaf fodder, which is used to feed the mules, and also for its edible fruit, which is used as a maize substitute, suggest that the third explanation is the most likely. If the tree had little or no known economic value, as in many other site markers such as Betula and Carex in Greenland (Mathiassen 1934:39), prickly pear in the Southwest (Nelson 1914), or the grass that marked the Ptolemaic irrigation systems found in the

Fayum (Caton-Thompson 1934:140), Jones' third explanation could be fairly safely eliminated. As it cannot be eliminated, however, we must investigate the alternatives. Expanding somewhat on Jones' list to meet the special situation at Tikal, these alternatives include minimally the following:

1. The possibility that chemical changes in the soil, resulting from Maya occupation produced new conditions especially favorable for the ramon.
2. The possibility that physical disturbance of soils brought about by the Maya in settlement areas produced an unusual advantage for the tree.
3. The possibility that the tree moved rapidly or was brought into the area after Maya abandonment.
4. The possibility that natural conditions of soil, drainage, elevation, slope, and exposure, favored by the ramon tree were coincidentally also preferred by the Maya for the location of their settlements.

In regard to the first of these, it would seem that the addition of phosphorus to the soil is the most significant chemical change that might be brought about by Maya occupation. The possibility that any significant amounts of phosphorus would have remained long in soils after abandonment seems unlikely. The rapid cycling of rainforest soils and the leaching effect of heavy rainfall, suggest that any divergence in chemical content would soon be equalized or removed unless there was a constant

source

source of replacement. The impermanence of soil chemical changes of this nature is indicated even in areas where they would be very slow as a result of cold and low rainfall, such as Disko Bay, Greenland. Under arctic conditions there the enrichment of soils produced by human occupation seems to disappear within eight or nine hundred years (Mathiassen 1934:39). It should be noted, however, that in the Tikal area Cowgill (1963:23) has found a larger amount of available phosphorus in soils near former settlements on high ground in her study of the Santa Fe bajo. As only five samples were taken, and only one of these was from an area of settlement, the probability of this correlation, however, is quite low. It is quite possible that the difference is due, in fact, to local variation in soils or perhaps to the inherent differences in the soils of the logwood swamp and the forested uplands rather than any residual effect of former Maya occupation. The samples from Tikal, presently under study at Cornell, should shed new light on this problem.

In considering the second possibility, it is suggested that few physical changes wrought by the May in the area of settlements, such as those brought about by cultivation or compaction, could have survived the vigorous activity of burrowing animals including the *tusa* (a pocket gopher, *Heterogeomys hispidus*, LeConte var. *yucatanensis*

Nelson and Goldman) and tree roots. This is at least partially borne out by the resounding failure of magnetometer tests carried out in housemound areas of Tikal in 1961. The one major exception to this obliteration of physical changes, of course, is in the remains of the buildings and platforms themselves. The largest of these do seem to provide a microhabitat that is favored by the ramon as has been indicated. It seems quite probable that this factor accounts for the great density of the tree on the Central Acropolis of Tikal and the heavy concentrations of it on other large buildings between 0.0 km. to 1.0 km., a little further south. Once the elevation of the platforms goes below a meter or two, however, this effect seems to be eliminated. This lack of concentrations of the trees on building platforms can be seen on the strip from 1.0 km. to 12.0 km., with the striking exception of Navajuelal at 9.5 km. where really substantial volumes of collapsed fill occur once again. Thus, it appears that only really gross changes in the physical environment have any effect on the distribution of the tree.

In respect to the third possibility, the best means of rapid transport of the seeds of trees into ruin areas would be by birds and animals. The tree by itself does not appear to be equipped for rapid spread. The seeds are not wind borne and because of their weight, fall more or less directly to the ground. Wash from rain can only carry them downhill, which is of little help here since Tikal and most other Lowland Maya sites are situated on high points. The trees could, however, advance even uphill by dropping the fruits from their outstretched branches. It can probably be assumed that a tree can reach its maximum breadth by at least 20 years of age, and that with the assistance of wind and a few favorable bounces, a significant number of seeds might be dropped as far away as 10 meters.within that time. On this basis, 50 generations of the tree could carry the species only half a kilometer. Thus, it can probably be safely assumed that wherever it is found that ramons are important in secondary growth, the tree already occurs in the immediate area. Even with the assistance of dispersal by animals, more than a few fruits must be involved to make up for the high rate of loss through fruit eaten or damaged by these animals and insects once they have fallen to the forest floor. The abundance of fruit produced by a single tree is probably an important factor in the survival of the species.

The size of the seeds and their lack of any protective covering excludes the possibility that they can be carried in the gut of the animals that eat them, without being destroyed. Thus, propagation is limited to animals that regularly carry food in their paws or mouths. This includes parrots, possibly other birds, rodents, bats, and monkeys. Any distributive effect brought about by these animals would tend to be random, however, without any particular orientation to ruin areas. This is with the exception of the bats which occupy in large numbers the vaults and inner chambers of the larger palaces and temples. Individuals of a fruit-eating genus of Tikal (Artibeus), kept in captivity in 1967, were observed to pick up ramon fruits from a table-top and fly with them to a place they could hang from, where they ate the fleshy receptacle around the seed by rotating it in their forelimbs. When they had finished their meal, the seed was dropped. Though noisy flocks of unidentified frugivorous bats were seen feeding in a Tsol tree (Cupania prisca Standl.), the fruit is not always eaten on the spot and apparently can be carried some distance if the bats have young. The floor of the nest of the individuals mentioned above was found to be littered with whole ramon and zapote seeds.

Walker (1964:308) says of the bats of this genus:

> "The small fruits are carried to feeding sites during the night, but toward morning these bats carry their fruit to their regular roosts...Nuts, seeds, and fruit cores accumulate beneath roosting areas; Artibeus thus aids in the dissemination of seeds of tropical fruits."

The bats, which occupy the vaults and chambers of the ruins, though different from those already discussed, include other species. Tadarida laticaudata yucatanica, a free-tailed bat, collected from Temple I, is insectivorous according to Walker et al. (1964:387). But at least one species of another genus Carollia is one of the most common bats in the ruins and also a fruit-eater (Walker 1964:296). Walker's account of this genus makes no mention of fruit-carrying tendencies such as noted for the genus Artibeus. Interestingly enough, deposits of seeds and nuts have not been noticed in buildings occupied by this bat. Even if fruits were carried to the roost by this species, however, this would only occur in areas of the large ceremonial structures at the center of Tikal.

In view of the fact that bats are occasionally found occupying chultuns, the possibility that the ramon-settlement correlation was related to this factor was also considered. The possibility was rejected, however, for two reasons; 1) because of the relative scarcity of chultuns which have been observed to be so occupied, and 2) because they are so often sealed with a limestone lid or filled. The few notable chultun bat colonies at Tikal have moved in only after the chultuns were excavated.

Clearly, dispersal could be significant only in those areas where long-standing stone-vaulted buildings were numerous. Thus, it seems unlikely that the spread of the ramon after abandonment either by the tree itself or with the assistance of animals, can satisfactorily explain the overall correlation of the tree with settlement. These other possibilities were powerful arguments when heavy concentrations appeared to be limited to the main ruin areas. It is only with the data from a really large transect that the larger pattern has emerged.

The fourth possibility, that of coincidental association, is judged to be unlikely on the basis of the strength of the correlation and the irregular distribution of ramons in relation to terrain. The possibility that there is some great difference in the soils of the uplands between 7 and 10 kilometers, is presently being checked by the analysis of the soil samples taken at half kilometer intervals along the center of the survey strip in 1967. The general similarity of the vegetation on the uplands near Tikal with the uplands between 7 and 10 kilometers would seem to preclude major differences in the soils as a causal factor.

In summation, the possibility that the high correlation between housemound settlement and ramons is due to physical or chemical differences in soils in association with former occupation seems highly unlikely. It is further judged unlikely that this correlation was brought about by selective dispersion by animals or the trees themselves.

Returning to Jones' explanations, we are left with the possibility that the trees, through selective clearing or cultivation, were given an overwhelming advantage over other species during Maya occupation. Presumably, after abandonment, they were able to establish quickly dominance and hold these positions in spite of competition until the present day. Lundell (1937:10) says "... we may assume that the dominance is due to an initial advantage accruing to the species through its presence in large numbers when the places were abandoned."

We would like to explore now the historical and ethnographic evidence in support of the possibility that the Maya were actually cultivating these trees in the immediate vicinities of their homes in Pre-Columbian times.

MAYA ARBORICULTURE

In this section the sub-headings are arranged in ascending order of pertinence to the hypothesis that ramon trees were grown in Pre-Columbian kitchen gardens.

Evidence for Pre-Columbian Importance of Fruits:

Here we attempt to establish the importance of fruit in the Pre-Columbian diet irregardless of how it was cultivated.

Landa (Tozzer 1941:198-200), writing of Yucatan, reveals that the 16th century Maya, in spite of their well-developed agriculture, made good use of many fruits.

Calocarpum mammosum (L.), mamey colorado
"There is a very large tree which bears a large and somewhat long and thick fruit, the flesh of which is red and very good to eat,..."

Carica papaya L., papaya
"...another tree, wonderfully beautiful and fresh, and it bears a fruit like large eggs. The Indians pick it green and ripen it in ashes..."

Jacartia mexicana D. C.
"There is a tree, spongy and ugly although large, and bears a certain kind of fruit, large, full of yellow insides, very savory and with little seeds like hemp seeds but much larger, which are very healthy for urine. From this fruit they make a good preserve..."

Brosimum alicastrum Sw., ramon
"There is another very beautiful and fresh tree which never loses it leaves and bears small savory figs, which they call ox."

Other fruit trees specifically described in similar fashion include the chico zapote, Manilkara zapota (L.); the guaya, Talisia olivaeformis (H.B.K.); the avocado, Persea americana Mill.; Cereus undatus Haw; Parmentiera edulis D.C.; Bixa orellana L., and others. This interest in fruits is hardly confined to the Maya. The 16th Totonac Relacion de Paplanta reports native fruits "in quantity," suggesting their extensive use in the central Veracruz area (Kelly and Palerm 1952:141).

Evidence for Pre-Columbian Arboriculture:

The purpose here is to present evidence for the fact that Maya did and still do actively cultivate trees.

Landa, unfortunately, does not give us any definite evidence as to whether or not the just-cited fruits were cultivated. However, we can be fairly sure that the Maya were skilled arboriculturalists on the basis of other evidence. As Montejo's soldiers approached Sinsimato in northern Yucatan, they passed through two leagues of well-tended groves of incense trees, Protium copal (Schlecht and Cham) outside the town (Oviedo y Valdes 1853 III: 230).

Landa, in describing preconquest towns, suggestively informs us that "They kept the land well cleared and free from weeds, and planted very good trees" (Tozzer 1941:62). Landa does not say specifically that these were fruit trees, although they are described as such in the Tozzer translation of Herrera (Tozzer 1941:217). "They found them living together in pueblos in very civilized fashion, and they kept them clean, the weeds cleared away and fruit trees planted."

In the Relacion of Gaspar Antonio Chi, as translated by Roys (Tozzer 1941:230), we find mention of fruit trees in owned plantations.

> "The lands were in common and (so between the towns there were no boundaries or landmarks to divide them)

> except between one province (and another because of wars) and in the case of certain hollows and caves, (Plantations of fruit trees and) cacao trees..."

It is interesting to note here that though lands generally were held in common, fruit tree plantations as well as cacao trees were not. This would appear to emphasize their value and importance.

Chamberlain (1953:30) mentions that "Cacao from fine carefully cultivated groves" were a principle product of the Rio Ulua area in Honduras at the time of the Conquest.

Roys (1957:161) mentions a town in southeast Yucatan which contained 2000 houses. Around it were orchards of mamey (Calocarpum mammosum) and cacao trees and prosperous maize fields.

Evidence for an Arboricultural Technology:

The Maya cultivation of trees seems to involve a sophisticated technology which is probably traditional. To Hayes (1945:90), a horticulturist with considerable experience in fruit growing in India, the high degree of development found in the avocado, guava, papaya, and custard apple all "indicate a fairly high type of horticulture" of some antiquity.

Evidence of a sophisticated arboricultural technology is indicated in several modern ethnographic studies. Redfield (1934:47) reports the use of grafting at Chan Kom. Indians of Quintana Roo, though they do not practice grafting are familiar with the techniques of pruning and transplanting (Villa Rojas 1945:57). Grafting among the Totonac, in the ecologically similar central Veracruz area, is practiced by specialists (Kelly and Palerm 1952:141). The Chorti are sophisticated arboriculturists, practicing irrigation in their own orchards. Among them, transplanting apparently goes on all the time, men often returning from hunting and trading trips with interesting and useful plants which are replanted in the courtyard or garden. The average orchard contains at least a dozen varieties of fruit tree, the most important today being the banana and the plantain (Wisdom 1940:58).

The practically instantaneous acceptance and wild-fire spread of bananas and plantain upon their introduction by the Spaniards (Tozzer 1941:199) are suggestive of a similar interest in arboriculture of the Maya at the time of contact. The implication that such interests and attitudes existed in Classic times is of course risky, but it does provide us with a provocative alternative to explain the Tikal ramon data.

Finally, in consideration of the ramon, the facility with which it can be transplanted should be noted. Descourtilz (1821-33:10) reveals that the tree can be propagated by cuttings which is one of the most convenient means of propagation if not the easiest.

Evidence for the Importance of Pre-Columbian Arboriculture:

The fruit the Maya grew appears to have been more than a luxury. The importance of their orchards and groves to the subsistence is exemplified in Scholes and Roys' study of ancient documents relating to the Maya Chontal Indians where we learn that the Spanish were apparently able to increase greatly the effectiveness of forced population movements by cutting down the trees of village orchards.

> "There is also evidence that Pesquera had the cacao and copal trees cut down at Acalan-Itzankanac in order to compel the abandonment of the old capital and to discourage disertions from Tixchel." (Scholes and Roys 1948:171-172)

> "In accordance with Governor Fegueroa's instructions the fruit trees at Tzuctok and Ichbalche were cut down and the houses burned to discourage the Indians from returning to their old locations." (Scholes and Roys 1948:288)

The use of the same technique is described in the Relacion of Dzonot (Tozzer 1941:72).

> "And this Tomas Lopez was responsible for the moving and for the death of so great a number of people as have died, because the Indians say that since they ordered them to move by force and burned their houses and cut down their fruit trees which they owned..."

Turning now to the ramon, Thompson, working in British Honduras, has had numerous opportunities to observe the importance of this tree in subsistence and its significance as a semi-cultivated tree.

> "The bread-nut tree (Brosimum alicastrum) is not in the true sense a cultivated plant, as there is no difference between the cultivated trees and those growing wild in the forest. Nevertheless the plant is of such economic importance that it seems best to class it as one of the cultivated group...the modern Maya to a certain extent purposely plants bread-nut trees in and around his villages or at least abstains from cutting down those that are already growing." (Thompson 1930:185).

He further notes (ibid), "There is no information as to whether it was cultivated in Pre-Spanish times."

<u>Evidence for Pre-Columbian Kitchen Garden Arboriculture</u>:

In spite of these references which appear to demonstrate rather conclusively a tradition of fruit tree cultivation, which goes back to the time of the conquest, there are very few references which actually describe fruit trees being grown in kitchen gardens or in close association with residential areas. Since this is the pattern indicated by the Tikal data, it is important to explore this point. Archaeological evidence is scarce, though suggestive evidence is provided by the famous murals in the Temple of the Warriors and the Temple of the Tigers at Chichen Itza, where trees are shown in association with dwellings (Morris 1931).

Turning to historical evidence, Chamberlain (1953:66) published a letter from Montejo to the King of Spain in which it is stated that "...all the towns are (veritable) fruit gardens." Though these colonial panegyrics must be taken with a grain of salt, it would appear to imply the growing of fruit within the residential nucleus of the town.

Landa says, in describing the growing of Lonchocarpus longistylus Pitt., the roots of which were used to make the intoxicating drink balche: "...I will speak of wine a thing which the Indians esteemed highly and so almost all of them planted it in their yards or spaces around their houses." (Tozzer 1941:198). Here at last we have a specific reference to contact time arboriculture in kitchen gardens, though it is not a fruit tree. More conclusive is a quote from the "Relacion de los Pueblos de Chuaca y de Chechimula" (Colleccion de Documentos Ineditos 1900:69), sent to the King of Spain about 1577. "...likewise he ordered them to set fire to all the fruit trees which they had behind their houses in the said town." (trans. by Wauchope 1938:133). For the Peten we have at least one fairly certain reference to kitchen gardening in the 17th century. Father Avendaño (Means 1917:156) provides this important datum in the description of his departure from Yalain, a town apparently west of Lake Peten, "...an Indian...guided us to the other farms, half a league from there, which from the abundance of fruit, appeared an orchard." It is fairly clear from earlier material in the text that these "farms" are individually associated with houses.

Turning now to more recent ethnographic data, we find numerous references to kitchen garden arboriculture, though to be sure, these data are of diminishing reliability when it comes to drawing inferences for Classic times. As has already been mentioned, the Chorti are constantly transplanting useful and ornamental trees into kitchen gardens around their houses. Wauchope, in his book Modern Maya Houses (1938:129), includes a sketch plan of a typical Maya backyard in which the presence of fruit trees is indicated. He comments on the Yucatecan's love of their fruit trees and the fact that a wealthy Indian may have many trees on his property. "Guatemalan houses, especially in the Alta Vera Paz are sometimes almost hidden by surrounding (fruit) trees (including coffee) or cornstacks." (Wauchope 1938:199).

The Tajin Totonac, though they plant trees in both the milpa and in house clearings, prefer to plant them in the latter to better protect the fruits from birds and the ravages of the arriera ant (Kelly and Palerm 1952:141).

As an indication of the broad distribution of this practice, it may be added, that splendid kitchen orchards are maintained in Nicoya, Costa Rica (Wagner 1958). In reference to the ramon, Lundell (1938:41) notes that "In every village of the modern Maya in the Yucatan Peninsula it (the ramon) is one of the most conspicuous trees, being planted in dooryards, along fences, and in the streets."

In so far as references for the southern Maya Lowlands are concerned, Thompson (1930) does not specifically note the cultivation of the ramon in houseyards or kitchen gardens of southern British Honduras, but a photograph of ramon trees in a Peten kitchen garden, taken in 1967, is shown in fig. 9. The house is located in the relatively remote village of Dolores in the southeast Peten. Questioning revealed that the owner, a man of Maya descent, got the trees started with the intention of utilizing them for fodder and food. Whether they were transplanted or planted is not known. This information is supported by the fact that ramons do not appear to grow in the immediate vicinity of the village. It is perhaps for this very reason that the photographed trees stand alone in defiance of a local ordinance which required all larger trees in the village to be cut down some years ago. It is doubted that they will stand much longer.

USE OF THE RAMON AS A STAPLE

Historical Evidence:

Turning now to specific historical evidence for the use of the ramon in subsistence, we have already noted Landa's reference to the fruit as "savory figs" (Tozzer 1941:199), and Father Avendaño's wistful reference to the fruitless trees (it was early February) he encountered in his harrowing exodus from Tayasal (Means 1917:167).

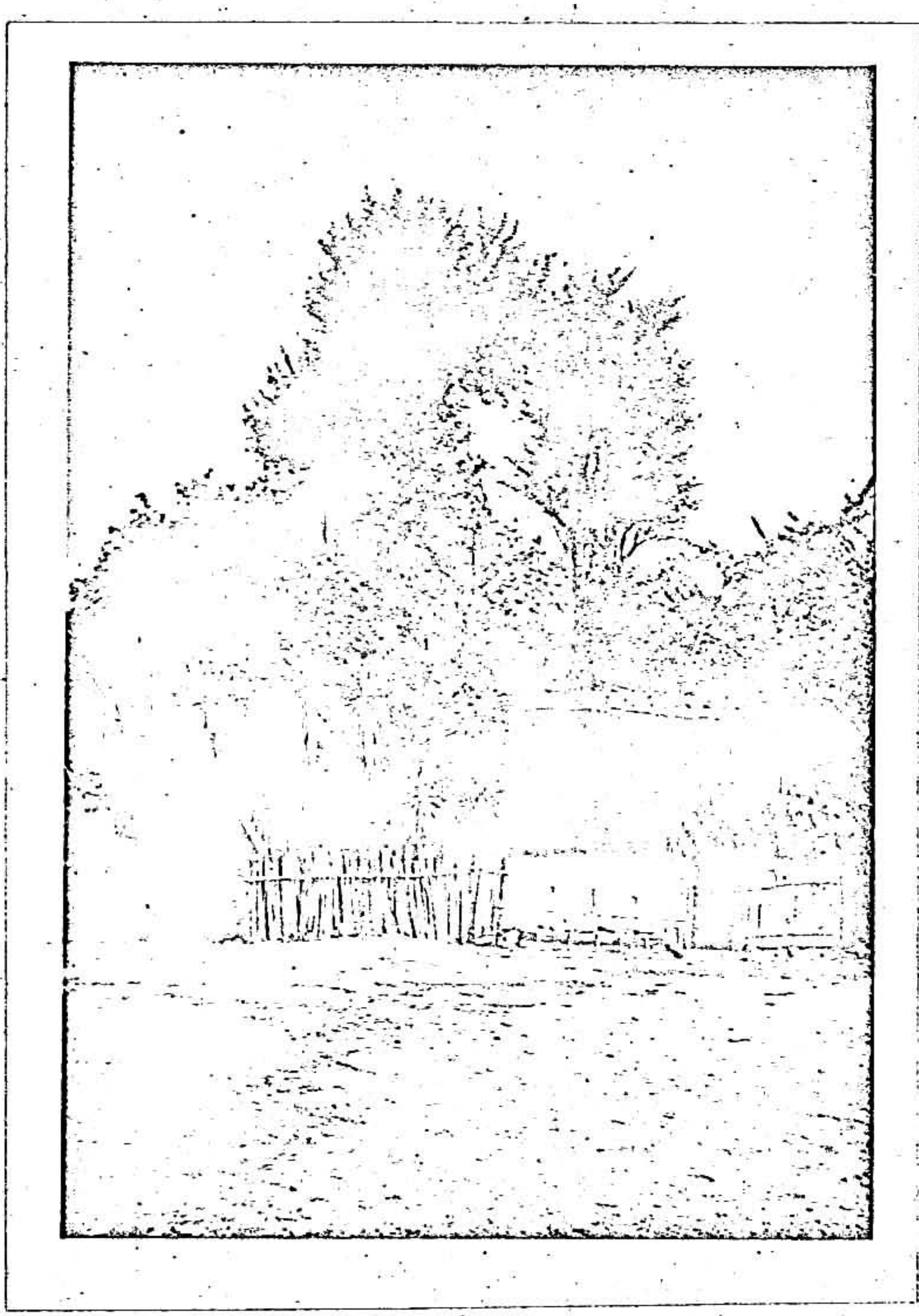


Figure 9: Ramon trees growing in a kitchen garden, Dolores, El Peten. (Photo by the author)

In the Books of Chilam Balam of Chumayel, the fruit of the ramon, along with two root crops, *cup* (*Calopogonium coeruleum* Benth.) and the *batun* (*Anthurium tetragonam* var. *yucatensis* Engl.) is significantly associated with famine. In one particularly dire prophecy where it is foretold that "vultures will enter the houses," it is recorded that "...the bread-nut (ramon) shall be their bread" (Roys 1933:122). Tozzer (1941:199), in footnote 1084, writes "With the *cup* two plants appear almost as a symbol of famine in the Prophecies." This is clearly in reference to use of the seed to make meal, wherein also lies the origin of the Creole name "breadnut" (Bartlett 1935:18).

These references clearly indicate the remarkable reliability of the ramon and certain root crops as food sources in northern Yucatan when all the regular crops failed. This is a most important point in spite of the famine association which might be taken to indicate that these foods were virtually inedible.

There is no evidence whatsoever to indicate that the ramon as a food is inedible or that it has any debilitating effect on those who eat it, in fact the evidence is quite to the contrary as shall be seen. Much as the upper classes of Guatemala and Mexico today would be forced to give up their bolillos (white wheat bread rolls) and eat tortillas in the event of a famine, the Yucatecan Maya may have been forced to eat the ramon.

Modern Evidence:

Reminiscent of the role of the ramon, in the Books of Chilam Balam, is the statement of a Tajin Totonac informant, that in former times of famine, the Totonac subsisted on the ojite (ramon) "collected, shelled, and boiled with salt; or they are stewed with brown or white sugar." (Kelly and Palerm 1952:163). Roys (1931:272) records that among the Yucatecan Maya, "the boiled fruit is eaten alone or with honey and cornmeal." Martinez (1959b) says that the fruit is prepared as a "conserva" (sweetmeat). Gann (1918:243) reports that "When dried they are ground into a meal, from which a kind of bread is made, and they are also boiled and made into sweetmeat." It appears possible in this case that the seeds are not cooked in the preparation of the meal.

In regard to the other species, Calderon (1941:87) says that the fruit of the Brosimum terrabanum is eaten after cooking, in Salvador. Allen (1956:142) further reports that the fruit of the Brosimum terrabanum is used in some parts of Nicaragua to make tortillas. In the area of Tula, Guatemala, the seeds of Brosimum terrabanum are boiled and eaten or made into a sort of tortilla (Standley 1946:16). A specimen of Brosimum costaricanum I have seen in the collections of the Philadelphia Academy of Natural Sciences has fruits virtually identical to those of Brosimum alicastrum (fig. 10). Use of the ramon

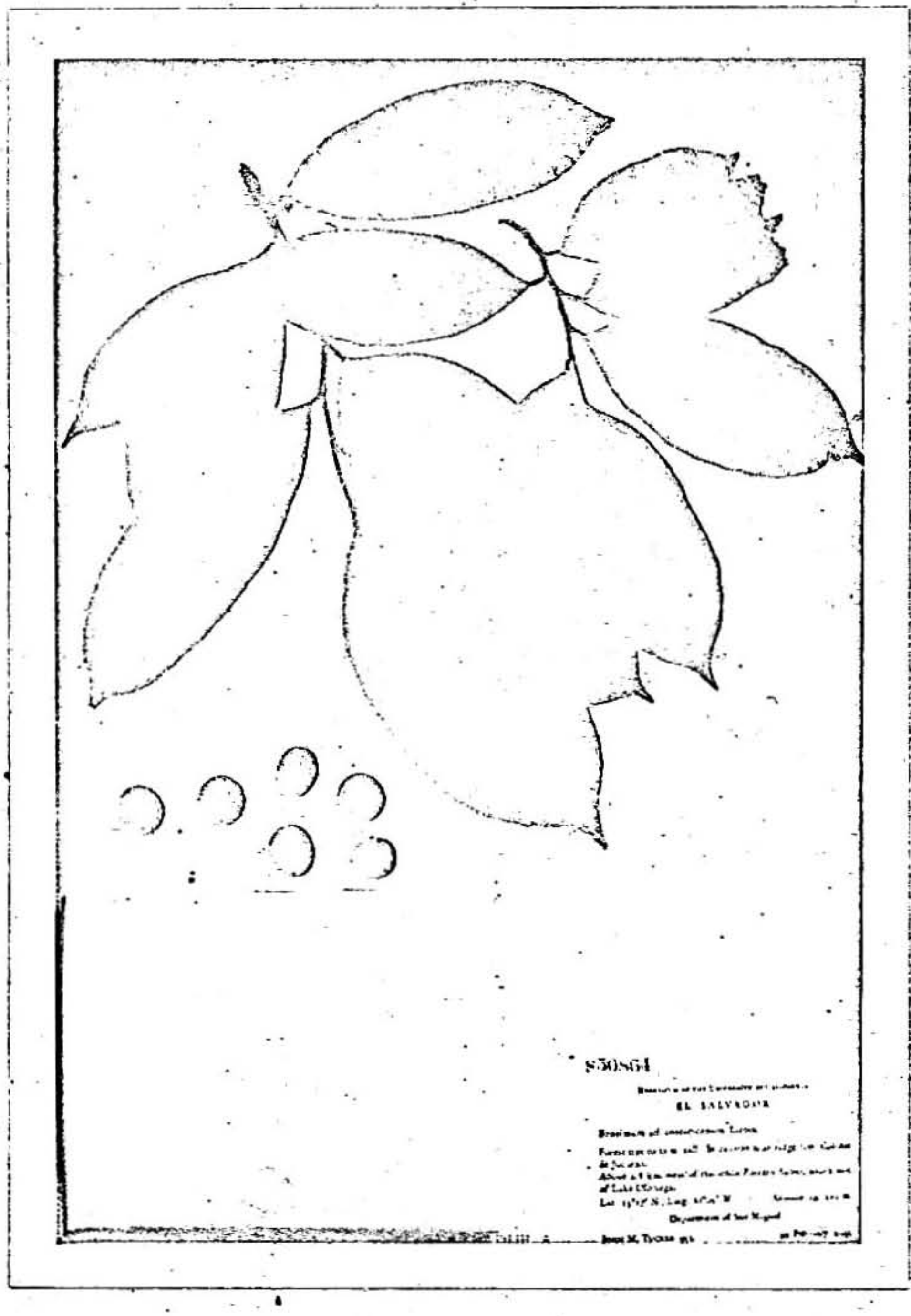


Figure 10: Specimen of Brosimum costaricanum from the collection of the Philadelphia Academy of Natural Sciences.

in these areas appears to be limited, perhaps because of the reliability of the milpa, or as among the Totonac, because of the reliability of the bananas and plantains. In this light, Thompson's report (1930:185) of the systematic collection of the fruit in large quantities by the Maya of southern and central British Honduras is particularly interesting: "...in the months of April and May,...it is gathered in large quantities. The outer covering is eaten raw. The kernels are either boiled or, after being steeped in water or lime, are ground and mixed with maize to make tortillas."

Today the ramon continues to be of importance to subsistence in various parts of the Peten in Guatemala. In 1967, when there was a shortage of corn early in the year, villagers of Dolores went several miles into the jungle to collect the fruit of this tree (personal information).

After the fall, when the fruit is still fresh on the ground, the rather tasty flesh may be peeled off the seed and eaten as mentioned by Thompson. Though this is not preserved today, it is not inconceivable that this portion of the fruit might have been preserved by the familiar processes of drying or smoking in former times. Note the reference to fruit preservation already quoted in Landa's description of _Jacartia mexicana_ D.C. (Tozzer 1941:200). The seeds which remain after the flesh is either removed, eaten off by insects, or dried up, can be collected in large quantities with relative ease.

The following recipe for ramon tortillas was collected in Tikal from Elias Contreras, a local workman from Dolores and of Maya descent, who was given 5 lbs. of the seed to prepare.

1. Place the fleshed seeds in a large cooking pot and cover them with water.

2. Add a handful of ashes from the fire, and boil for about half an hour. (This boiling and addition of ash is apparently to remove the slight bitterness of the seed which is probably attributable to a certain amount of tannin in the fruit.

3. After removal of the pot from the fire, the water is allowed to cool a bit, then it is poured off and the seeds are washed with clean water.

4. The seeds may now be eaten but generally they are ground into paste. This grinding is done today with little handmills though formerly the familiar <u>mano</u> and <u>metate</u> would have been used.

5. Elias added the apparently modern ingredients, manteca (hydrogenated cottonseed oil of Guatemalan manufacture), a ground-up stick of cinnamon, and sugar. In former times and probably occasionally today, honey would be substituted for sugar.

6. The paste is kneaded into tortillas which are cooked on banana leaves because of their fragility in comparison to cornmeal tortillas. In view of the supposedly late arrival of tortillas in the Maya area, it is interesting that Elias reported that the paste is sometimes kneaded into little loaves which are actually baked inside the typical table-hearth oven. (The tortillas were eaten and found to be tasty with a flavor rather like that of unleavened bran muffins.)

The seeds, simply boiled, taste like potatoes, according to Gann (1918:243). Standley (1920-26) says they taste like chestnuts. We, however, would compare them to something a little more tasteless; perhaps they are best described as a combination of something with the consistency of soggy chestnuts with a flavor of brazil nuts. The opinion of Descourtilz (1821-33:10) as a Frenchman may be of assistance here:

> "Ces fruits sont très-bons, soit grillés, soit bouillis; on ne peut mieux les comparer qu'aux chataignes (chestnuts) d'Europe; leur substence est farineuse et d'un goût, très-savoureux; elle n'a pas l'inconvénient de surcharger l'estomac et d'occasioner des flatuosités."

Lexical Evidence:

As an introduction to this section, the following list of names for Brosimum alicastrum is presented. This list is probably incomplete. References for each name and locality of occurence are given. Apparently non-native terms are asterisked.

Native Term	Location and Reference
aja	Chiapas (Martinez 1959a)
ajah	Chiapas (Martinez 1959b)
ajash	Chiapas (Souza-Novela 1950)
ajocosochitl	Oaxaca (Martinez 1959b)

Native Term	Location and Reference
ash	Chiapas (Martinez 1959a,b; Souza-Novela 1950; Record and Hess 1943)
ahx	Chiapas (Moran 1935:30)
*apomo	Sinaloa (Standley 1920-26; Record and Hess 1943)
*breadnut	British Honduras (Souza-Novela 1950; Record and Hess 1943) Jamaica (Record and Hess 1943)
*capomo	Tepic, Jalisco, Oaxaca, Veracruz (Standley 1920-26) Nayarit (Souza-Novela 1950) British Honduras (Record and Hess 1943) Sinaloa, Michoacan (Martinez 1959a,b)
choch	Yucatan, possibly Brosimum alicastrum, (Perez dictionary -Standley 1930:174)
guaimaro	Cuba (Record and Hess 1943) (Roig y Mesa 1953:438) (Leon and Alain 1951: II: 54)
guimaro comestible	Colombia (Record and Hess 1943)
gueimara	Cuba (Souza-Novela 1950)
iximche	The Cakchiquel area of the Guatemalan Highlands (Recinos and Goetz 1953:17; Stoll 1958:184; Guillemin 1967:25)
jocote de ujushte —	Jutiapa, Rio Paz - (personal data)
*Juandiego	Oaxaca, Reko (Standley 1920-26) Mexico (Record and Hess 1943)
jujushte	Salvador (Calderon 1941:87)
ju-sapu?	The Tajin Totonac area of Veracruz (Kelly and Palerm 1952:325)
ju·ksapu	The Tajin Totonac area of Veracruz (Kelly and Palerm 1952:325)
*maseco	Guatemala, Honduras (Standley 1920-26)
*masicaron	Guatemala, Honduras (Record and Hess 1943) British Honduras - B. terrabanum (Standley 1946)
*masico	British Honduras (Souza-Novela 1950) Guatemala (Standley 1946 Honduras (Record and Hess 1943)

Native Terms	Location and Reference
*masisco	British Honduras (Record and Hess 1943)
mesica ojoche	Nicaragua (Record and Hess 1943)
mo	Chiapas (Martinex 1959a & b)
moj	Colima (Martinez 1959a)
mojito	Colima (Martinez 1959a)
mojo	Chiapas (Souza-Novela 1950) Colima (Martinez 1959a & b)
mo'ju	Chiapas (Miranda 1952:69)
motzoque	Chiapas (Souza-Novela 1950)
muju	Chiapas (Souza-Novela 1950:Martinez 1959a)
*nazareno	Oaxaca (Souza-Novela 1950; Martintez 1959a&b) Mexico (Record and Hess 1943) Reko (Standley 1920-26)
ojite	Oaxaca, Tamaulipas, Veracruz (Standley 1920-26) (Possibly Quintana Roo Standley 1930:177)
ojoche	Nicaragua (Standley 1920-26)
ojoche blanco	Mexico (Record and Hess 1943)
ojochi	Coatzacoalcos Drainage (M.D. Coe pers. comm.)
ojochillo	Mexico (Record and Hess 1943)
ojotzin	Oaxaca (Martinez 1959b)
ojushte	Salvador (Record and Hess 1943)
oox	Veracruz (Souza-Novela 1950) Mexico (Record and Hess 1943)
osh	Yucatan, Tabasco (Martinez 1959a&b)
ox	Maya (Standley 1946) Mexico (Record and Hess 1943)
oxitl	Veracruz (Souza-Novela 1950), Mexico (Record and Hess 1943), from Nahuatl (Standley 1920-26)

Native Terms	Location and References
oxoctsin	Mexico (Huart 1902)
oxotzin	Veracruz (Standley 1920-26) Tamaulipas, Oaxaca (Martinez 1959a)
*ramon	Oaxaca, Yucatan, British Honduras (Souza-Novela 1950) Quintana Roo (Martinez 1959a) Jamaica (Long 1774)
*ramon blanco	Quintana Roo, probably <u>B. alicastrum</u> (Standley 1930:177)
*ramon de Mejico	Cuba (Record and Hess 1943)
*ramoon	British Honduras (Record and Hess 1943)
*samaritano	Oaxaca (Souza-Novela 1950: Martinez 1959a)
tsotash	Chiapas (Martinez 1959b)
tzotz	Chiapas (Martinez 1959a)
uji	Michoacan (Martinez 1959a)
ujo	Michoacan (Martinez 1959b)
ujushte	Salvador (Calderon 1941:87)
ujuste	Guatemala (Standley 1946) Salvador (Record and Hess 1943)
ujuste blanco	Guatemala (Standley 1946)
*wild cherry	British Honduras (Souza-Novela 1950)

With the exclusion of the obviously Spanish and English names asterisked above, the native names for ramon can be arranged into groups which appear to be cognates. The apparently Maya forms <u>ash</u>, <u>ahx</u>, <u>oox</u>, <u>osh</u>, and <u>ox</u>, where x=(š), all seem to be cognates. Another group, possibly derived from Nahuatl, includes oxitle, ojite, ojoche, ojochi, ujushte, and ujuste, is vaguely where x=(x) or (h). A third group centering on mojo, and a fourth which includes aja, ajah and ajash look like they are related to this "Nahuatl" group. The vague similarity of the second syllable in certain forms of the latter three groups to the Maya cognates suggests the possibility that we may be dealing with a loan word transformation or borrowing between two distinct linguistic groups, probably Uto-Aztecan and Maya. Since the tree occurs primarily in Lowland areas, it might be suggested that the Maya form is the original, but geographical origins of the various linguistic groups needs to be clarified before such speculation can have any basis.

Since it is the hypothesis of this paper that the ramon was of primary importance to ancient Maya subsistence in certain areas before it was replaced by maize, it seems worth considering the evidence that might be taken to suggest a linguistic connection between the Maya words for ramon (ox) and corn (ixim). Two routes for such a connection can be suggested. One of these is through earlier och-ich roots. The other is through a suffixed form. Before proceeding, let it be emphasized that, since the basic sound laws of the Maya languages have not yet been worked out, everything presented here is highly speculative.
In regard to the first of these possible routes, we are examining a possible derivation for the word for corn

(ixim), suggested by the definition of the Maya word "ich."

The Ticul Dictionary (Perez 1847:119) gives us, "fruta de cualquier arbol o mata: ich." Thus, ich can be defined as the fruit of any tree. The Motul Dictionary (Martinez 1929) elaborates on this with "ich: fruta o fruto, ...yich abal, buul, on, etc.; la fruta de ciruelo, de los frisoles, aguacates, etc." Assuming, without any real evidence, the possibility of (ch > x), maize can fit this formula as yich im. Im, however, is not a fruit tree but happens to be the word for breast, providing a construction which might be translated, "her fruit -- the breast." The evidence for an intrinsic relationship between the maize plant and a woman's breast has not been explored but the possibilities are fascinating if not demonstrable.

If the yich im derivation for ixim is accepted, for the sake of argument, a similar derivation for ox, also involving (ch>x), requires no new assumptions. The derivation is suggested by one of the Motul definitions for och, "sustento o comida, mantenimiento o provision de comida." If, indeed, the ramon was an important source of sustenance that was stored in ancient times, such a link between ox and och is not illogical. Possible evidence of such a connection is provided by O. F. Cook (1935:615) who traveled widely in the Maya area and writes: "the Maya name ox or osh is also applied to Xanthasoma (a root crop), and stocks of shelled maize kernels, although the general name for maize is ixim."

Unfortunately, a dictionary reference for stored food as ox where (x=sh or s) has not been found. Thus, with a faintly possible yich im derivation for maize and an equally faint possible och derivation for the ramon, a final link between is far more likely than either of the other two since it involves only a single vowel change between two words of similar meaning. Apart from the possibility that these, words are remnants of a link between the ramon and maize, their similarity alone suggests an association between tree fruits and subsistence or stored food.

The second route between maize and ramon is much simpler. We start with a root for ramon such as "ohx" and a Vm (Vowel m) suffix. Many modern Maya languages have such a suffix which derives substantives (Fought, personal communication). Assuming that this substantive was ohx-Vm, a change in the vowel of the root (o > i) would be plausible since the root in the two-syllable form would be lightly stressed compared to the monosyllabic root. If the vowel of the suffix were i or e at the earlier stage, the root vowel might well become shortened and assimilated to the suffix vowel by umlauting. In this scheme, the suffixed form would have had a "basic food source" meaning that shifted in application from ramons to maize. The possibility of a verbal root need not be rejected. From the Motul Dictionary (Martinez 1929:463) we learn that ich can function as a verb, with the definition "llevar fruta los arboles." This allows us to sidestep in one move the problem of the maize-breast association in the first route and the problem of a substantive derived from a substantive in the second route. Unfortunately we are again face-to-face with an undemonstrable (ch > x).

An unrelated fragment of evidence for a link between ox (ramon) and ixim (maize), which might be applicable to either route or their combination, is provided by examination of the forms of words for the cardinal number three in various Mexican and Guatemalan languages. These are presented in fig. 11. Here ox (three) seems to be generically related to ixim (three). In light of the second route proposed, it is interesting to see that forms such as oxim and oxib occur.

Quiche	Quiche de Ixtavaca	Cakchiquel and Zutuhil	Cakchiquel de Santa Maria
ox, oxib	ochip	oxi	ochi

Pokomchi	Tzendale	Chorti	Maya	Huastec
ichim	oxim	uxte	ox	ox

Figure 11: (From Charency 1882:3). The words for the cardinal number three in several languages of Mexico and Guatemala. Stoll (1958:90) gives the Pokomchi word for three as ixib and for Pokomam, ixiém.

The ch forms can probably be rejected as evidence for (ch > x) since ch probably = š as an artifact of Charency's French background. A generic relationship for ox and ixim, however, as forms for the cardinal number three, might be taken to be suggestive of a generic relationship between ox and ixim as forms for a basic food source. Cook's inclusion of *Xanthasoma*, in a generic relationship with the ramon and stored maize, would seem to support this impression of basicness. It is interesting in this regard that the Motul Dictionary (1864:246) gives us a broader definition of *ich* than that found in the Martinez edition (1929). In this manuscript, we find "fruta de arbol o tierra: ich." suggesting the inclusion of root crops and possibly maize.

Another problem which has bearing on the former role of ramon, is the derivation of the name of the former capital of the Cakchiquels, Iximche. Translated literally this has the meaning "maize tree." In publications of Guillemin (1967: 25), Stoll (1958:184), and Recinos and Goetz (1953:17), it is identified as the ramon. Unfortunately, we have been unable to find this identification in a dictionary. It appears first in an earlier edition of Stoll's work as a translator's note. This translator was Antonio Goubaud Carrera. His note follows (Stoll 1958:184, p. 146 in the 1938 edition).

> "Iximche no significa 'la cana del maiz,' como erroneamente se cree, sino que es el nombre de la planta que en castellano llaman 'Ramon' (*Brosimum Alicastrum*)."

Roys (1931) lists an *iximche* which he identifies with *Casearia nitida* (L.), *Andira inermis* H. B. K., and *Citharexylum schottii* Greenm. None of these produce a significant fruit and the latter two are shrubs or small trees. None of them have any maize-like quality mentioned in the literature with the possible exception of *Andira inermis* which is also called cornwood and has a bark with a nauseous odor which can be used as vermifuge, purgative, and narcotic

(Standley 1936:176). Steggerda (1941:106) indicated that <u>Casearia nitida</u> is a plant that grows in milpas with the local name of <u>ixim-che</u>. His only remark about it is, "No use. Possibly the I-xim-che of Roys. Birds eat the fruit." Unreliable as the opinion of Antonio Goubaud Carrera may be, this identity of the highland <u>iximche</u> with the ramon as a "maize-tree," seems worth looking into further.

In conclusion the, the available lexical "evidence" does not take us far. It does not conclusively show a relationship between <u>ixim</u> and <u>ox</u>. Nevertheless it does provide "suggestive leads" in several directions which deserve closer attention.

<u>Direct Archaeological Evidence:</u>

Direct archaeological evidence in support of the hypothetical importance of the ramon in Classic Maya subsistence is so meager it is hardly worth considering.

Longyear (1948:248), in excavations of what he refers to as a sub-pottery deposit at Copan, found: "Innumerable fragments of charcoal, most of them crushed beyond recognition of source. A few, however, could be identified as small sticks and nuts." These "nuts," though unidentified as yet, are about the right size for ramon seeds (Longyear, peronal communication).

At Tikal, ramon seeds have been identified from two possibly contemporary depostits. One of these was a burned layer in surface debris near the foot of the Temple I stairway (Lundell 1961:10). The other was in the fill of a Post-Classic burial intruded into the floor of the back room of Temple I. Both of these deposits were apparently Post-Classic and may actually be comparatively recent.

The deposit at the foot of the Temple I stairway may actually be a natural deposit of ramon "nuts" which fell from a tree growing on the side of the temple. Somebody's campfire, built over them some time later, may have burned them incidentally.

These are the only references to ramon or possible ramon fruits from archaeological contexts we have been able to find, though the search has hardly been comprehensive.

In view of the scarcity of corn-cobs and the other remains of vegetable matter in archaeological contexts in this area, this is really not too surprising, particularly when one considers that the ramon is almost pure carbohydrate. Even if the seeds were carbonized, their non-descript appearance after being broken-up might easily result in their ending up in bags for carbon 14 samples rather than as material to be identified.

THE RAMON AS A TREE OF MANY USES

The ramon tree has a multitude of uses beyond that of a carbohydrate staple.

Forage:

Today the tree is of real economic importance all through the areas in which it grows as a source of forage for cattle, horses, and mules. In the jungled heart of the Peten, the tree is essential for the maintainance of the mules used in the chiclé industry. Few trees in the world have leaves which are edible in this way, and its rapid recuperative powers make it doubly valuable. In Jamaica, fruit are used as stock feed (Fawcett 1901:42) for cattle, horses, and pigs.

In Pre-Columbian times, as today, the fruit was probably a major source of food for deer, the tepezcuinte (a very large relative of the agouti, Cuniculus paca L. var. virgata Bangs.) and wild pigs. As "bait" for these animals the trees may have been important for Maya hunting as the milpa is today (Reina 1967:16). Though domesticated animals other than the dog and possibly the turkey, are not usually associated with the Maya, Cortes' encounter with tame deer at the Majotecas is interesting (Means 1917:30). The fruit and leaves of the ramon could have been a food source provided for these animals by the Maya.

Landa mentions domesticated deer (p.127)

The Sap as a Beverage:

Gann reports (1918:243) that the milky latex which flows from the tree when a cut is made,"...resembles cream, and when diluted with water, is reputed to afford a satisfactory substitute for milk." Gaumer (1918:12) says that latex tastes like milk and that it is used as such, "...se emplea tambien como alimento, bien saludable y bastante nutritivo." In this respect the ramon is apparently similar to the cow tree of Venezuela (Brosimum utile), of which Allen (1956:144) reports: "The fresh milk has been tried in coffee and can scarcely be distinguished from good cream, while chilled it can be whipped and flavored with sugar and vanilla extract and served to unsuspecting humans. Dogs or cats, however, will not touch it."

Not so in my experience. Quite bitter tasting.

The species of the genus Brosimum as "cow trees" are not to be confused with those of the genus Couma, including Couma guatemalensis Stand. and various South American species of the family Apocynaceae. These have also been called "cow trees" because of their potable milk-like sap (Standley 1936).

Brewed Beverage:

The seeds are sometimes roasted and used as a substitute for coffee (Standley 1920-26). This coffee is said to have medicinal properties (Martinez 1959a).

Timber:

The whitish-yellow wood of the ramon, though more subject to decay than some other kinds of wood, is resilient, hard and strong. With a number of other species of Brosimum, its wood is virtually identical in basic properties to that of Brosimum columbianum Blake, which has a specific gravity when air dry of 0.87 and a weight of approximately 51 lbs. per cubic foot. The wood of this group has been compared favorably to hickory (Record and Hess 1943). In Jamaica, Brosimum alicastrum is considered an excellent timber and is apparently very good for boards because of the polish it takes and the ease with which it is worked. It is highly prized there for flooring and ornamental work of all kinds (Fawcett 1901:42). In the Maya area it is used locally for the curved parts of farm machinery (Gann 1918:243), boxes, furniture (Martinez 1959), tool handles, and pack saddles. It is exploited commercially to a small extent for veneer (Record and Hess 1943:380).

Fuel:

The wood provides a good source of fuel, in the form of wood and charcoal, (Allen 1956:142). It is much used in the making of Maya limekilns (Gonzalez 1939:240).

Shade:

Another important aspect of the tree is the dense shade it provides. In Jamaica it is often used as a shade tree in pastures (Fawcett 1896:26). On the streets of Merida (Fairchild 1945:199) today, as well as in practically every other Maya village on the Yucatan

Peninsula (Lundell 1938:41) it functions as a welcome source of sháde along streets and fences and in back-yards.

Cloth:

It is perhaps worth noting that the bark of the closely related Brosimum utile is apparently used to make cloth which can be used for clothing, blankets, and even sails. Standley (1937) in Costa Rica saw a piece of bark cloth being used as a curtain which had been made from a tree called mastate, a common name for Brosimum utile.

Medicinal Uses:

The Maya texts studied by Roys (1931:4) prescribe the sap as a remedy for asthma, coughs, and phthisis. Evidently, it is still used as a calmant for asthma and bronchitis (Herrera 1897:84, Martínez 1959a, Gann 1918:243). The seeds are also believed to stimulate lactation (Gaumer 1918:14, Gann 1918:243, Martínez and Campos 1924). It is further reported that an extract is useful for treating slow-healing cuts and ulcers (Gaumer 1918:14). Descourtilz (1821-33) ascribes medicinal uses to the flour but here the cures seem to be applications of 19th century European medical knowledge rather than anything Central American.

[illegible]:

Miscellaneous Uses:

Diviners' rattles or sonjas formerly were made by placing ramon seeds in a hollow calabash. This was called topoxte (Maler 1908:55).

Today the latex is sometimes used as an adulterant for chiclé (Record and Hess 1943:380).

The sap is also reported to yield a kind of rubber (Standley 1920-26).

In summary, as Gonzalez (1939:240) so correctly states, "Todo el ramon es utilizable."

CULTIVATION

Before serious consideration can be given to the possibility that the ramon was cultivated and utilized as a major food source by the Classic Maya, certain aspects of cultivation of the tree must be considered. These are best phrased as questions. How can the trees be propagated? Under what conditions do they grow? What sort of maintainance do the require? What spacing do the trees demand for maximum production?

mention name of experimental station in Campeche.

Fortunately the ramon has been of importance in recent times for its use as a source of forage and at least three published sources on its cultivation have appeared in the last 150 years; these are Descourtilz (1821-33), Herrera (1897), and Gonzalez (1939). Though these authors propose somewhat divergent methods of planting, they otherwise seem to be in general agreement about how the tree is to be cultivated. The latter two specifically attest to the surprising strength and ruggedness of the tree.

Planting:

After clearing the ground, Herrera advocates the planting of 5 or 6 seeds in holes spaced at distances of 5.02 meters (6 varas). Then after 4 or 5 years of growth, the branches of the young trees are pruned in February or March and 3-4 months later, they are transplanted to the intended plantation with a spacing of 6.69 meters (8 varas) to assure maximum productivity. If the trees are evenly-spaced by the hexagonal system, a density of about 104 trees/acre (257 trees/hectare) can thus be planted. It is interesting to note how close this optimal spacing is to spacing in naturally occuring groves of the tree. Wagner (1964:228) reports natural stands of the tree in the Peten, "With as many as 240 (ramon trees) per hectare." Edmund Johnson (1873:498), a former U. S. Consul at Tampico, found densities of 100 trees/acre in the area of Tuxpan, which is about halfway between Veracruz and Tampico.

Gonzalez (1939:22) evidently felt that this form of transplantation was detrimental to the tree and advocated the planting of individual seeds in bamboo-like tubes of jimba (Guadua?) which had been filled with earth. Germination is apparently more likely if the seeds are planted at a depth of about 4 cm. Under proper conditions of humidity and temperature, the seeds should germinate in 14 to 15 days. The seedlings are then allowed to grow in this tube until they produce 4 or 5 leaves. At this point the tube is split slightly with a machete and the whole apparatus is carefully planted in the desired location. Gonzalez advocates a wider spacing of trees, 100-125 trees/hectare, so that the same terrain may be used for the cultivation of other crops between the trees. A broader, denser crown resulting in a maximum production of leaves and fruit would thus be assured. Such spacing also gives greater access to soil, water, and nutrients which in turn generally stimulate production and reporduction in fruit trees (Yarnall 1964:95) The higher organic (Harraline 1954) carbon and phosphate (Johanessen 1958) content of soils under trees has been noted.

Descourtilz (1821-33:10) advocates propagation with cuttings, which must be started in the spring. He also mentions the use of marcottage, a horticultural practice which is also known as air layering.

Maintenance:

For the first few years of growth, Gonzalez and Herrera both suggest that the tree be given shade. A natural preference of the tree for shade is suggested by the fact that it grows best along fence rows in Jamaica (Long 1774:768) and shady canyons in Chiapas (Miranda 1952:69) and Central Mexico (Wagner 1964:252). To meet this need in the new plantation situation Herrera (1897:84) suggests that a stake of chaya, probably Cnidoscolus aconitifolius, be planted beside the young trees.

Maintainance of the trees, once they have been started, involves two or three weedings during the rainy season (Herrera 1897:84).

As for pruning, since it inhibits fruit formation by reducing carbohydrate production through photosynthesis in the leaves (Hayes 1945:48), it offers no real advantage to the Maya except perhaps in transplanting. The height of the trees probably would have made the practic difficult anyway.

It is worth noting that fruit production can be temporarily increased by girdling (Smith 1929:14). This technique, though I can find no record of it being practiced in the Maya area today, is very simple. It is performed by simply cutting away a half inch ring of bark around the tree, and thereby removing the phloem while leaving the deeper xylem intact. By thus interfering with the downward flow of sap in the phloem, carbohydrate is concentrated in the upper half of the tree, stimulating greater fruit production. Vegetative growth is meanwhile virtually stopped. While a greater crop is produced one year, this usually results in a significant drop below the normal crop, in the following year (Hayes 1945:55). Under certain conditions, however, such knowledge could be used to advantage by the Maya as, for instance, in a year when it was known ahead of time that supplies were going to be particularly low.

Manuring:

One of the stunning advantages of kitchen garden arboriculture and mixed farming is the high return of nutrients to the soil through defecation around the house, as practiced by the Maya today, and the disposal of what can be broadly termed, "kitchen sweepings." If, as seems to be indicated by the ramon survey data, the trees were planted around the houses, the fertilization of the kitchen gardens by the Maya was "not only probable, it was practically unavoidable," as pointed out by Hester (1954:96). This is, of course, one of the great weaknesses of milpa agriculture. Though large harvests of maize, beans, and other crops are removed from the plot, practically nothing is returned. The kitchen garden, on the other hand, is virtually a closed cycle. Everything that is removed is eventually returned.

Harvesting and Storage:

Harvesting consists of little more than picking up the fruit from the ground after they have fallen. It would be advantageous to rake away leaves and litter before the fall started to facilitate the work of gathering the harvest. As indicated on the nutrition charts, (Table II), the moisture content of the seeds, 6.5%, is extremely low. This probably represents an adaptation of the tree to the rainforest environment which would rot most other seeds, particularly if they were lying on the jungle floor. This adaptation of the tree would have been a great boon to the Maya who would certainly have been interested in storing the fruit for as long as possible if it was being used as a basic food source. Among the Indians of California, acorns were of greatest importance for exactly that reason. Of all the wild foods available, acorns were the most amenable to storage with only 9% water content (Baumhoff 1963:161). Unfortunately we have no ethnographic data on how ramons are stored today. It is suggested, however, that ramon harvests could have been stored in chultuns by the Ancient Maya. Experiments, carried out in Tikal, have revealed maize and beans tend to mildew in chultuns. Dried maize, possibly because it has a lower moisture content (Table II), did not seem to be as seriously affected. Experimental work with ramon fruits is to be carried out at the first opportunity.

Disease:

Ailments of the ramon seem to be very few and Gonzalez (1939:240) writes that virtually all the trees he has seen appeared to have been healthy. In some cases, however, a variety of termite can be found on the bark. A certain fungus also occasionally will grow all over a tree and attack particularly the younger leaves.

Summary:

In summary, then, no particular difficulty is involved in the planting of the ramon seeds. Little effort or technique is required for maintainance or exploitation of the tree. Fertilization of the soil in a kitchen garden situation would have been automatic. Clearly, techniques of transplanting, pruning, and grafting could have been, and most probably were, developed and employed, the way they are on other fruit trees in the Maya area today.

PRODUCTIVITY

The productivity of the tree is truly astonishing. In an attempt to estimate the quantity of this production, a ramon, relatively isolated from others, was singled out and the fruits that fell from it were systematically collected. Its position is S 353, W 15 on the survey strip. Unfortunately, the tree was rather old and evidently suffered from competition with other species, so we hardly feel that our results express the full potential of the species.

The fall of the fruit, which lasted for most of the month of April, was collected from the litter beneath the tree, about once a week. By the end of the fall, the tree had produced a total of 12,546 seeds weighing 32.6 kgm. (72 lbs.). Some of the seeds had been partially eaten by insects. This loss was calculated, however, by multiplying the average seed weight of 3 grams by the number of seeds for a total of 37.6 kgm. Presumably, if the seeds had been picked up more regularly, this could have been reduced. A large additional amount of food was available in the fleshy receptacle or rind. As the wet weight of the rind averaged 1.5 grams, which means that another 18.8 kgm (41.4 lbs.) of food was actually produced by the tree. Thus, though we only collected 37.6 kgm. of food, a potential of something on the order of 56.4 kgm (124.3 lbs.) may have been available. Much more of this could have been collected if we had saved the flesh and picked up fruits on a daily basis.

This figure is not out of line with other estimates. Gonzalez (1939) says that a large tree can produce up to 60 kgm. (132.3 lbs.) of seed. According to Martinez (1936:100), in humid areas where production is higher, a medium-sized tree can produce up to 75 kgm. (165.3 lbs.)

of seed annually. It seems likely that these weights do not include the rind, which tends to dry up or be eaten off within a very short time after the fruit falls.

As we have already seen, optimum spacing of trees with room for other crops allows at least 100-125 trees/hectare (40.5-51.0/acre), though as many as 240/hectare can be planted if a more solid grove is desired.

Using the lowest production figures available, those for the fruit actually picked up from beneath the tree at Tikal, 32.6 kgm (72 lbs.), a productivity of 3260-4075 kgm./hectare (2905-3635 lbs/acre) would appear to be possible. The comparatively high rainfall for the Tikal area would probably favor productivity, as Martinez indicates. The annual average for Tikal was 1402 mm (55.2 inches) for the period 1959-1963 (Smithe 1966:xviii). Thus with the possibility that groves could have been twice as dense (up to 104 trees/acre) and more than twice as productive (up to 165.3 lbs./tree) productivity probably could have been substantially greater under the apparently favorable conditions found at Tikal and other southern Lowland sites.

The full significance of the apparently minimal 3000 lbs./acre production potential is best realized when it is compared to the production potential for maize.

It should be noted at the outset that maize production/acre in the Peten is low for at least two reasons; (1) the impossibility of irrigation or chinampa cultivation. All the water that was collected in the reservoirs surely had to be saved for household use and the making of plaster; (2) the long fallows necessitated, apparently because of the inability of the unfertilized soils to meet continuously the high and selective demands of the annual crops.

Certainly one of the most optimistic estimates of the milpa production potential for the Peten is that of Cowgill (1962). She estimates that a stable slash-and-burn agriculture could be carried out with a four year fallow after a single crop (1962:279). Since a census of 40 farmers estimated an average production of 1,425 lbs. of maize/acre on first year plots, the yield of only one acre/year over a long period of time would be 285 lbs./acre. Two harvests from the same piece of land provide even less because of the necessity of extending the fallow. This figure is 270 lbs./acre according to Cowgill's data. A third harvest reduces productivity/acre drastically. In other areas, of course, production is often higher because fallows can be shortened or even eliminated as a result of location in areas of natural alluvial flooding or through the practice of irrigation. Such alternatives are not possible for most areas of the

Peten. The natural limitations of the soil and the non-availability of water simply will not permit it. In comparison to the ramon, yields are further reduced, when considered in terms of an overall average, by loss of crops due to locusts, drought, hurricanes, high winds, hail, and occasional devastation of fields by deer or other wild animals. These factors force the milpero to plan on producing much more than he expects his family to actually consume (Hester 1954:108).

The ramon, on the other hand, is hardly affected by these factors. Wind cannot so easily blow down and destroy the trees, the way it can maize. The trees are little affected by drought, which again can utterly destroy a maize crop. Locusts, the plague of grain crops all over the world, have no interest in ramon trees. The only serious pests would be parrots, which evidently relish the nuts (Calderon 1941:87). Termites and ants could have a debilitating affect as has been mentioned. Deer and rodents, of course, are unable to get at them until they fall, which is a great advantage. Once the fall begins, when they can get at the fruit, man would be devoting his energy to picking them up anyway. Bats would not be a serious threat since they do not eat the seed which simply falls down through the tree after they have eaten the flesh.

In summary, then even without consideration of these losses to which maize as an annual crop is so much more susceptible, the yield/acre of the ramon is possibly on the order of 10 times that of slash-and-burn cultivation of maize in the Peten.

LABOR

How the Classic Maya could have invested so much labor into slash-and-burn agriculture and still have had the time and energy for their voluminous architectural achievements is a question which has puzzled scholars for a long time. The dimensions of this discrepancy have recently been spelled out by Reina (1967) who reveals that the labor demands of milpa agriculture leave little time for other activities. In his own words, "...the milpero just manages to 'break even' all of his life by expending a maximum amount of physical energy and by planning carefully." (Reina 1967:15).

When it is considered that the Maya used stone tools, the amount of labor involved in slash-and-burn agriculture greatly increases. Experiments carried out by Hester (1952) indicated that clearing with stone tools took about twice as much time as clearing with the modern steel machete and ax.

Today a man spends about 6 months of the year in the milpa (Morley 1958:140) clearing, burning, seeding weeding, bending the stalks, harvesting, and finally transporting the harvest home. All this is to produce the 2400-3800 lbs. of maize necessary for the annual subsistence of his family. (Steggerda 1941:130; Hester 1954:106; Cowgill 1962:277; Reina 1967:106).

This is to be compared with the approximately 20 man-hours of leisurely ramon nut gathering it took us to produce 72 lbs. of food. This time could probably be more than halved if the litter were cleared away from beneath the tree before the fall began. This means that the same job could probably be done in less than 12 hours. Working an 8-hour day, a woman and, let us say, two children could gather a full 3000 lbs. in less than 20 days. Since the fall of the fruit lasts 4 or 5 weeks, ample time would be available to pick up the fruit as it fell. The labor involved in weeding or clearing beneath the trees during the rest of the year would probably be neglible; 1) because the area involved is so small and 2) because the dense tangle of weeds and brush so typical of secondary growth in the milpa, would not grow beneath the dense and shady foliage of the trees.

NUTRITION

In terms of nutrition, the ramon holds as many surprises as almost any other aspect of this amazing tree one might wish to consider. Several nutritional studies of the ramon have been carried out including those of Otera (1939), Souza-Novela (1950), Massieu, et.al. (1951), and INCAP-ICNND (1961). Those of Souza-Novela and INCAP-ICNND are summarized in Table II, and compared with nutritional data on maize, beans, squash, two root crops and another fruit, all of which were almost certainly cultivated by the Classic Maya. By comparing the figures, first on calories, it may be noted that nothing is quite as high as the ramon which has 363 calories/100 gram edible portion. In terms of moisture content, nothing is quite as dry as the ramon, which is of vital importance to the storability of the seed in this climate, particularly if it is to be underground. The protein content is significantly higher than that of corn, though corn still has more fat.

The high ratio of calcium to phosphorus in the ramon, chico zapote, and jicama, all of which grow wild in the Peten (Lundell 1938), is indicative of the adjustment of these crops to the limestone-derived soils of the Maya Lowlands. Maize, beans, and squash do not seem to be so much in harmony with the Lowland environment in this regard. Maize puts a notably high demand on phosphorus which Hester (1954:145) found is the one major element in "critically short supply" in the Yucatan soils he tested.

Ash gm	Ca mg	P mg	Fe mg	Carotene (Vit. A) mg	Thiamine (Vit.B) mg	Ribo-flavin ($Vit.B_2$) mg	Niacin (a B Vit.) mg	Ascorbic Acid (Vit.C) mg
4.4	211	142	4.57	0.17	0.03	0.14	2.11	91.00
4.4	211	142	4.6	0.065	0.03	0.14	2.1	-
0.9	45	36	0.8	0.064	0.05	1.52	0.78	28
0.4	86	10	1.0	0.010	0.01	0.01	0.2	15
3.6	24	247	7.6	0.005	0.54	0.19	2.1	-
1.3	9	290	2.5	0.070	0.43	0.10	1.9	tr.
0.6	19	22	0.5	0.095	0.04	0.04	0.5	15
0.9	31	37	1.0	1.815	0.11	0.04	0.08	31
0.3	18	16	0.8	tr.	0.03	0.03	0.3	21

- No data reported, or available data considered not reliable.+
() Denotes "imputed value."+

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Adelaide Sorts Nov 1977. Rows 4 Plague of Corn lime treatment of maize makes niacin available. Without lime pellagra & mental deficiency result

In terms of Vitamin A, riboflavin, niacin, and ascorbic acid, the ramon seems to compare fovorably with corn, beans, squash, and root crops. It is quite low in thiamine, however, but then it is almost twice as rich as corn in iron content.

The high content of ascorbic acid is of possible importance since the only other sources for large quantities of this vitamin are the chili pepper and the guava, with 45-106 mg (dried) and 218 mg. (fresh)/100 gram edible portion, respectively. The seasonal nature of the guava limits its usefulness for the year-round diet and though chili can be dried and stored, the small quantities eaten limit its usefulness (Cravioto 1945). Boiling of the nuts would of course destroy this vitamin but in this regard it is noteworthy that Gann's (1918:243) note on preparation of the seeds suggests that they are not boiled. "When dried they are ground into meal from which a kind of bread is made, and they are also boiled and made into a sweetmeat." Dahlgren and Standley (1944:58) tell the serviceman who has become separated from his unit that "The fruit is eaten raw, stone and all."

More specific microbiological studies of common Central American foods, reveal that the ramon, along with the chickpeas,and pumpkins is high in tryptophan, one of the indispensable amino acids (Massieu 1950). What further surprises lie hidden in this innocuous fruit remains to be seen.

One further point needs to be covered here. In informal discussions it has been suggested to me several times that the ramon contains some unknown but malevolent compound that causes to it to have an ultimately debilitating or poisonous affect on those who eat it and that it is for this reason the Maya dislike the fruit today. Modern Guatemalans, most commonly those who have come to know the security of steady income and marketed foods, have been known to refer to the fruits as "monkey food." Peten milperos, who are still occasionally forced to eat them when crops fail, are somewhat less disdainful, remarking perhaps that they do not like the taste of them. The fact that Elias' family ate several pounds of our experimental tortillas with relish before we were able to weigh the finished product belies the point.

Speculation on the possibility that the ramon harbors detrimental nutritional factors, thus seems idle in view of the evidence. Clearly the Maya eat large quantities of the fruit, even today. Gonzalez (1939:240) notes that people have lived for as long as 15 days on the fruit without ill effects. Experimentation has revealed that ramon forage increases milk production by 1.5-2.0 liters/day in cows that normally produce 8.0 liters/day on normal forage (Gonzalez 1939:222). Clearly then, the ramon does not harbor factors detrimental to cattle, or, for that matter, any of the many wild animals which eat the fruit in large quantities.

Attitudes of suspicion in regard to wild foods which are little eaten are apparently common and almost always abysmally ill-founded as a perusal of any of Euell Gibbon's interesting books, including _Stalking the Wild Asparagus_ (1962), will surely convince the interested reader.

As for a reason as to why the Maya do not enjoy the ramon today, one has only to note the declining favor of the maize-tortilla in upper class Mexican and Central American circles where it is being replaced by wheat-flour _bolillos_. The relatively new wheat-flour breads besides "tasting better" are more prestigeful. Perhaps the ramon once suffered the same fate that corn seems to be advancing toward even today.

In summary, then the ramon can probably be considered superior to maize in terms of nutritional values. It far outranks the rather watery root crops which also have a low protein-fat/carbohydrate ratio. It has several distinct advantages over the bean; 1) more calories, 2) less moisture, 3) much more vitamin A, and 4) much more ascorbic acid.

DISCUSSION

Flexibility of Subsistence Systems:

Perhaps the strongest argument against the hypothesis of primary position for the ramon in ancient Maya subsistence is the unimportance of this food source today and apparently at the time of the Conquest. But it is a long jump back into Classic Maya times and archaeological confirmation is important for even the most basic of our assumptions. As Meighan et al. (1952:132) points out, "Even in areas of known archaeological development such as Mesoamerica, the interpretation of the site as representing an agricultural economy is often a mere assumption, not an inference from anything in the archaeological picture." One might ask what validity there is in the popular assumption that Maya subsistence techniques have been static for more than 2000 years in spite of the great demographic changes including sweeping decreases in population density as well as changes in distribution. Boserup (1965:116) points out that economists "have assumed agricultural systems were the result of geography uneffected by changes in population size." Anthropological data do not seem to bear the economists out.

As Heider (1967:62) has recently indicated, it is important to base assumptions on more than a single ethnographic model. In consideration of the role of extensive agricultural systems, Mayanists have tended to base their assumptions on that single ethnographic model which is the modern Maya peasant. Recent studies in Africa, however, reveal the startling inter-relationship between population size and subsistence techniques, particularly in regard to extensive, as opposed to intensive, land-use systems. Udo (1965:158) shows how increasing population density in certain parts of Nigeria are related to a shift to "permanent cultivation in areas where the rotation of bush fallow has been the traditional method of farming." The reverse has been noted in various parts of West Africa and Southeast Asia where extensive slash-and-burn cultivation has replaced more intensive systems when large tracts of land became available as a result of pacification or migration (Gourou 1956:345).

In our own country, a shift to more intensive forms of agriculture such as truck farming is apparently related to population increase. In New York State, while the total number of farms decreased 33% in the 1949-1959 period, the number of farms producing over $10,000 worth of products/year increased by about 50% (Bratton 1962). Surveys (Nobe, Hardy, and Conklin 1961) reveal the increasingly high proportion of the actual area under more intensive forms of agriculture. This relationship between population growth and intensive and extensive agricultural techniques is championed by

Boserup (1965) in her exciting book, The Conditions of Agricultural Growth. Generalizing broadly from the data, slash-and-burn agriculture seems to be more typical of frontier situations such as exist in much of the Maya Lowlands today where the man-land ratio is low. The whole psychology of man's relationship with land is different under this system. In light of the many ways in which agriculture can be intensified, Cowgill's statement (1962:283) that "the present system of agriculture appears to be the most efficient possible for the present environment" hardly ~~seems to represent the final word.~~ does not take into account the many factors besides environment which can influence a subsistence system.

Settlement Patterns:

Sanders (1967:53) says, "The primary determinant of rural settlement patterns in a peasant society is the agricultural system practiced." He goes on to postulate, "that the agricultural system in such a society is primarily the product of interaction of technology and environment." We would feel inclined to amend this to include the role of population density, first, as a primary determinant of agricultural systems and, secondly, through the agricultural system, a determinant of settlement patterns. Surely then, with all the differences between kitchen-gardening subsistence and a slash-and-burn cultivation of maize subsistence, a certain amount of evidence one way or the other would survive in settlement patterns.

Traditionally, it has been assumed that the dispersed nature of settlement around the ancient Maya sites was a reflection of the demands of slash-and-burn agriculture. We doubt this very much. Inspection reveals that around the fairly evenly spaced housemound groups of Tikal, there tends to be little more than a hectare (2.47 acres; for conversions of measurements see Table III) of cultivatable land. For all the 173 house groups on the strip map from 0.5-6.5 km. there is a máximal 1.7 hectares assuming that hillslopes and swamps were all equally cultivatable. Even if it is assumed that only one family, (5.6 people) occupied each plaza-oriented group of "housemounds," one hectare, or even two hectares, is not nearly enough to provide the necessary food by slash-and-burn agriculture. Cowgill's data (1962:276-277) indicates that at least 5.4 hectares (13.5 acres) of good land are needed to provide the 1735 kgm (3816 lbs) of maize necessary to support a family of six persons. Clearly this is impossible with the spacing given. Only by assuming that at least 75% of the groups were abandoned all the time can it be made feasible, as Sanders (1962) himself was forced to conclude in order to rationalize the Barton Ramie and Dos Aguadas data.

If the same data are considered to be the result of some form of intensive kitchen gardening with ramons as the principle crop, the accommodation of the facts is much easier. The ramon, with a productive capacity of probably greater than 3000 lbs./acre, could easily provide the necessary bulk of food on the land given. As only a little more than half a hectare of ramon trees is needed to provide for the annual requirements of a family of 6 persons, ample rooms remains for the intensive cultivation of corn, beans, and many other annuals. With a spacing of 40.5-51.0 trees per acre, plentiful room is available for the cultivation of certain crops beneath the trees. This includes root crops such as the camote or sweet potatoe, Ipomoea batatas (L.), which is commonly planted in dooryards today (Lundell 1938:40); the jicama, Pachyrhizus erosus (L.); various Xanthosomes; and the yuca, Manihot esculenta Crantz.

The variety of plants which can be planted in a kitchen garden situation would probably allow for utilization of much more of the total 1.7 hectares available. Trees, for instance, can be planted on hillslopes without exposing them to erosion the way extensive cultivation would. Certain crops, including the ramon, would appear to be able to grow in swampy areas, excluding, of course, the logwood bajos. Cucurbita pepo L. and C. moschata Duch., the squashes; the tomato, Lycopersicum esculentum Mill.; the chaya, Jatropha aconitifolia Mill.; and various species of chili pepper, Capsicum, could all have been cultivated between the trees. Other tree crops, some of which, like the ramon, have been noted to be common in ruin areas, include the mamay, Calocarpum mammosum (L.); the avocado Persea americana Mill.; the zapote, Manilkara zapota (L.); the papaya, Carica papaya L.; at least six species of Annona including the custard apple and cherimoya; the guayo, Talisia olivaeformis (HBK); the manax, Pseudolmedia spuria (Sw.); the black zapote, Diospyros ebenaster Retz; and many more discussed by Lundell (1938).

The very fact that the ramon is so productive and can be planted on hillslopes and in swampy areas allows the room necessary for production of the many other species which would have provided important [illegible] supplements and variety to the diet. Mai[illegible], in this situation, would seem to have been a luxury item. Small plots could be cultivated in the kitchen gardens as they are in the highlands today (Wauchope 1938:199). Perhaps larger milpas under the control of land holders of higher social status were especially cultivated in areas beyond the 4-5 km. radius indicated for Tikal. It is doubted that such would have been the general practice, however, because of the labor involved and also because even with this practice it is doubted that there would be sufficient land available. Uaxactun and Jimbal lie not far to the north of Tikal and the land between is by no means vacant, as recently completed mapping has indicated.

In order to make shifting cultivation more feasible, Sanders (1962:99) assumes that ancient Maya "hamlets were very unstable communities and repeatedly abandoned and reoccupied." Clearly, if intensive agriculture were being practiced, such instability would not be necessary and here, too, we feel the evidence argues against such a possibility. One of the notable difference between ancient and modern Maya residences is the fact that ancient Maya houses were typically constructed on platforms, while such platforms are rare for modern Maya homes. This would seem to suggest a greater stability of residence for the ancient Maya.

This makes excellent sense in view of the investment one would have in an established grove of ramon trees to say nothing of many other long-lived kitchen garden trees and plants. Further evidence of the sedentary nature of Maya residence seems to lie in the great earthworks recently found at Tikal (Puleston and Callender 1967) which actually enclosed the indicated areas of greatest settlement density.

Chultuns:

One further subject remains to be touched upon and this is the function of the mysterious subterranean chultuns, so typical of Classic Maya sites in the central southern Lowlands. It has already been indicated (Puleston 1965), that the most logical explanation for these curious chambers relates to their use for some form of food storage. Recent tests, carried out in a chultun, have revealed that though they provide excellent protection for foods from rodents and most insects, corn and beans are subject to mildew, which is probably the reason that similar arrangements are not used for food storage today. It was also noted, however, that the drier these foods were when placed in the chultun, the longer they remained, and the better they were able to survive this menace. In view of the very low moisture content of the ramon seed, it is suggested that chultuns served for the storage of this food rather than for corn and beans or root crops which could have been left in the ground anyway.

O. F. Cook (1935) appears to have been the first and perhaps the only other person to suggest this connection between the function of chultuns as storage chambers and the fruit of the ramon. The distribution of chultuns would appear to support this hypothesis. For though they occur all over the southern Lowlands, they are notable absent from sites along rivers where annual deposits of alluvium might have made permanent cultivation of maize more feasible. Chultuns do not seem to occur at Seibal, Piedras Negras, Yaxchilan, or Palenque, where limestone occurs near to the surface, making construction of chultuns possible. At Seibal, it is perhaps significant that the dominant tree in the ruin areas is not the ramon but the corozo palm, further suggesting that the ramon may not have been of great importance there, at least in the final stages of occupation.

If it is to be assumed that the ramon was of primary importance in Classic Maya times, the fact that the fruit is so little eaten today suggests that abandonment of the Lowlands may be linked to a change in food habits. A change in food habits is also suggested by the fact that the chultuns of the southern Lowlands were not constructed in Postclassic times and are not constructed today. Possibly the invasions hypothesized by Willey and Sabloff (1967) can be related to a shift in diet and subsistence techniques.

CONCLUSIONS

In summary, then, the following points can be made in regard to the hypothesis of the importance of the ramon in ancient Maya subsistence.

1. The tree is found in dense groves on almost all ancient Maya sites in the southern Lowlands with the exception of at least Seibal, located on along the Pasion River. and possibly other sites

2. The Tikal Ramon Survey reveals that this association includes not only the ceremonial precincts of these sites, but also areas of "housemound" settlement.

3. Natural factors of distribution do not appear to be able to explain this highly significant correlation except in the central ruin areas.

4. In light of the above points, the distribution suggests the cultivation of the trees in residential areas around "housemounds."

5. A tradition of kitchen gardening appears to be of considerable antiquity among the Maya today.

6. The importance of kitchen garden abroriculture at the time of the conquest is suggested by the fact that fruit trees of unknown quantities were often destroyed to implement the forced migration of groups from one place to another.

7. The ramon is and was an important and reliable staple in times of famine for the Lowland Maya.

8. The seeds are boiled and eaten or ground with a mano and metate to produce a flour from which tortillas or bread can be made.

9. Several studies reveal that the ramon seed as a food is highly nutritious.

10. The trees produce up to, and probably more than, 3000 lbs. of edible seed/acre. Thus ramons are more than 10 times as productive as maize as it is cultivated today in roughly the same area. This production is with a spacing of only 40-50 trees/acre, leaving ample room for the cultivation of many other plants on the same 1-2 hectares (2.47-4.94 acres) around each housemound group.

11. Cultivation of the ramon and other crops in kitchen gardens would have assured an efficient cycling of nutrients if the sanitary habits of the Maya today are any indication of their habits in the past.

TABLE III: Conversions for commonly used weights and measures in consideration of data from the Maya area.

Linear Measure

1 foot	=	0.3048 meters
3.28 feet	=	1 meter
1(statute)mile	=	1,609.3 meters
0.621 mile	=	1 kilometer
1 linear cuerda	=	25 varas
1 vara	=	33 English inches (36 Spanish inches; Stadelman 19[illegible]:95)
33 English inches	=	83.6 cm. (Cowgi[illegible] 1961:15)

Square Measures

1 sq. foot	=	929 sq. centimeters		
1,549.9 sq. in. (1.196 sq. yards)	=	1 square meter	=	10.76 sq. feet
1 acre	=	4,047 square meters (0.4047 hectare)		
2.471 acres	=	1 hectare	=	10,000 sq. meters
0.386 sq. mi.	=	1 sq. kilometer	=	100 hectares
1 sq. mi. (640 acres	=	2.59 sq. km.	=	259 hectares
1 mecate	=	625 sq. varas	=	0.108 acres (wrong? = 625 sq yards (Land Use B.H. p.184))
0.108 acres	=	0.044 hectares		
1 cuerda*	=	625 sq. varas	=	0.108 acres (Stadelman 1940:95)
9.22 cuerdas	=	1 acre		
1 manzana	=	(4 linear cuerdas sq)	=	1.73 acres
64 manzanas	=	1 caballeria	=	11.6 acres

* a special cuerda used in Decrees [illegible] 40 varas square = 0.28 acres (Stadelman 1940:94)

8 mecates = 1 acre (San Antonio people. – Olgin's notes)
7.75 mecates = 1 acre (Land Registry Office, Belize City – Olgin's notes)
1 mecate = 625 sq yards.

Weights

0.03527 ounce	=	1 gram
1 ounce	=	28.3495 grams
1 pound	=	0.4536 kilograms
2.2046 pounds	=	1 kilogram
1 carga	=	100 pounds (Cowgill 1961:15)
1 carga of corn on the cob/mecate	=	17 bushels/acre (Cowgill?)
1 quintale	=	110 lbs. (Land Use Survey of B.H. p.184)

1 carga of corn on cob = amount that yields 1 quintale (110lbs) of shelled maize. (Land Use p.46)

12. The ramon tree appears to have many uses beyond those of food production.

13. The labor involved in the cultivation of the tree is negligible, amounting to little more than the harvesting of the "nuts" as they fall.

14. The Tikal settlement pattern, far from suggesting slash-and-burn agriculture, seems much more likely to be the result of permanent intensive kitchen or dooryard cultivation. Slash-and-burn is clearly impossible with the spacing that exists between housemound groups.

15. The permanency of Classic Maya settlement is suggested by the use of platforms and paved plazas in association with houses. A relatively permanent nucleus of population around Tikal is also suggested by the recently discovered earthworks which enclose this area.

16. Assuming that chultuns were used for food storage the fact that they are not used today suggests a change in food habits since Classic times.

17. Chultuns may have been used for the storage of ramon stocks. This possibility is suggested by the extremely low moisture content of the seeds

18. Chultuns have not been found at several riverside sites, a fact that suggests that at these sites subsistence may have been on a different basis from that of sites in the central areas. The present-day cultivation of maize on alluvial soils along the Pasion suggests that permanent cultivation of annuals may have been possible in these areas in Classic times.

On the basis of these points and the evidence presented in the text, it is suggested that the Classic Maya practiced intensive cultivation in association with residential areas. Ecological data as well as information on productivity, nutrition, and cultivation suggests that the ramon was of primary importance. Archaeological evidence in support of this hypothesis may lie in the function and distribution of ancient Maya chultuns, which seem to have been used for food storage but do not appear to be favorable for corn and beans. In view of present food habits of the Maya and the predominance of extensive agricultural systems, it is proposed that drastic changes in subsistence may have taken place at the termination of the Classic period (ca. 900 A. D.). As a final point, support for the hypothesis from the standpoint of ecological considerations comes from a perceptive and almost prophetic statement made by Sanders in his Cultural Ecology of the Maya Lowlands (1962:88).

> "Looking at tropical agriculture as a whole and the problems involved, it would seem that orchard crops involving trees or tree-like 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 conclusion, then, the image of the ancient Maya farmer, struggling ultimately unsuccessfully with the hostile jungle environment, becomes about as real as the supposed hostility of the arctic. Irving (1960), in a classic study of adaptation has shown that the unfavorability of the arctic is actually only as great as the limitations of an organism's adaptations to that environment. It is this variable of adaptability which makes Meggers' (1954) ideas on environmental determinism so difficult to apply cross-culturally.

The new image of the ancient Maya suggested here reveals an industrious and creative people, well-adapted to life in the rain forest, through skillful and efficient use of natural resources they found around them. The dynamism and spirit we can see today in the monumental achievements of their religion, arts, and sciences are surely reflections of the harmony of the relationship they were able to establish with their environment.

These conclusions lead us to suggest that the abandonment of the southern Maya Lowlands and the initiation of the Postclassic period may have entailed much greater changes than has been imagined. It was the end of a way of life that may have involved profound changes in subsistence as well as the more commonly recognized changes in ceramics and ceremonialism.

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32

SERIES 100 PROGRAM SHEET   TITLE: NO.   Page   of

Step No.	Code	Key	Step No.	Code	Key	Step No.	Code	Key

23

24

100,818 − (1985 − 621)/23

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√[(396,301 − 3,940,225/23)(44,405 − 385,641/23)]

16,767

171,314

√[( )(44,405 − 544,644/24)]

51.96

100,758

(~~3,768,910~~)(368,874)

137,621

(~~3,768,910~~)(521,950)

PROGRAMMING CODES
SERIES 100

NUMERIC KEYS	
CODE	KEY
00 00	0
00 01	1
00 02	2
00 03	3
00 04	4
00 05	5
00 06	6
00 07	7
00 08	8
00 09	9
00 10	DECIMAL POINT
00 12	CHANGE SIGN
00 15	CLEAR DISPLAY

ALGEBRAIC KEYS	
CODE	KEY
07 15	PRINT
08 00	STOP
08 08	$\|X\|$
08 09	INT X
08 10	$Log_e X$
08 11	e^x
08 12	X^2
08 13	$\sqrt{x}$
08 14	π
08 15	1/X

FUNCTION KEYS HIGH ORDER	
CODE	KEY OR SWITCH
01 XX	TOTAL
02 XX	ADD
03 XX	SUBTRACT
04 XX	MULTIPLY
05 XX	DIVIDE
06 XX	STORE
07 XX	RECALL
11 XX	F(x)

SPECIAL FUNCTIONS	
CODE	OPERATION
15 15	RUB OUT
11 14	RESTART IF POSITIVE

REGISTER KEYS LOW ORDER	
CODE	KEY
XX 00	0
XX 01	1
XX 02	2
XX 03	3
XX 04	4
XX 05	5
XX 06	6
XX 07	7
XX 08	8
XX 09	9
XX 10	10
XX 11	11
XX 12	RIGHT REGISTER
XX 13	LEFT REGISTER

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