OLD BOTTLE, NEW WINE: THE FUNCTION OF CHULTUNS IN THE MAYA LOWLANDS

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Prior research on the function of shoe-shaped chultuns found in the southern Yucatan peninsula has focused on their use for household level storage of dry foodstuffs. We found that inter- and intra-site distribution patterns of chultuns do not support the household storage hypothesis. At Tikal only 20–25% of the households had chultuns, and most of these households had two or more chultuns. We believe the distributional data suggest that chultuns were associated with a cottage-level industry in the context of a vending economy. Because the internal environment of chultuns appears favorable for conducting fermentations, we propose that they were used as places to process, and for limited periods to store, fermented foods such as alcoholic beverages and pickled fruits. The greatest demand for chultun products was apparently centered around large urban sites in northeastern Peten and northern Belize where frequent civic/religious festivals encouraged a small to moderate market potential.

An intriguing problem for Maya archaeologists for over 100 years has been the function of chultuns, or holes cut into bedrock near habitation sites in the Maya tropical lowlands. In general, most archaeologists think that chultuns served either as water cisterns or for the dry storage of agricultural crops (Puleston 1971). The term *chultun* is thought by Puleston to be derived from the Maya word *chul,* meaning either "wet" or "becoming wet" or possibly *tsul,* meaning "to clean-out or excavate" and the word *tun,* meaning "rock" or "stone," thus chultun meaning "wet rock" or "rock that becomes wet," but perhaps more loosely "rock place that becomes wet." The term *chultun* in modern Yucatecan Maya is used to refer to a hole in the ground that is wet or contains water.

It has long been known that the large (ca. 6 m deep), plaster-lined and bottle-shaped chultuns found in northern Yucatan, and occasionally further south such as at Uaxactun (Smith 1950:17), were in fact water cisterns. However, still in dispute is the function of smaller (ca. 2 m deep) unlined, shoe-shaped chultuns, which often have lateral chambers (Puleston 1971:Figure 1b, reproduced here as Figure 1). This type of chultun is found predominately in the southern and eastern Yucatan peninsula (Figure 2) and is primarily, though not exclusively, associated with residential structures that date to the late Preclassic and Classic Maya periods (ca. 300 B.C. to A.D. 900). Shoe-shaped chultuns, with typical lateral chambers, generally have small orifices (ca. .5 m diameter), which are dug into slightly elevated bedrock, with some even having low stone walls built around the opening. The intent here appears to be to keep water out of the chamber. In fact, tightly fitting lids of cut limestone are often found near the chultun orifice, or even in place; it may be that where they are not found, the lids were broken into unrecognizable fragments or possibly the lids were made from wood or other material that has long since disintegrated.

The shoe-shaped chultun itself consists of an antechamber directly below the orifice, and one or more lateral chambers that have a low sill dividing the antechamber. Also, in some lateral chambers niches were dug into the walls that are large enough to accommodate moderate to large ceramic vessels. Haviland (personal communication 1984) notes that the sill may be intended to keep water out of the inner chamber. The sill is invariably positioned lateral to the drip line where seepage around the cover drips into the antechamber. Water that accumulates on the floor of the antechamber

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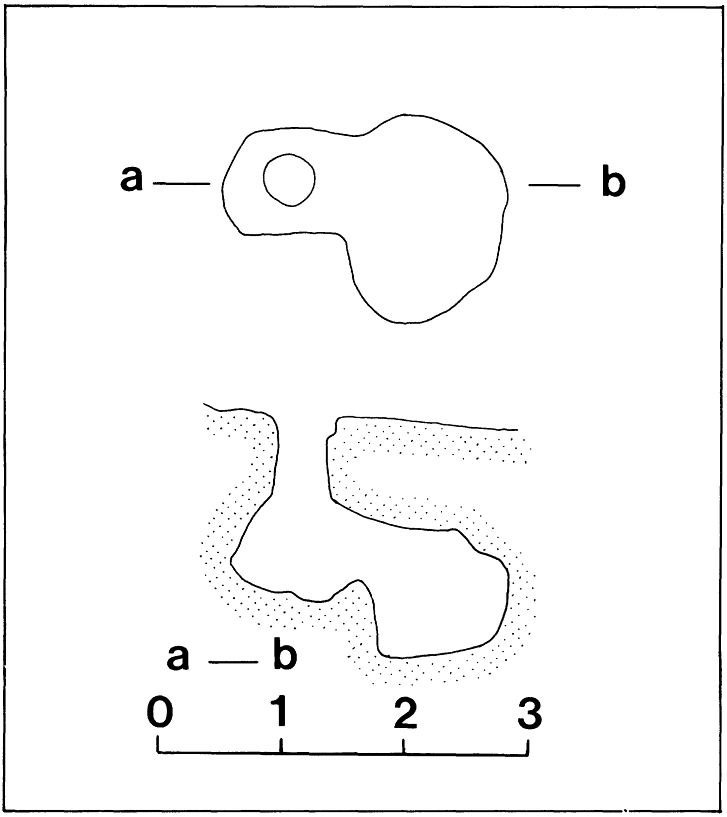

Figure 1. A typical shoe-shaped chultun (after Puleston [1971:Figure 1b]).

eventually percolates into the bedrock. Little capital and labor is represented in chultun construction. Puleston (1971:328) reports digging a chultun and fashioning a lid in a little over 30 hours using only chert tools of the kind used by the ancient Maya. Finally, the internal environment of the shoe-shaped chultun is constantly humid, hot, and stuffy. Puleston (1971) reports humidity levels of 100%, with temperatures of 75–80°F inside a chultun at Tikal.

THE STAPLE CROP STORAGE HYPOTHESIS

Puleston (1971) reviewed the earlier alternative hypotheses of the function of chultuns. Besides being considered as cisterns, chultuns have been hypothesized to be refuse pits, latrines, drainage holes for runoff, mines for marl, sweat baths, ceremonial chambers, places to weave fine fabrics (cf. Smith and Cameron 1977:110), storage rooms for tools, household items, or crops. Though doubts persisted, a consensus of sorts was probably achieved by 1913 (Tozzer 1913:191), if not by 1883 (Maudslay 1889–1902:195), that the shoe-shaped variety of chultun was used to store crops. And, by 1918 (Gann 1918:85) the distinction had clearly been made between the cistern type of chultun and the shoe-shaped chultun, and the differential distribution of each type had been discussed. Empirical verification of this hypothesis has been frustrated, however, by the fact that the analysis of artifacts contained within the soil matrix of chultuns has not shown a noteworthy association with storage activities, a difficult activity to demonstrate in any case, particularly in climates where foodstuffs rarely survive the ravages of time. On the other hand, the absence of a clear pattern of non-perishable tool or ritual assemblages probably was taken as tacit support for the crop-storage hypothesis. Equally important, though rarely emphasized, is the fact that most materials contained

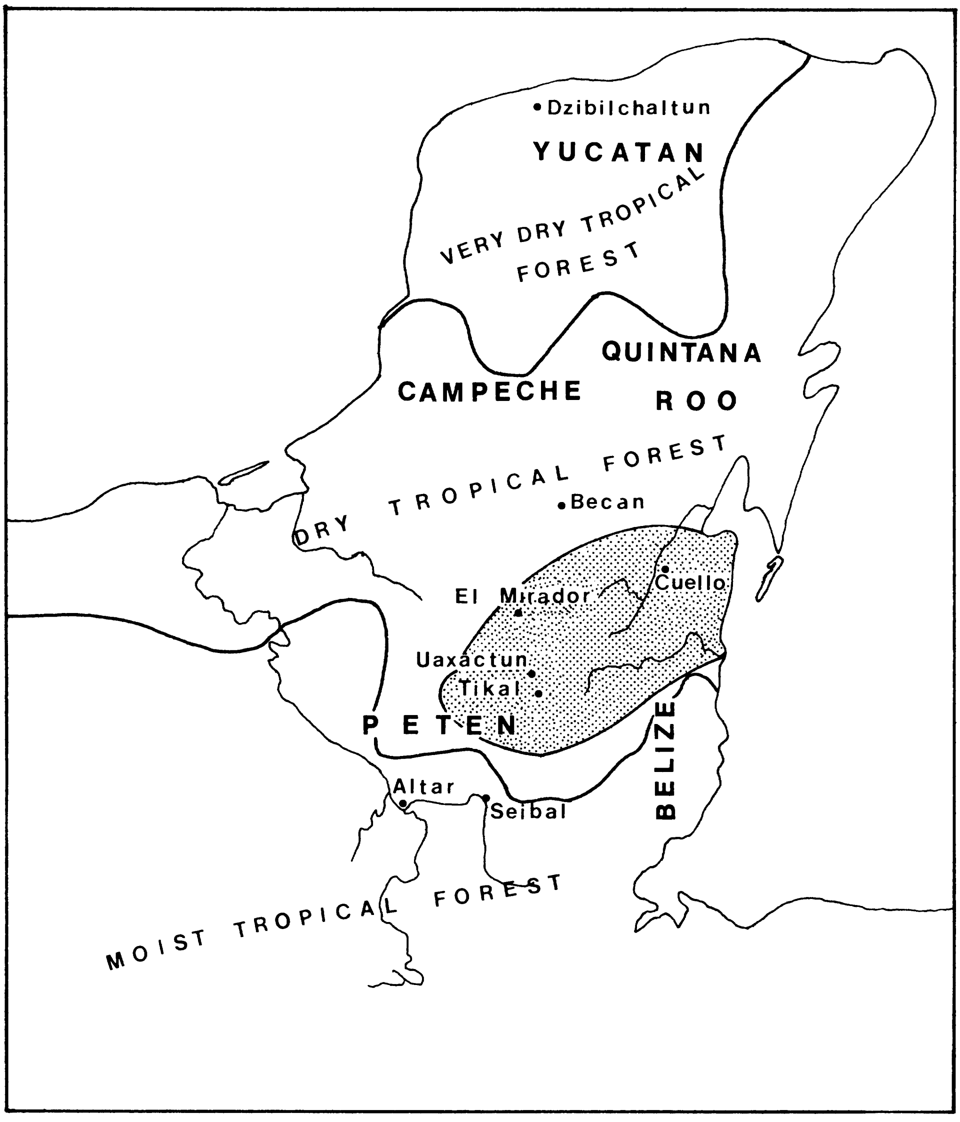

Figure 2. Map of the Maya lowlands and locations of sites mentioned in the text. Shading indicates the area believed to have the greatest concentrations of shoe-shaped chultuns.

in chultuns are secondary deposits; that is, materials that were deposited after the chultuns had ceased to serve their primary purpose. Some chultuns in fact were deliberately filled with trash and sometimes even covered over by house or plaza floors (Smith 1950:48–49). Minimally, this suggests chultuns had a limited lifespan and could fall into disuse long before the house mounds with which they were associated. We find this observation somewhat at odds with the staple crop-storage hypothesis in that preservation of food crops at a site is expected to be conservative, universal, and largely unvarying in both time and space.

Only a handful of instances have been reported where primary deposits were recovered that date to the period of primary usage of the chultun and these were all reported at Tikal by Puleston (1971: 327). Chultun 3F-6 had five large, wide-mouthed "storage" vessels that were apparently left in situ and intact on the floor, and two or three other chultuns had fragments of similar vessels in them.

Such a sample of primary deposits is too small to enable reliable conclusions, but is nonetheless the only positive evidence reflecting primary usage reported so far. We are virtually compelled to use these data at face value. Minimally, it is reasonable to suggest that wide-mouth ceramic jars had something to do with chultun function, and that direct evidence should probably be sought inside intact, in situ vessels rather than in the secondary soil matrix within the chultuns. For example, Miksicek et al. (1981) report finding a variety of plant remains present within a chultun at Cuello, Belize, recovered by flotation: although 83% of their samples contained maize cob fragments, more than has been found in such a context before, these remains are not necessarily connected with the actual (primary) use of the chultun.

Because of the lack of good primary depositions in chultuns, modes of inquiry into chultun function shifted to experimentation and argumentation from the few ethnohistoric references of chultun use. Based on three years of experiments, Puleston (1971) suggested that the shoe-shaped chultun was used to store nuts of the ramon tree (*Brosimum alicastrum*), a crop presumably grown in the dooryard gardens that he believed primarily supported large populations such as at Tikal. He showed that ramon nuts, with a moisture content of 6.5%, could be preserved up to 13 months, while a variety of maize with a moisture content of 10–15% lasted only 11 weeks. Puleston also found that root-crops storage in chultuns was only marginally beneficial. Because of their high moisture content, they are best kept growing in fields and gardens until needed. Reina and Hill (1980) dispute Puleston's conclusions by pointing out that long-term storage is not needed for ramon nuts because the tree bears fruit twice a year. Instead, Reina and Hill cite a *Relacion* written by Viana et al. in the sixteenth century in Alta Verapaz, Guatemala, that suggests that smoked maize was stored in holes in the ground. Smoking was thought to allow storage of maize for more than a year, while unsmoked maize lasted only four months. Reina and Hill also cite Bishop Landa's sixteenth-century comments noting maize and other seed crops being stored underground in northern Yucatan, but apparently without special preparation. Reina and Hill conclude that Landa simply failed to observe or neglected to mention that the maize and other seeds were first cured by smoking. However, the drier climate of northern Yucatan (ca. 450 to 1,000 mm annual precipitation and low relative humidity) may have made underground storage of unsmoked maize feasible. But it should be noted that shoe-shaped chultuns are not common in Yucatan, nor have they been reported from Alta Verapaz.

Recent research on chultuns is reported by Miksicek et al. (1981). They report on experiments done in a chultun at Cuello, Belize, where they found only unsmoked, shelled maize kernels and three types of unprocessed roots were still usable for food or planting after 16 weeks of storage. Though the results are short term, both Puleston's ramon-nut hypothesis and Reina and Hill's smoked-maize hypothesis are disputed. Without making unequivocal statements, Miksicek et al. give the clear impression that chultuns were suitable for storage of a variety of foodstuffs, particularly unprocessed roots and unshelled maize.

REGIONAL DISTRIBUTION OF CHULTUNS

Puleston (1971) argued that the distribution of shoe-shaped chultuns roughly corresponds to the distribution of ramon nut trees. This in part supports his assertion that chultuns were primarily used for ramon nut storage. The ramon tree, however, is part of evergreen and subdeciduous tropical forests (Dahlin 1986; Lundell 1937; Miranda 1958) having numerous other edible fruit and nut-bearing plants that potentially could have been stored in chultuns. Indeed, Puleston (1973:Table XI) cites a Guatemalan government forestry survey of Peten that shows that 16% of the tree species counted, and almost 35% of the individual trees counted, produced edible portions. This is, of course, an unmanaged forest today; the diversity of edible forest plant products has enormous potential if managed properly (see Table 1).

The distribution of tropical forests in which ramon is an important component (9.45% of the total according to the forestry survey) is largely determined by climatic conditions, with atmospheric and ground humidity being the dominant factors. Thus, the northwestern tip of the Yucatan peninsula, which is very dry today, can support only medium to low thorn forests and scrub in which ramon trees do not naturally occur (Thien et al. 1982). Some authors have argued that forest

Table 1. Examples of Fermentable Fruits in the Maya Lowlands (see also Bruman 1940 and Schwartz 1948 re Honey).

Botanical Name Family Genus Species	Description	Availability	Type of Product
Anacardiaceae			
Anacardium occidentale L.	Small trees, mostly cultivated in dooryard gardens	Continuous	Beer made from the fleshy pulp of the fruit
Spondias spp.	Small trees, cultivated in dooryard gardens	Seasonal	Wine from fruits
Annonaceae			
Annona spp.	Small trees, mostly cultivated in dooryard gardens and in small orchards	Seasonal	Wine from fruits
Bixaceae			
Bixa orellana L.	Small tree, cultivated in dooryard gardens	Continuous	Beer made from the fleshy pulp of the fruit
Bombaceae			
Pachira spp.	Small trees common along aguada banks, in bajos, form dense thickets in areas of secondary forests	Seasonal	Pickled preserves from fruits
Boraginaceae			
Cordia spp.	Medium sized trees of both primary and secondary forests, and small trees and shrubs cultivated in dooryard gardens	Seasonal	Pickled preserves from fruits
Bromeliaceae			
Ananas comosus (L.) Merrill	Herbaceous perennial, cultivated in dooryard gardens and as a field crop	Seasonal	Wine made from the fused sterile inflorescence

Table 1 continues on p. 732.

distributions and agricultural potentials in prehistoric Yucatan may have been different from today's, perhaps characterized during the Classic Maya period by the same sort of semideciduous and evergreen forests as found further south (Dahlin 1980, 1983; Folan et al. 1983). If Puleston's hypothesis is correct, arguments for climate change are weakened, as shoe-shaped chultuns would be expected in northern Yucatan during periods of more humid climates. Be that as it may, Puleston's hypothesis is vulnerable on other grounds. If his assertions are true, then one would expect all or most sites covered with ramon forests today (or in the past) to have chultuns associated with them in proportion to their populations. This expectation is not supported because chultuns are not known at Seibal (Tourtellot 1983), Altar de Sacrificios (Willey and Smith 1969), and in the Belize Valley (Willey et al. 1965). Moreover, at sites where chultuns do occur, their number is not apparently dependent on population size. Becan, for example, has only 15 chultuns, for a density of .625 chultuns/km^2 (Thomas 1981). El Mirador, one of the largest known sites, has only 26 chultuns in the mapped portion of its peripheral area, for a density of 6.9 chultuns/km^2: although the site center map is not complete and the exact number of chultuns is not known, chultuns appear to be densely concentrated in areas of downtown El Mirador. Uaxactun has 22 chultuns in its site center for a density of 16.13 chultuns/km^2, with 28 chultuns located in the survey strips for a density of 15.6 chultuns/km^2. Tikal has 200 mapped chultuns in its central 9 km^2 for a density of 22.2 chultuns/km^2 (after Carr and Hazard [1961]) and 323 chultuns along the survey strips, for a density of 22.39 chultuns/km^2 (after Puleston [1973]). Puleston, however, cautioned that chultuns could easily be missed by the mapping techniques used on the survey strips, resulting in more chultuns being missed than were missed by Carr and Hazzard in the central 9 km^2 of Tikal.

Table 2. The Frequency of Residential Groups of Various Sizes Having Varying Numbers of Chultuns on the South Survey Strip at Tikal (after Puleston 1973).

No. Chultuns/ Group	Structure/Group													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0														
1		4	3	4	2	2	2	2			1			1
2		2	4	1	1	2	1							
3			1				3	1						1
4					1									
5						1		1						
			46.3%			36.5%					16.9%			

Note that the smaller groups of residences tend to have chultuns more frequently than larger groups.

Based on the present limited data, we could say that chultuns appear to be limited in geographical distribution to tropical forest areas sustaining a high variety of edible fruit and nut trees. However, within this huge and diverse region the frequency of chultuns at sites seems to have been determined more by cultural factors than by ecological factors, for neither the frequency nor even the presence of chultuns at a site are predictable on biogeographical grounds. Instead, the majority of sites where chultuns are common appear to be in a small fraction of the tropical forest area occupied by the ancient Maya.

INTRA-SITE DISTRIBUTION OF SHOE-SHAPED CHULTUNS AT TIKAL

The storage of staple crops is a universal and annual activity for all subsistence farmers. We assume for the ancient Maya that the storage capacity of a site should be commensurate with the total needs of the inhabitants. We also assume that crop storage was an activity carried on by individual households, because no communal storage facilities have ever been found. Based on these assumptions we can state several predictions regarding the distribution of chultuns for crop storage:

(I) All, or almost all house mound groups, which are thought to have been inhabited by farmers in nuclear or extended families, should have chultuns to store their crops.
(II) Residential groups containing larger numbers of structures, and presumably more inhabitants, should have more or larger chultuns and thus more storage capacity, than groups containing smaller numbers of structures.
(III) The more farm land available to residential structures, with obvious limits in extremely underdeveloped rural areas, the more chultuns there should be to store crops.

Our examination of the available data on the distribution of chultuns at Tikal shows that chultun storage capacity is not distributed in a manner that suggests a storage function.

By our count, of 499 residential mound groups on Puleston's survey strips at Tikal (here including the intersite areas he sampled beyond the 120 km^2 he defines as the site), only 139, or 27.8% are associated with one or more chultuns. By everyone's estimation, the vast majority of the inhabitants of these residential mounds were farmers. It is highly unlikely that only slightly over ¼ of the farmers in the residential and rural areas of Tikal required storage space for their crops. As would be anticipated, the percentage goes down in central Tikal. Of the roughly 476 residential mound groups in the central 9 km^2 of Tikal, only 89 or 18.6% had one or more chultuns with them. In any case, it does not seem plausible that ⅕ to ¼ of the residential groups having chultuns performed the specialized service of storing crops for their neighbors. Thus we find that prediction (I), as stated above, is not satisfied.

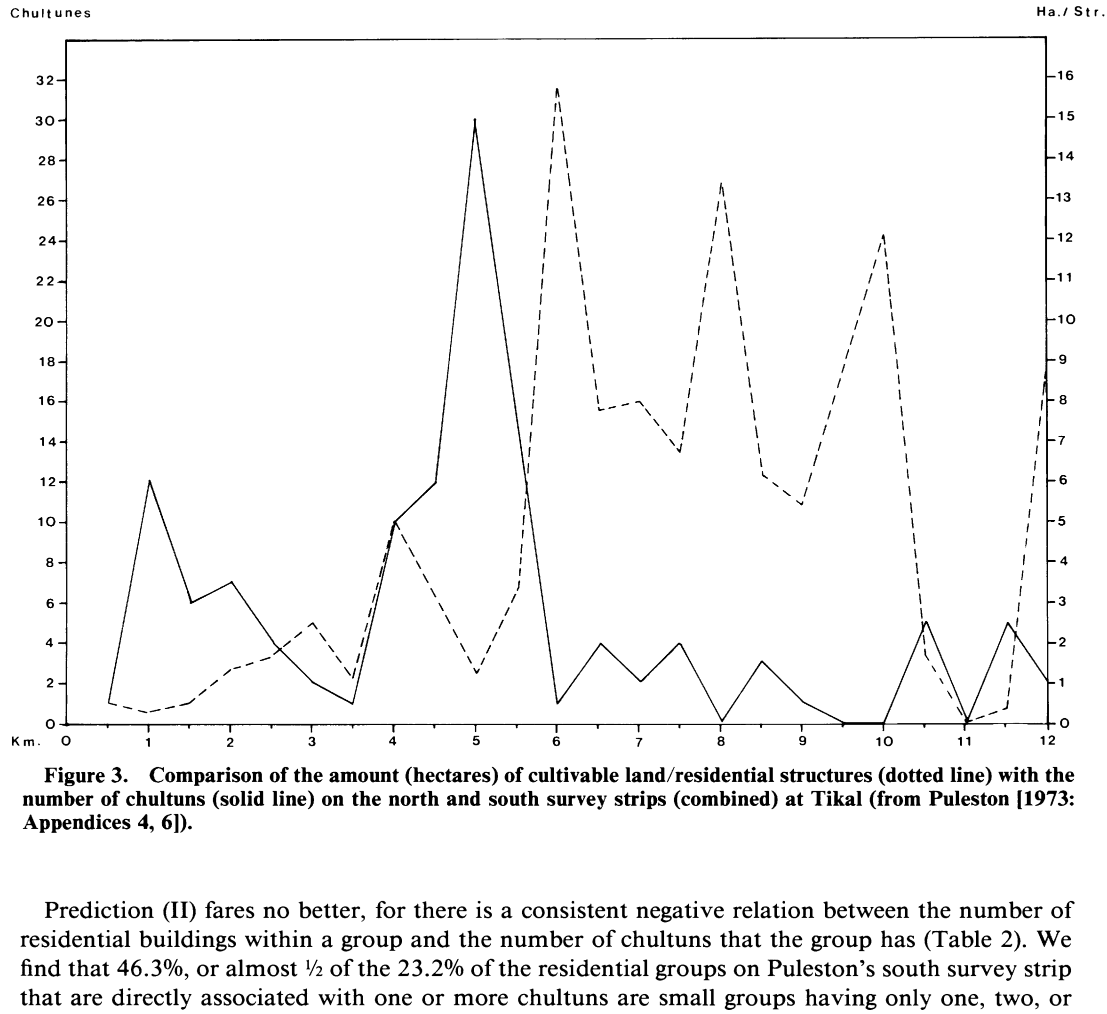

Figure 3. Comparison of the amount (hectares) of cultivable land/residential structures (dotted line) with the number of chultuns (solid line) on the north and south survey strips (combined) at Tikal (from Puleston [1973: Appendices 4, 6]).

Prediction (II) fares no better, for there is a consistent negative relation between the number of residential buildings within a group and the number of chultuns that the group has (Table 2). We find that 46.3%, or almost ½ of the 23.2% of the residential groups on Puleston's south survey strip that are directly associated with one or more chultuns are small groups having only one, two, or three structures probably housing a single nuclear or small extended family. Moderate sized groups of four to six structures having one or more chultuns constitute 36.5%, and large groups with seven or more structures account for only 16.9% of all groups having chultuns. Table 2 also shows that smaller groups are more likely than larger groups to have more than one chultun if they have any at all. However, large groups can have multiple chultuns, such as group 2B-6 through 9 near downtown Tikal, which has a cluster of eight chultuns.

Figure 3, which shows the amount of cultivable land per structure plotted against the number of chultuns on the north and south survey strips (Puleston 1973:Appendices 4, 6) strongly contradicts prediction (III): chultuns are more likely to be found where the amount of cultivable land is restricted, not where it is most abundant. The amount of cultivable land is calculated by subtracting the areas of architectural construction and *bajos* (seasonal swamps) from the total of .25 km^2 in each .5 km × .5 km grid block on Puleston's survey strip maps. As could be expected, there is a much better correlation between chultuns and constructional areas. The negative correlation with upland cultivable soils indicated in Figure 3 suggests a partial correlation with *bajos* and *bajo* edges (Figure 4), particularly because constructional areas were not large except near the center of Tikal. Thomas (1981:20), in fact, explicitly noted that chultuns occur within 25 to 100 m of *bajo* edges at Becan. A similar tendency is evident at Tikal, where chultuns are found to cluster around *tintal bajos* out to 6 km from the site center, and some clustering occurs around the upland *escoba bajos* beyond

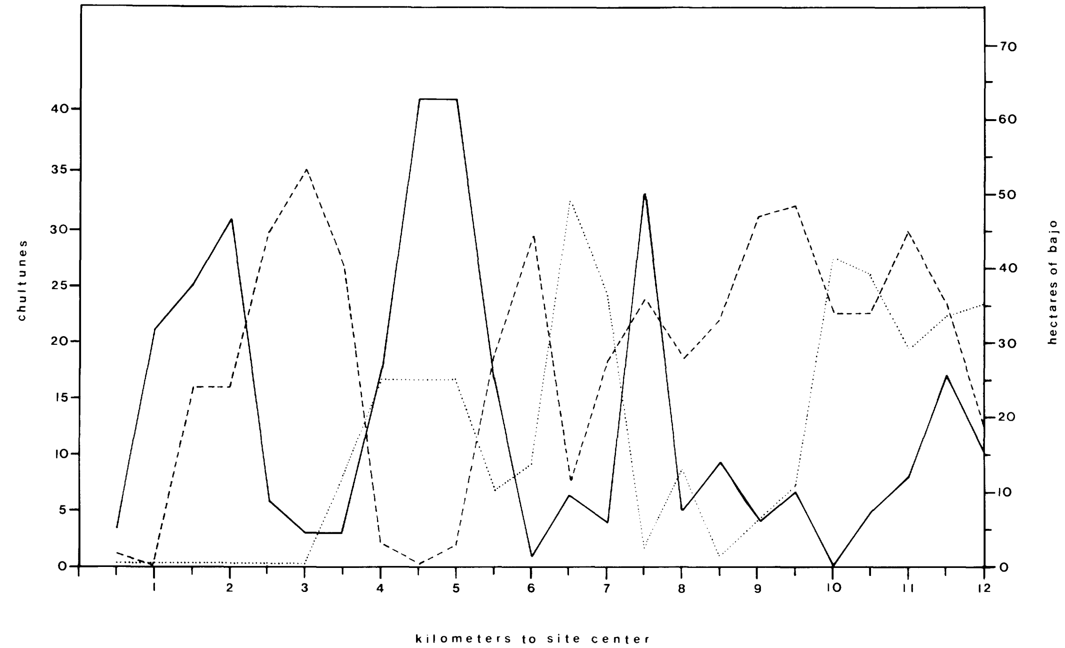

Figure 4. Comparison of chultun frequency (solid line) with hectares of *escoba bajos* (dashed line) and *tintal bajos* (dotted line) along survey strip maps of Tikal (from Puleston [1973]).

that point (Figure 4). *Tintal bajos* have little agricultural potential (Dahlin et al. 1980) although some fruits can be collected there; *escoba bajos* support some fruit and nut trees and are sometimes used today for an emergency dry season crop (Reina 1967). *Bajos* have been managed by use of fire in historic times to increase the production of certain crops such as the nance (*Byrsonima crassiflora*) (Lundell 1937). However, some chultun clusters, such as the large one around the satellite site of Bobal, have no *bajos* in the vicinity.

Cultural factors appear to be more important in determining chultun distributions than the amount and type of land available. We believe the non-random spacing suggests chultuns served some economic instead of storage function. First, there is the obvious frequency difference between residential groups associated with chultuns on Puleston's survey strips (27.8%), and the residential groups associated with chultuns in central Tikal (18.6%). This implies that whatever chultuns were associated with, supply needs could be met in both rural and urban contexts, but more easily satisfied in rural contexts. Second, clusters of chultuns are also apparent in concentric bands between .5 and 1.5 km, 4.0 and 4.5 km, and around 7 km out from Tikal's center. The spacing of slightly more than 3.0 km between these bands suggests a limited range of demand for chultun products outside the residential groups with which the chultuns are associated. These low ratios of producers to potential consumers, coupled with a limited demand or service area, suggests frequent but small transactions in chultun products.

The failure of expectations (I), (II), and (III) might be taken as arguments in support of Puleston's ramon-nut storage hypothesis. Ramon is considered a low status, maize substitute and famine food by contemporary Maya (Puleston 1973); thus, chultuns for storage of ramon nuts would be found mostly at smaller, presumably poorer, residential groups not having enough land available to grow sufficient quantities of maize. However, the spacing of household groups associated with chultuns argues for some sort of specialized service function being provided to extra-household consumers. Moreover, the lack of convincing correlation between the number of chultuns and residential group size, the absence of chultuns at most small and presumably poorer groups, and the occasional association of house mounds with chultuns near public plazas, causeways, and ritual and civic architecture do not suggest an activity as universal as crop storage.

OLD BOTTLE, NEW WINE

The intra-site and inter-site distributions of chultuns reveal some patterns that were never seriously considered before. For example, chultuns are not found to be evenly distributed within the moist and dry subtropical forests where they were thought to occur most frequently. Instead, chultuns seem to be concentrated in and around some of the larger cities within the area of northeastern Peten and northern Belize, although one or two shoe-shaped chultuns are found elsewhere. Furthermore, chultuns are not distributed evenly within sites, but in non-random patterns that do not suggest a storage function. We concur, however, that there is a relationship between agriculture and chultuns. First, chultuns are found in greater frequencies in rural Tikal, where the vast majority of households were peopled by farmers. Also, chultuns are primarily found in association with residences in areas of restricted cultivable land, which implies an alternative or supplement to subsistence farming.

We suggest that chultuns are associated with some sort of economic activity beyond household consumption of staple goods. Support for this comes from the fact that only ⅕ to ¼ of all residential groups at Tikal are associated with chultuns, which suggests a common but specialized cottage industry. Also, the existence of zones of chultuns suggests a demand for chultun products within restricted geographical areas (e.g., neighborhood vendors). Finally, that smaller, poorer, or less prestigious family units were engaged in the economic activity focused on chultuns is suggested by the greater frequency of chultuns at smaller to moderate-sized residential groups, the low capital and labor investments involved in chultun construction, and the circumstance that chultuns tend to be more frequent where the amount of cultivable land is restricted.

The level of economic complexity in the late Preclassic and Classic Maya lowlands allowed for the development of an entrepreneureal system based on small-scale household production. Obsidian, flint, and pottery workshops have been identified at Tikal (Becker 1973a, 1973b; Fry 1969). These industries produced inexpensive, frequently used or consumed items intended for local consumption rather than bulk or expensive products or infrequently transacted items destined for export. Indeed, Fry and Cox (1974) have indicated the existence of exchange mechanisms (e.g., local markets) that dealt with intra-site distributions of utilitarian ceramics, among other things. We believe that the available evidence of chultun distributions points to a cottage industry in perishable farm products at the same general economic level as utilitarian-pottery production and stone-tool production.

Armed with data that seriously challenge the dry-storage hypothesis, it now seems appropriate to ask, "Why would a sane and practical farmer of antiquity introduce any of his precious foodstuffs or seed crop into the hot, humid, and stuffy interior of a chultun?" Anyone who has spent more than 30 seconds in a chultun can hardly doubt that they represent a perfect environment to promote—rather than prevent—the growth of bacteria, yeasts, and molds. It is a bit like asking a prehistoric farmer to put his precious food supply into something resembling a gigantic petri dish. Contemporary farmers in the tropical lowlands of Latin America store their crops in dry, well-ventilated, and protected cribs, either in their fields or above the rafters of their houses (Puleston 1971; Wauchope 1938). A wide variety of techniques are employed to protect stored foodstuffs from losses due to rodents, birds, insects, and microorganisms, depending on local custom and the prevailing pests of each region. We refer back to the sixteenth-century descriptions of Landa and Viana et al., as cited by Reina and Hill (1980). Looking closely at these passages we find that Landa refers to "muy lindo silos y trojos," and Viana et al. observed "para conservalo por todo el año lo meten debajo de tierra en unos hoyos o silos." We believe it is significant that both these authors mention "silos," which of course refers to a special storage place for making ensilage. Production of ensilage is a very old European process of burying, covering, or putting into a "silo" green fodder mixed with urine or other chemical substances to promote microbial digestion of otherwise indigestible plant materials. The object of the European process is to produce fodder for animals, a practice not likely to have been employed by the ancient Maya because they did not have herds of domesticated animals such as cattle and horses. However, the ancient Maya may have been practicing another form of underground food processing that was similar to ensilage and that was commonly known throughout the tropical lowlands of Latin America. Conzemius (1932) describes several underground food-processing techniques for making products such as fermented palm fruits or bananas, and a kind of maize kernel beer made by a two-step process of first molding smoked maize in underground holes, then mashing and boiling it and allowing it to ferment in an underground vat. Underground fermenting or underground short-term storage of fermented foods and beverages is a common practice throughout Mesoamerica (Bruman 1940; Litzinger 1983). The obvious intent of underground food processing is to alter the foodstuff by some form of microbial action, whether by bacteria, molds, or yeasts. Temporary storage may be a secondary, though important, aspect of underground food processing.

Mesoamericans are known to utilize techniques for molding, souring, and fermenting a great variety of foodstuffs (Bruman 1940; Cruz-Ulloa and Ulloa 1974; Litzinger 1983). Food-processing techniques using microorganisms are worldwide in distribution, and are so numerous in kind that space does not permit their description here (for reviews see Batra and Millner [1974], Hesseltine [1966], Phaff et al. [1978], and Thom and Church [1926]). Microbial processing of foodstuffs has several important features. First, it tends to increase the overall productivity attainable from plants by increasing the availability of amino acids and vitamins, particularly of the B vitamin group, and by synthesizing enzymes that act on raw plant tissues to render them more digestible by humans. Second, color, texture, and other variations in food qualities produced by microbial processing add diversity to what might otherwise be a rather bland diet. Furthermore, some fleshy fruits that are highly seasonable in their availability can be pickled to preserve them as delicacies or condiments that enrich staple foods the year round. And last, but certainly not least, microbial processing offers the possibility of converting sugars and starches into alcoholic beverages.

Even in the absence of controlled experiments, it can hardly be denied that the high relative humidity and temperature, the exclusion of light, and the possibility of sealing the chultun from the flow of air presents an environment that is ideal for promoting the growth of microorganisms. We believe that the long-overlooked potential of chultuns resides in their capacity for being used in a process involving microorganisms, particularly in the processing of foodstuffs. Furthermore, we suggest that wines and beers were the primary products processed in chultuns.

Evidence for this, of course, is circumstantial. While there are no actual descriptions of chultun use, there is an established association in the Maya area between alcoholic beverages and underground or "pit" processing or storage. Moreover, two things become evident by looking at the details of how the Maya, in historical and contemporary times, produce and consume their traditional alcoholic beverages. First, we find that for the small batch-type fermentations used by the Maya to produce their traditional alcoholic beverages, the internal environment of the chultun would have been beneficial for promoting the fermentation in several ways. Second, we find that the consumption of traditional alcoholic beverages among the Maya shows patterns that may help in explaining what we now know about the inter-site and intra-site distributions of chultuns.

A POTENTIAL ROLE FOR THE CHULTUN IN ALCOHOLIC-BEVERAGE PRODUCTION

Contemporary Maya fermentation practitioners, and their counterparts throughout the rest of Mesoamerica, know that an even, uninterrupted fermentation cycle is most desirable for producing beverages of the best quality. The more even the temperature, the better the beverage produced. This is because of the growth characteristics of the fermentative yeasts, which are typically varieties of *Saccharomyces cerevisiae,* the common brewer's yeast (Litzinger 1983). It is also well known that disturbance, particularly during the beginning of the fermentation cycle can cause an incomplete or failed event. For these reasons, underground fermentation has some advantages, and it is obvious that the even temperatures and protected environment inside a chultun would have provided a good location for alcoholic beverage production. When above-ground fermentations are conducted today (e.g., among the Lacandon Maya), heavy ritual restrictions usually accompany the process to help minimize disturbance and much effort is undertaken to keep the temperature even around the fermenting beverage. Because chultuns are most often found with houses, the chultun would have offered a protected recess where fermentations could be conducted without disrupting normal household activities.

One contrary consideration is that the environment within the chultun would have equally promoted the growth of desirable fermentative yeasts and undesirable contaminating organisms. The chultun could even act as a trap for air-borne spores of bacteria and fungi. However, the fermentation practices of the Maya would have minimized this problem. Field studies conducted by Litzinger (1983) showed that the Maya fermentation system is able to function with a diversity of kinds of microorganisms present, with success dependent on keeping contaminating microorganisms in relatively low numbers by the use of plant additives. These plant additives, typically in the form of bark strips of *Lonchocarpus, Hibiscus,* or *Heliocarpus,* and bundles of *Nicotiana* or *Datura* leaves, serve as a means for maintaining an inoculum of fermentative yeasts. The bark strips and leaf bundles are immersed directly into the fermenting beverages, where they become covered with a very dense, and relatively pure inoculum of fermentative yeasts. The strips and bundles are saved and used from batch to batch until their chemical potency is depleted. The yeasts can survive many months between batches but in practice the cycle time is seldom that long. The chemicals in these plants retard the growth of many kinds of bacteria and fungi, but the yeasts apparently suffer no ill effects. As these chemicals consist mostly of alkaloids, phenolics, and glycosides, they act on humans as cardiac stimulants and hallucinogens (Bruman 1940; Emboden 1979; Litzinger 1983).

Because of the diversity of microorganisms present, traditional Maya alcoholic beverages are difficult to store once the fermentation cycle is completed. However, short-term storage of beverages is often accomplished by hermetically sealing fermentation ollas and placing them in a pit underground. Hermetic sealing is widely employed in Mesoamerica for the short-term storage of perishable foodstuffs, and the technique predates the use of ceramics (Adovisio and Fry 1976). Bruman (1940: 103–104) cites the seventeenth-century account by Thomas Gage among the Cakchiquel Maya in highland Guatemala, who kept alcoholic beverages in hermetically sealed ceramic ollas for up to a month. Gage does not mention if the sealed ollas were stored in underground pits, but the passage indicates that the ollas were hidden within houses, and that a toad was placed in the ollas before they were sealed. Bruman suggests that the use of the toad, which has alkaloids in its skin, is no doubt similar to the use of plant additives in the primary fermentation. It could have been that the plant and animal additives were used in chultuns both for conducting fermentations and for the short-term storage of the product. Short-term underground storage capacity is used by many Mesoamericans when making quantities of alcoholic beverages beyond immediate household needs, such as in preparation for a large religious event, and also for extension of the availability of a seasonally produced beverage beyond the final harvest of the crop (Litzinger 1983).

EXPLAINING REGIONAL AND LOCAL DEMAND FOR CHULTUN PRODUCTS

Given what we now know about the intra-site and inter-site distributions of chultuns, we would find support for our hypothesis that chultuns are associated with alcoholic beverage production if Maya drinking patterns could be shown to be (1) strongly regional in character, and (2) associated with a cottage-level industry having local product demand. Both of these expectations we found to be true. It was on the basis of the regional preferences for traditional alcoholic beverages that Bruman (1940) described his "drink areas" of Mesoamerica. This regionalism is strongly exhibited within the Maya area. In Yucatan, and among the Lacandon groups in the Usumacinta River Valley, a single type of beverage is found. This is a ceremonial honey wine called *balche* that is made exclusively with bark strips of *Lonchocarpus*. In other parts of the Maya area a number of different kinds of beverages have regional importance; these include beers made from sprouted or molded maize kernels, palm-sap wines, jocote wine (fruits of *Spondias* spp.), and honey wines made with *Hibiscus* or *Heliocarpus* bark strips. Local variation is also increased by selective use of *Nicotiana, Datura,* and other kinds of additives.

Maya drinking patterns may have changed somewhat during the last 1,000 years. The drastic

Table 1. Continued from p. 725.

Botanical Name Family Genus Species	Description	Availability	Type of Product
Cactaceae			
Cerus spp.	Climbing vines, found in secondary forests and old milpas	Seasonal	Wine from fruits
Opuntia spp.	Herbaceous perennials sometimes like shrubs or small trees, cultivated in dooryard gardens	Seasonal	Pickled preserves from fruits
Cesalpiniaceae			
Dialium spp.	Medium or small tree found in secondary forests	Seasonal	Pickled preserves from fruits
Diospyroaceae			
Diospyros spp.	Medium sized tree of the primary forests	Seasonal	Pickled preserves from fruits
Esterculiaceae			
Theobroma cacao L.	Small tree or shrub, cultivated in dooryard gardens and orchards	Continuous	Beer made from the fleshy pulp of the fruit
Leguminosae			
Prosopis juliflora D.C.	Shrub, cultivated in dooryard gardens	Continuous	Beer made from the fleshy pulp of the fruit
Malpighiaceae			
Byrsonima crassiflora (L.) HBK.	Shrub common in bajos and savannas, fire resistant, forms dense thickets	Seasonal	Pickled preserves from fruits
Malpighia spp.	Medium sized trees found in secondary forests	Seasonal	Pickled preserves from fruits
Malvaceae			
Hibiscus spp.	Shrub cultivated in dooryard gardens	Seasonal	Pickled preserves from fruits
Moraceae			
Ficus spp.	Medium or small sized trees, found in both primary and secondary forests, and cultivated in dooryard gardens and along streets in towns	Both seasonal and continuous	Pickled preserves from fruits, and wine from fruits
Pseudolmedia spp.	Medium sized trees found in both primary and secondary forests	Seasonal	Pickled preserves from fruits
Myrtaceae			
Psidium guajave L.	Small trees cultivated in dooryard gardens and in orchards	Continuous with seasonal peaks	Pickled preserves from fruits, and wine from fruits
Olernaceae			
Ximenia americana L.	Small tree or shrub common in secondary forests and savannas, fire resistant, forms dense thickets	Seasonal	Pickled preserves from fruits
Palmae			
Acrocomia spp.	A palm of medium height, fire resistant, forms dense thickets in savannas and in secondary forests	Continuous	Wine from sap produced by the trunk

Table 1. Completed.

Botanical Name Family Genus Species	Description	Availability	Type of Product
Orbignya spp.	Medium sized palm known only in groves or dense thickets in secondary forests, savannas, associated with archaeological sites	Continuous	Wine from sap produced by the trunk
Polygonaceae			
Coccoloba spp.	Small trees or shrubs forming dense thickets along edges of aguadas and bajos, and in coastal mangroves	Seasonal	Pickled preserves from fruits

reductions in Maya populations during the ninth- and tenth-century collapse of Maya civilization and the devastating sixteenth-century conquest by the Spanish almost certainly affected community infrastructures, particularly political and religious, upon which many of the drinking patterns depended. However, drinking among the ancient Maya probably followed patterns similar to the three basic drinking modes that Taylor (1979) suggests were common throughout ancient Mesoamerica. One mode was an individual daily drinking pattern that was restricted to the highest ranking members of society, such as nobility and military heroes. A second mode involved group drinking that accompanied religious events and a number of different kinds of ritual occasions. All levels of society participated in group drinking events that occurred many times throughout the year. The third mode was drinking that took place in markets where alcoholic beverages were sold commercially. Alcoholic beverages in markets were supplied by roaming venders and small stalls resembling drinking establishments. Alcoholic beverages were also important in curing ceremonies where they often served as a medium for ingesting herbal remedies (Litzinger 1983). Except, of course, for the individual drinking mode of the upper classes, these patterns of consuming alcoholic beverages persist among the contemporary Maya. Group drinking on religious and special occasions is still common throughout the Maya area. Market drinking, however, is confined to the highlands of Chiapas and Guatemala and adjacent lowland areas. Distillation, unknown to the Maya prior to the arrival of the Spanish, along with the early introduction of sugar cane (*Saccharum officinarum* L.) and the subsequent development of the rum or "agua ardente" industry had a great effect on the traditional drinking habits of the Maya, especially in tropical lowland areas. Bruman (1940) suggests that sugar cane not only became important for distilled beverage production but it was also quickly adopted by the Maya as a substrate for making traditional forms of alcoholic beverages, supplanting in particular wine made from maize stems and undoubtedly other aboriginal substrates. The Yucateco Maya and the Lacandon in the Usumacinta River Valley make their ceremonial *balche* from sugar cane, though honey is preferred when available. And sugar cane wine has supplanted sprouted maize kernel and maize stem beverages in highland markets where traditional beverage forms are still in demand (Litzinger 1983).

The Maya pattern of market place drinking has obvious importance for our discussion of chultun function. And we expect that there would have been a good potential for vending alcoholic beverages in and around ancient Maya cities where chultuns are found. The chultun would have provided the fermentation practitioner a means to meet variability in demand by allowing the extension or reduction of production in anticipation of needs. Moreover, alcoholic beverage production could have offered an economic option depending on the vicissitudes of personal fortune and enterprise. In this context, it is interesting that some chultuns are found that were apparently abandoned under housefloors (cf. Ricketson and Ricketson 1937) suggesting that the lifespan of a chultun could be shorter than the lifespan of the residential unit. Perhaps when a family's fortune took a turn for the worse, some member of the family could gain supplementary (hard cash) income by making alcoholic beverages until luck improved. For this reason, possibly, chultuns are more often found at smaller and presumably less prestigious residential mound units. Making alcoholic beverages requires little in the way of capital investment, or specialized skills in production or marketing. And we would expect that there would have been a relatively high abundance of quality raw materials available for making alcoholic beverages (cf. Table 1). Also, the environment within the chultun would have favored repeatable conditions of production and thus good reliability of product quality. The chultun, as a fermentation chamber, would have fit well into a production pattern for market vending.

SUMMARY AND CONCLUSIONS

We find that the inter-site and intra-site distributional data for chultuns argues against the hypothesis that they were used to store staple crops. However, these same data suggest an association of chultuns and agricultural production, and that chultuns possibly constituted the locus for some low-level economic activity that supplied an extra-household demand.

The hypothesis proposed is that lowland Maya shoe-shaped chultuns were primarily used to ferment alcoholic beverages. Though direct ethnographic evidence is lacking, there is an association with alcoholic beverages and the use of shallow pits for processing and short-term storage. The internal environment of the chultun is thought to be ideal for conducting fermentations. The chultun appears to have been a fermentation pit with the innovation of being easily accessible from the exterior without undue disturbance to the internal environment. We further suggest that chultun production capacity is geared toward a vending economy, principally marketplace vending of alcoholic beverages.

We believe that the distribution of chultuns is best explained by cultural factors. Today, regional preferences in traditional alcoholic beverages are a strong factor in the geographical distribution of beverage types. Thus, the product made in chultuns may have been a regional specialization of northeastern Peten and adjacent coastal areas. Chultuns would not necessarily be expected to occur elsewhere.

We offer these suggestions in order to stimulate new lines of inquiry on how the chultun could have functioned. We believe our hypothesis is verifiable both empirically by careful examination of in situ chultun contents, and by experimentation. Recalling that the only in situ remains thus far recovered from a chultun were large ceramic ollas, it would be possible to identify them as fermentation containers by examination of paleo-organic remains (cf. Litzinger 1983). Also, much more information is needed about such simple things as variability in chultun size and shape. We suspect, however, that the experimental approach will be the most productive avenue for future research.

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