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ARTICLE

Estimation of Early Classic Maya Population: Methodological Challenges and Modeling at Naachtun, Guatemala

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Abstract

Most population estimates for Maya sites are for the Late Classic period, a time of peak population in the Central Maya Lowlands. At Naachtun, Guatemala, a major city during the Early Classic that continued into the Late Classic period, researchers recently carried out an ambitious program of test pitting in residential areas; its aim was to model the growth of residential units during the entire Classic period and so better contextualize the rise of Classic Maya dynasties and the scale of their economic and political power. This article presents an improvement to the existing method for estimating population for periods preceding the population apex (in this case, the Early Classic period): it not only estimates the occupancy rate of residential units occupied pre-apex but also assesses their size, using a typology I developed based on their morphology and pattern of transformation.

Resumen

La mayoría de las estimaciones de población de los sitios mayas pertenecen al Clásico tardío, época de auge demográfico en los asentamientos de las Tierras Bajas Centrales. En Naachtun (Guatemala), una de las ciudades más importantes durante todo el período Clásico, emprendimos recientemente un ambicioso programa de sondeos en las zonas residenciales para modelar el crecimiento de las unidades habitacionales durante dicho período y, contextualizar mejor el surgimiento de las dinastías del período Clásico y la escala real de su poder económico y político. Este artículo refuerza el método de estudio de las estimaciones de población para los períodos anteriores al apogeo demográfico, como es el Clásico temprano. No basta con estimar la tasa de ocupación de los grupos residenciales habitados durante el Clásico Temprano, sino que debemos considerar su tamaño antes del Clásico Tardío, teniendo en cuenta que pudieron expandirse entre ambos períodos. Para ello, utilizamos una tipología específica, que desarrollamos en base a la morfología y al patrón de transformación de las unidades.

Keywords: population estimates; Maya Lowlands; Early Classic period; Naachtun

Palabras clave: estimaciones de población; Tierras Bajas Mayas; Clásico Temprano; Naachtun

With the widespread use of lidar survey in the Maya area, the study of the demography of cities has made a resounding comeback in the literature. With a landscape that is almost covered by residential mounds, it is tempting to give high population numbers for the Late Classic demographic apex (AD 550–800) in the Maya Central Lowlands (e.g., Canuto et al. 2018; Chase et al. 2011; Inomata et al. 2018), and population estimates tend to disproportionately focus on this period (Canuto et al. 2018; Chase and Chase 1994; Culbert and Rice 1990; Nelson 2004).

This tendency to estimate population only for the period of demographic apex—which is understandable because estimates based on remains with good archaeological visibility are straightforward (Houston et al. 2003:217)—is not limited to Maya research (see Smith et al. [2019] for

Teotihuacan). In the Central Lowlands, lidar surveys show an overwhelmingly Late and Terminal Classic residential landscape, albeit with a significant minority of Late Preclassic (400 BC–AD 250) unmodified mounds (Garrison et al. 2019; Inomata et al. 2018). Early Classic (AD 250–550) residential remains are relatively invisible in both surficial excavations (Chase and Chase 2005) and lidar imagery because of their age and changes in residential patterns. In fact, Preclassic remains are often more visible than Early Classic ones. This is why the widespread use of lidar surveys has not significantly improved identification of Early Classic settlements but has instead shed even more light on Late Classic ones, which is problematic because in that period urbanization processes often preceded or accompanied dynastic formation (Martin and Grube 2008).

In this article, I explore pre-apex, Early Classic population estimates using the case study of Naachtun, Guatemala. I simulate the population of the city and the evolution of different types of residences between the Early and Late Classic periods through typologies of residential unit growth. I progress back in time toward the Early Classic state of the city from its visible—mainly Late Classic—settlement pattern. In doing so, I consider the Early and Late Classic universes to be largely spatially continuous.

Existing Methods for Estimating Maya Population and Why They Are Unsuited for Estimating the Early Classic Population

The Maya had no cemeteries that we know of, with the possible exception of the necropolis on Jaina Island, and only an unknown proportion of the population was buried under house floors and residential courtyards (Chase 1997; Goudiaby 2018). If Classic period censuses ever existed, none survive. Therefore, among the array of proxies used for estimating ancient population, only two have proved useful in assessing the precolonial Maya population: agricultural carrying capacity and the remains of dwellings.

Carrying-capacity-based methods indicate the maximal, rather than true, population sustainable by a given environment. No consensus exists on the implications for carrying capacity of the many agricultural intensification techniques that were previously unknown to archaeologists but are now seen on lidar images. In some regions, such as the Puuc, the carrying capacity of water reservoirs (*chultun*) can be used as a proxy (Becquelin and Michelet 1994). However, because the climatic conditions, orography, and duration of occupation are region specific, in the Central Lowlands we are left with residential remains as a proxy.

Classic Maya Dwelling Patterns

Central Lowland Classic period cities show low-density forms of urbanization (Fletcher 2009; Hutson 2016; Marcus 1983), with residence clusters at different scales. Population estimates are based on two intersecting factors: social (What is the basic residential unit?) and functional (What are the functions of structures or of their rooms?). The distribution of inhabitants among these structures is at the core of population estimates, but no straightforward numerical association exists between inhabitants and buildings. Some families cohabited; others lived spread over more than one dormitory. Some units had ancillary structures, whereas others did not. These patterns probably coexisted and merged, further complicating calculations.

When a household used several buildings or when several households lived together, the different structures were generally organized around a shared central activity space: the courtyard or patio (Becker 1982; Chase and Chase 2014; Haviland 2014; Wilk 1988). Together the structures and activity space formed a spatially and socially coherent co-residence feature, limited by the number of buildings it could accommodate. The typical Maya patio accommodated up to six buildings; a few had seven or eight (Tourtellot 1988). Often, social and family ties intensified so much that no space remained around the original patio, and some inhabitants had to create a new patio, either adjacent to or isolated from the original. Adjacent patios formed a multi-patio cluster (Haviland 2014) that probably retained biologically and socially constructed ties to a "common ancestor" (Duncan and Hageman 2015; Haviland 2014; McAnany 1995) but did not result in a pattern of contiguous residences.

What were probably agricultural infields or drainage sectors separated discontinuous clusters of structures that I term "residential units." Residential units range from a single, isolated structure to multiple structures (with no maximum), as long as they are closer to each other than to the structures of the nearest residential unit(s). A residential unit may comprise only one patio or two or more patios; Haviland (2014:147) calls them single plaza-residential units or multi-plaza-residential units, respectively. Although no maximum number of patios exists, fission frequently occurred (Haviland 2014; McAnany 1995).

Basic Units of Calculation

A less inaccurate way to estimate the population of a Maya city based on residences is to count the number of residential "features" occupied at one time and to multiply this number by an average number of inhabitants per feature. Depending on the archaeological resolution in terms of data or time period, different scales in the taxonomy of the dwelling groups may be the basis for calculations. The smallest scale is the structure (Culbert et al. 1990; Rice and Culbert 1990:13; Turner 1990): it may be a dormitory and may function independently of other structures. The next higher scale is the patio, used by Marken (2011) to estimate the Classic population of the city of Waka' (Guatemala). The largest scale is the residential unit. Calculation at the scale of the neighborhood (Hutson 2016; Lemonnier 2011; McAnany 1995) is impracticable because neighborhoods have heterogeneous, ungeneralizable dynamics. However, the neighborhood scale, with its social trends, may guide the modeling of residential unit diachronic growth.

At many sites—for example, at Quirigua (Ashmore 1990) and Seibal (Tourtellot 1990)—patios and residential units largely coincide: there is one patio per residential unit. At other sites, such as Naachtun or Tikal, residential units are heterogeneous and have no upper limit on the number of structures. At Tikal, Becker (1971, 2003) suggested that units housed 25 inhabitants on average. I consider the patio the most suitable scale: because most serve fewer than seven structures, the margin of error is automatically reduced.

At many major sites, most residential units bear traces of Late or Terminal Classic occupation, including at Copán (Webster and Freter 1990a:79), Tikal (Stavrakis-Puleston 2015:62), Naachtun (Hiquet 2020), Caracol (Chase et al. 2011), and El Zotz (Garrison et al. 2019). Although researchers acknowledge issues of nonvisibility (due to non-mounded occupation) and contemporaneity (whether all structures from the same phase were occupied simultaneously; Hendon 1992), most agree that the landscape of archaeological mounds in the Central and Southern Lowlands is mainly Late Classic, with a strong minority of Late Preclassic unmodified platforms (Inomata et al. 2018). There is also consensus that the population peaked at some point in the Late Classic period (perhaps the eighth century), fueled by a demographic surge (Turner 1990:310; Webster 2018:43; Webster and Freter 1990b:48). Unsurprisingly, most population estimates are for the Late Classic period because they may be calculated almost directly from archaeological maps. When present, Preclassic mounds are highly distinguishable and do not cause confusion.

Shortcomings of Existing Methods When Assessing Early Classic Period Population

The application of these methods to Early Classic populations is not straightforward, because most Early Classic structures lie buried under later constructions. Without excavating them, it is almost impossible to know which residential units were occupied during the Early Classic—although mound orientation sometimes provides a clue (Hiquet 2020:286–288). More importantly, Early Classic residences have an unknowable morphology and composition, confounding attempts to estimate population by applying a factor of inhabitants per residential category.

Ideally, archaeologists should test every visible structure for earlier stages and every vacant space for non-mounded occupation. Bronson (1968) found at Tikal that most of the invisible structures in apparently vacant terrain date from the Early Classic period. At some small sites, such as Xcambó, Yucatan, it was possible to test every mound to obtain an accurate rate of occupation per period (Ortega-Muñoz et al. 2018). Yet, for the extensive residential areas of the Classic period capitals, sampling at the mound scale is challenging due to problems of visibility and identification (Tourtellot 1990:85).

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The few attempts to estimate Early Classic population at sites with a Late Classic demographic peak usually deduce it from the rate of occupation of structures. The relative rate of structures occupied during the Early Classic is calculated from the apex population, which is assigned a 100% occupation. Most estimates stop at this point and give an absolute number of inhabitants only for the Late Classic (Arnauld et al. 2017:26; Culbert et al. 1990; Fry 1990). Others go further and compute the Early Classic figure, applying the relative rate of structure occupation for the Early Classic to the population calculated for the apex (Turner 1990; Webster 2018:39–42). This is how Webster (2018) obtains a range of 3,861–5,372 inhabitants for central Tikal at the end of the Early Classic period. This may be an overestimate, however, because residential units in the Early Classic period were not only fewer in number but also smaller and less than their counterparts in the Late Classic period (Haviland 1982, 2003, 2014; Marken 2011; Webster et al. 1992:191). Moreover, as consistently evidenced by excavations at Naacthun (Goudiaby 2018; Goudiaby et al. 2023), Early Classic structures were smaller than their Late Classic counterparts. Depending on the method used for calculation, this tendency could result in a lower population estimate for each structure.

Previous Estimates of Pre–Demographic Apex Population

One of the few sites whose Early Classic population has been thoroughly debated, despite its low archaeological visibility, is Copán: some researchers considered the population estimate provided for the Early Classic period to be too low, considering the impressive remains of the Acropolis (Fash and Sharer 1991; Paine et al. 1996; Webster 2018; Webster and Freter 1990a; Webster et al. 1992; Wingard 2013). Various attempts in the 1990s to derive settlement-based estimates suffered from insufficient data (see Supplemental Text 1). Fundamental for my model of residential unit growth is that residential units probably had fewer inhabitants during the Early Classic than the Late Classic period; this makes it necessary not only to obtain an occupancy rate of residential units but also to account for their morphological growth.

Forms of Growth in the Classic Period

My model of residential unit growth between the Early and Late Classic periods is based on both the social significance and the mode of formation of residential units. Theoretical models of growth usually involve biological and socioeconomic factors. The simplest, most basic model envisions an evolution starting from the single house of a founding couple (Haviland 1988; Tourtellot 1988). As the family's size increases through natural demographic growth, new structures are built around the patio. Some Mayanists assume that, once grown up, the offspring of the founding couple settle right next to their parents. Generational replacement means that the next-oldest generation moves into the parental house after the parents' death.

However, both social and economic dynamics could affect the evolution of a Maya residential unit and the integration of a family into a co-residence group. For example, applying a model of a "house society," supported by ethnography, one can envision some families seeking to increase their wealth and social and political prestige by increasing the number of occupants in their residential unit, thereby fueling its growth (Arnauld et al. 2013; McAnany 1995:106–109; Tourtellot 1988; Wilk 1988). Social and economic strategies to attract occupants involved establishing client–patron relationships and marriages, as well as debt, feasting, and reciprocity systems (Hendon 2010; Lemonnier 2011:20; Sanders 1989). While the residential units of the ablest and most prosperous families grew rapidly, others were abandoned, and their former inhabitants either were absorbed by larger families or relocated close by (Arnauld et al. 2017; Haviland 2014:148). Thus, failure should not be excluded from the models (Wilk 1988). Although forming the largest family possible was the best way to gain resources, a large family was also an unavoidable source of familial conflict and fission, a pattern well documented ethnographically (Farriss 1984; Wilk 1991).

To summarize, multiple social interactions and strategies explain residential unit trajectories and result in a range of growth models. Some patios remained modest throughout their history, whereas others grew to become multi-patio units. Some were abandoned by their inhabitants. Some grew gradually, from the onset of the Early Classic; others appeared much later and grew rapidly.

Another issue is the possibility of a change in size of the elementary nuclear family—and, hence, of the extended family or household—linked to demographic conditions, including the reproductive rate, life expectancy, and maternal mortality. During early periods of slow growth, in an exponential curve (i.e., the Early Classic demographic situation), family size may have been smaller than during periods of more dynamic and faster demographic growth (i.e., the Late Classic surge). Webster and Freter (1990b:49) proposed an average household size of five members during rapid growth and of four in periods of slower growth (see also Tourtellot 1983:1074–1075; Turner and Lofgren 1966). Ortega-Muñoz and colleagues (2020) recently calculated that at Xcambó, life expectancy was shorter and mortality (particularly maternal) higher during the Early Classic than during the Late Classic period. However, high mortality can be compensated for by an increased birth rate.

According to these finding and principles, we should use a different inhabitant factor for the Early Classic period than for the Late Classic period. To accommodate the great differences in morphology and growth tendencies between Early and Late Classic residential units, we need typologies with specific inhabitant factors per type. Given that it is usually impossible to access the entire Early Classic settlement, these factors are most appropriately applied at the patio scale.

Naachtun: A Case Study

Located in northern Petén (Figures 1 and 2), Naachtun lies in a hilly landscape overlooking large *bajos* (seasonally flooded wetlands), long exploited for agriculture (Nondédéo et al. 2020). With more than 80 stone monuments, Naachtun is among the main Classic period regional capitals. Its dynasty was officially founded around AD 325, with the bat (*Suutz*) emblem glyph (Nondédéo et al. 2018), and as evidenced by the inscriptions written on stela, it claimed to have participated in the AD 378 takeover of Tikal. The Early Classic period, particularly the first half (AD 150–378), was a time of major architectural investment in the monumental epicenter; most of the largest buildings at the site were constructed during this time (Hiquet 2020; Hiquet et al. 2022). Knowing the size of the local population and, hence, the available pool of labor, is thus fundamental to understanding the extent of the incipient dynasty's power during this early period. For example, does this architectural investment indicate forced mobilization of the population and a high degree of state power? Naachtun had to successively cope with the expansionist ambitions of Tikal and the Kan'ul; indeed, signs of shifting alliances are found at the site throughout the Classic period. The royal elites left the city at the very end of the Late Classic period, but many commoners remained during the Terminal Classic period, before abandoning Naachtun at the end of the Terminal Classic (Nondédéo et al. 2021). The chrono-cultural sequence (Figure 3) was anchored using ceramic seriation (including comparisons with other Lowland sequences), radiocarbon dating, and epigraphy (Hiquet 2020; Nondédéo et al. 2018; Patiño 2016; Perla-Barrera and Sion 2018).

Naachtun's epicenter covers 33 ha and includes three groups aligned on an east–west axis (Figure 2). No monumental construction has been identified for the Preclassic period. Mostly built during the Early Classic period, Groups A and C serve politico-ritual functions: no residential structures, even royal, were identified there. Most of Group B is built much later. All visible architecture is either Late or Terminal Classic and mainly residential; plazas and pyramids exist, but on a smaller scale than in Groups A and C. Dense complexes of vaulted structures that hosted the Late Classic royal court form an unusual residential compound (Sion 2016), in which Early Classic platforms and fills are scarce.

A residential area of 175 ha surrounds the monumental epicenter. There, exhaustive field survey identified 603 structures, forming 119 residential units comprising 226 patios (44/119, or 37%, are multi-patio units). To the north and south, this residential area is limited by large *bajos*; to the east and west, two thalwegs carved by seasonal streams may have formed a natural border. Beyond these limits, residential unit size and density decrease across a belt that is a few hundred meters wide. Beyond that belt, residential cluster density rises again in places, as evidenced by a lidar survey showing that Naachtun's hinterland is among the most densely occupied in northern Petén (Canuto et al. 2018), with approximately 13,000 structures over 135 km^2. Because these structures remain undated, the calculations in this article concern only the 175 ha residential area and the 8 ha Group B. I argue that this area only became denser during the Late Classic (Hiquet et al. 2023; Sion 2016) and therefore extrapolate the Early Classic population of Group B from the density of the residential area.

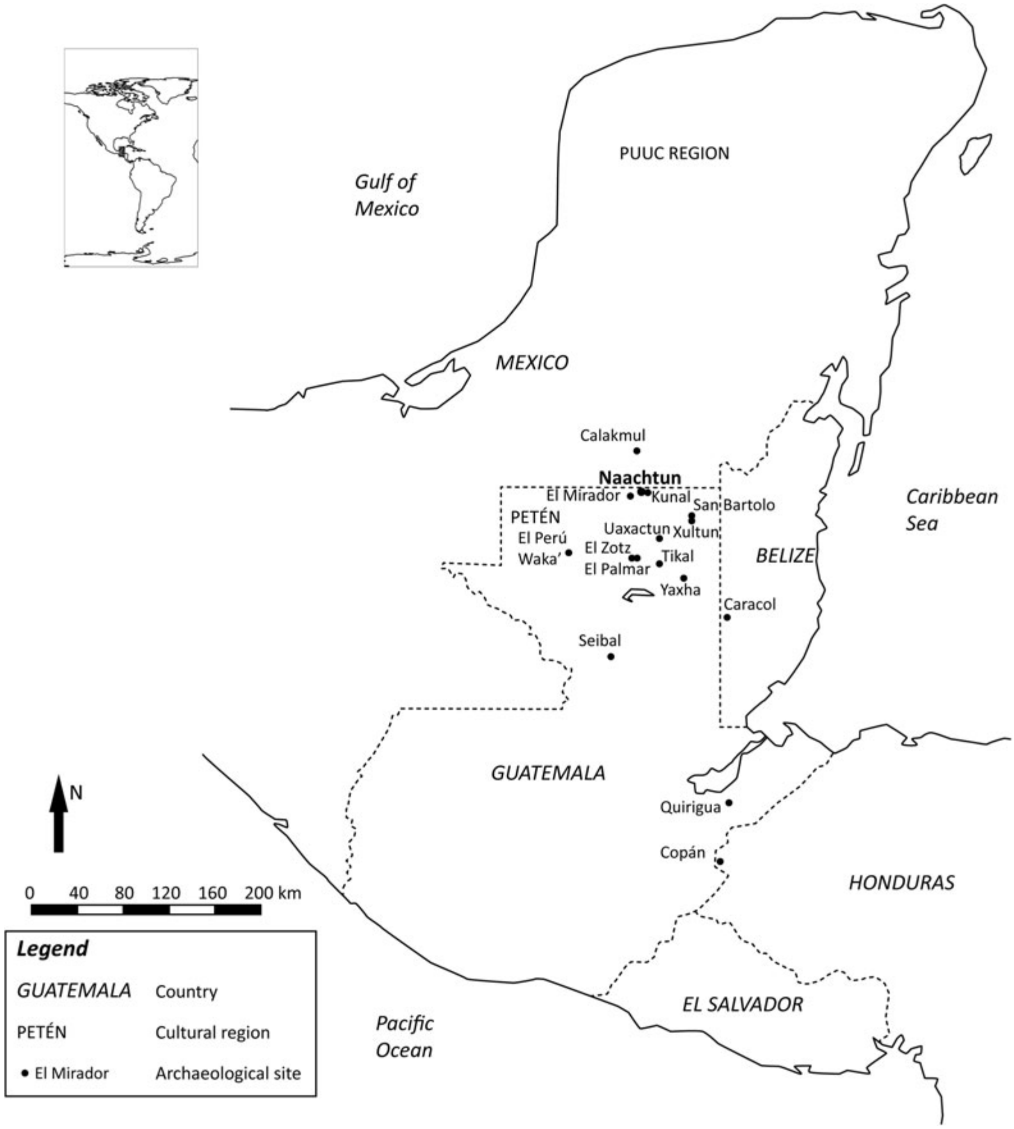

Figure 1. Map of the Maya area showing the location of sites mentioned in the article.

Typology of Growth of Residential Features

I developed two typologies to be used together to evaluate the growth and number of inhabitants of all residential units and patios. Unlike previous typologies—for example, those of Ashmore (1981), Marken (2011), and Tourtellot (1983)—my typology takes into account the way each unit grew between the Early and Late Classic periods: either horizontally, involving the construction of a new structure next to another existing one, or vertically, in which a structure was modified, which may have included rebuilding with a larger footprint and enclosing the earlier walls. In each case, I reconstructed the growth or lack thereof based on the morphology of the feature's final, "mature" stage and its deposition history (if the residential unit or patio was tested). When the Naachtun data proved insufficient, I used data on diachronic growth from other sites.

My typology of residential units provides a chronological frame based on the observed or assumed Early Classic occupation; the typology of patios then permits me to quantify their growth between the Early and the Late Classic and assign a factor of inhabitants per patio type for each phase. Finally, the

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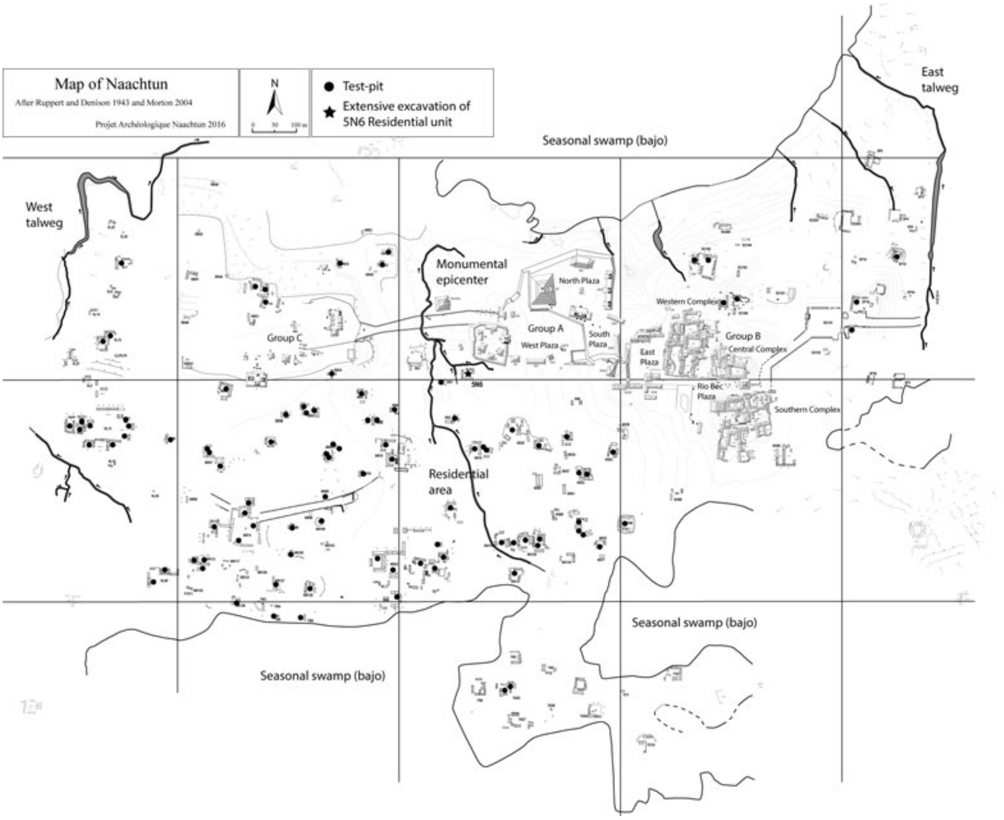

Figure 2. Map of Naachtun showing location of test pits and extensive excavations in the residential area.

sequence of occupation provides the number of patios of a particular type occupied during a particular subphase. This approach yields an occupancy rate per subphase for each patio type and accounts for morphological differences among patios in time and space due to growth or nongrowth. The growth typologies (Figure 4) and their implications are shown in Tables 1 and 2 and detailed in Supplemental Text 2.

Methods

I use four steps to calculate population. First, I estimate the number of inhabitants of each patio of the residential area in its mature state (whatever type this state pertains to). Next, I calculate the average number of inhabitants per type of patio in the mature state (Supplemental Table 1). Third, I assess the average number of inhabitants per type of patio for the Early Classic state based on the inferred mode of growth (Table 3). Finally, I multiply this average number per type by the extrapolated number of occupied patios of that type during each subphase of the Early Classic sequence, corrected for insufficient dating and lack of aboveground visibility (detailed in Supplemental Text 3). Adding the totals for each type of patio gives the population of the site.

Step 1: Calculation of the Number of Inhabitants for Each Patio in Its Mature State

I expressed the estimated number of inhabitants as a range. I used two approaches, each with two factors.

Method A: Factor of Inhabitants per Residential Structure. The first approach consists of multiplying the number of residential structures by a factor of inhabitants (for caveats, see Canuto et al. 2018; Culbert and Rice 1990; Kolb et al. 1985). A critical element is the definition of the "basic unit of production and reproduction" (Jongsma and Greenfield 2003:21; see also Wilk 1988:136).

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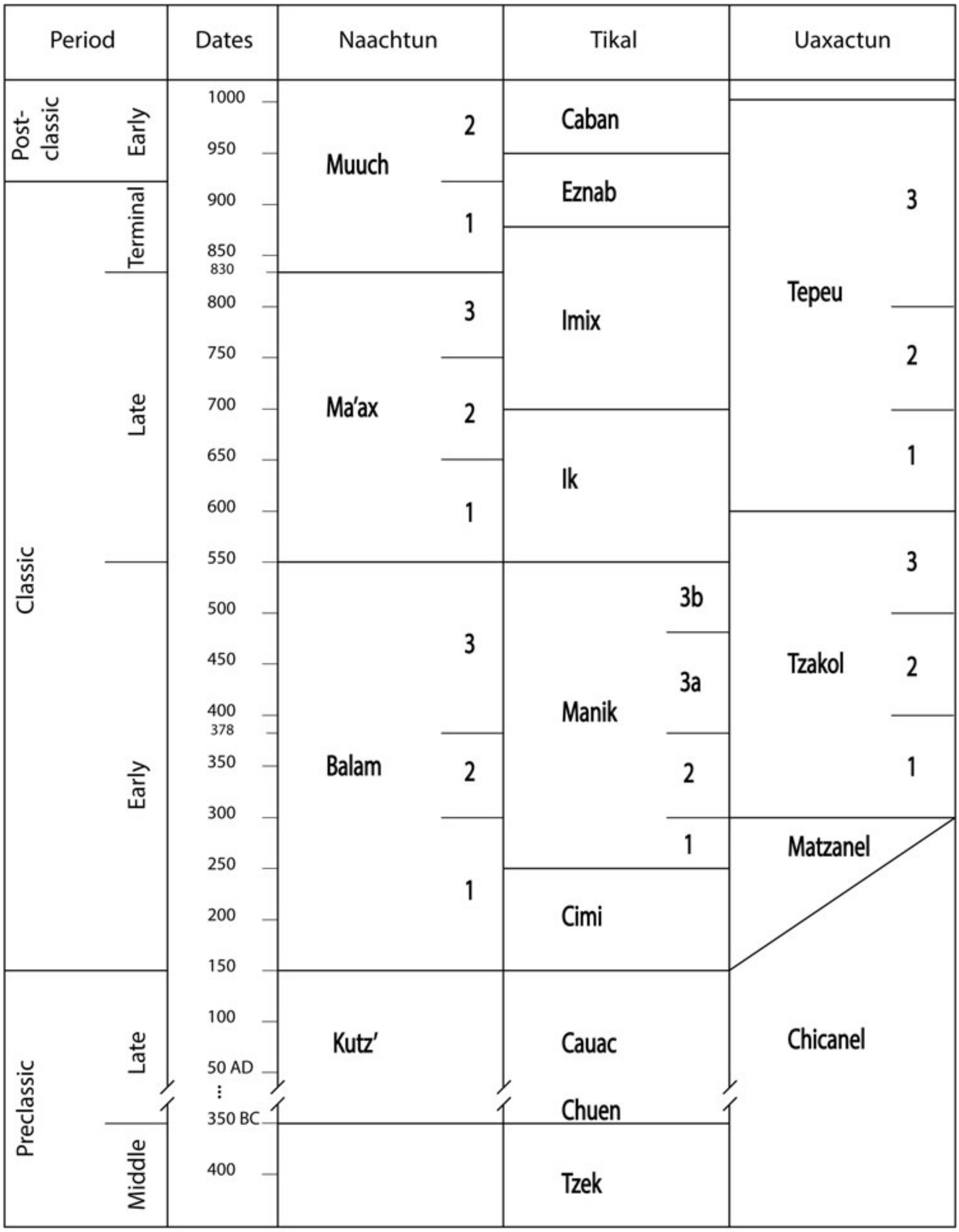

Figure 3. Chrono-cultural sequence of Naachtun.

In Maya demographic studies, the concept of the nuclear family, which is sometimes used (Garrison and Dunning 2009:531; Haviland 2014:149; Ortega-Muñoz et al. 2018:595; Tourtellot 1990:85; Webster and Freter 1990b:48), may prove too restrictive if one considers that grandparents, a widow, or recently married stepchildren may be part of the minimal group of people living together (Haviland 2014:149). The concept of household is thus more appropriate (Ashmore 1981:47). A clear-cut definition that distinguishes the household (persons) from the household cluster (the architectural and archaeological remains associated with the household's life; sensu Jongsma and Greenfield 2003) avoids conflation of a structure or a residential cluster with a household. Clusters and households did not necessarily coincide: many households used more than one structure,

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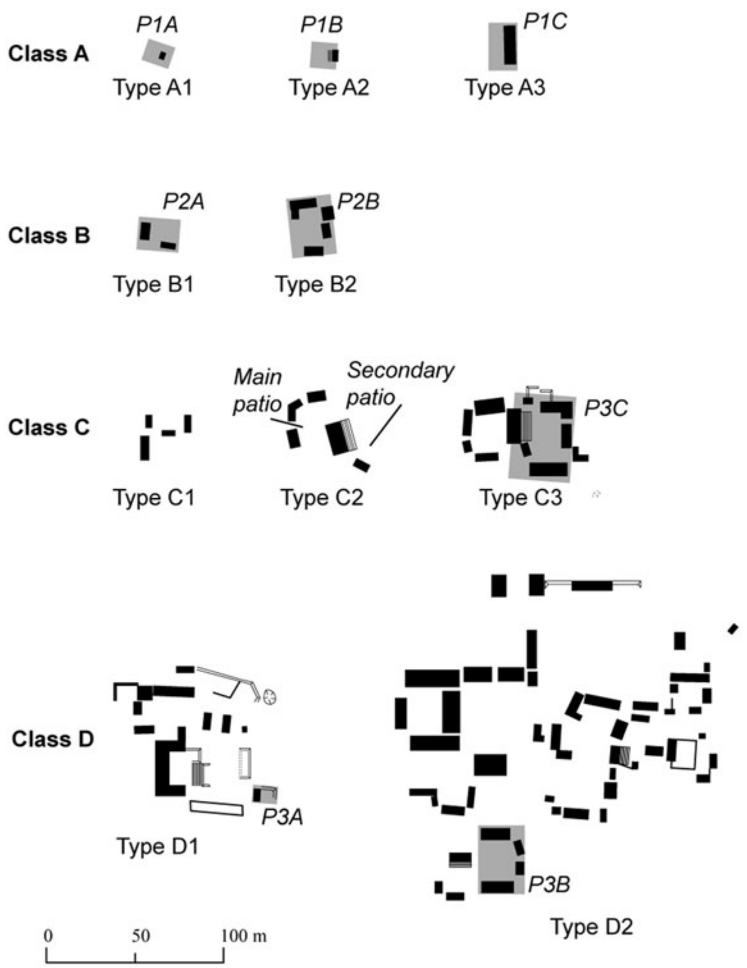

Figure 4. Example of each type of residential unit and patio (in gray).

and many residential clusters contained more than one household. Here, I limit household to its social meaning. This is important because most ethnographic numbers of inhabitants are averages per household, not per structure or residential cluster. Applying this factor to a structure is only one solution among several.

A factor of 5.6 persons per household, partly drawn from Redfield and Villa Rojas's (1934) twentieth-century ethnography of Chan Kom, Yucatan, is often used (e.g., Canuto et al. 2018; Nelson 2004:6). Note that this was the average divided over one or more structures, not the average per individual structure, much less per room. This factor is frequently applied to the number of strictly residential structures (i.e., dormitories) and not counting ancillary structures, kitchens, shrines, and altars. Others have proposed inhabitant factors for household size of 4 (Sanders and Price 1968) or 6.3 (based on the census of the more traditional Maya community of X-Cacal [Villa Rojas 1945]).

I use the interval of 4.0–5.6 inhabitants per residential structure and define nonresidential structures based on mound size and morphology (Ashmore 1981; Chase and Chase 2014). They are usually smaller than residential structures and generally fewer in number. Archaeologists and ethnologists note that, in a patio with more than four structures, at least one is not residential, and that patios seldom have more than two nonresidential structures (Ashmore 1990; Breton 1990; Haviland 2014; Tourtellot 1988). Applying these criteria to Naachtun, I obtained a figure of 173 nonresidential mounded structures (29% of the 603 structures). This is higher than the 16.5% that Haviland

Table 1. Residential Unit Typology and Criteria.

Residential Unit Class		Residential Unit Type				
Code	Criteria	Code	Criteria	*N*	Tested?	Observations Relating to Date
A	Isolated structure	A1	Small (<10 m^2), non-residential	6	No	
		A2	Middle and large	20	Yes	3/6 tested have Early Classic occupation
B	Single-patio residential Units	B1	2–4 (unvaulted) structures	22	Yes	8/9 tested have Early Classic occupation
		B2	3 (⩾1 vaulted)–8 structures	27	Yes	10/11 tested have Early Classic occupation
C	Smallest multi-patio residential units	C1	2 or 3 loosely linked small patios	3	No	Supposed lack of Early Classic occupation
		C2	2 unbalanced patios	11	Yes	6/7 tested have Early Classic occupation in one of the patios
		C3	2 balanced patios	16	Yes	9/10 tested have Early Classic occupation in one of the patios
D	Largest multi-patio residential units	D1	More than 3 large patios, short and late occupation	3	Yes	0/3 tested have Early Classic occupation
		D2	More than 3 large patios, long occupation	11	Yes	10/10 tested have Early Classic occupation, but not in all patios

(1965) calculated for Tikal or the 14.3% that Tourtellot (1990) proposed for Seibal, but much lower than the percentage of approximately 45% proposed by Inomata and colleagues (2018:27–28) for the rapidly abandoned Late Classic sites of Aguateca and Cerén.

Method B: Average Amount of Roofed Space per Inhabitant. The second method infers population from the roofed area per inhabitant as estimated from ethnographic data. Far-fetched applications—see explanations by Schacht (1981)—of Naroll's (1962) cross-cultural study give an average of 10 m^2 per inhabitant. Becquelin and Michelet (1994) give a more contextualized Maya figure, which is consistent with the Mesoamerican figure provided by Kolb and colleagues (1985), of 8.36–6.87 m^2 of roofed space per inhabitant; this estimate is based on the work of Breton (1990) among the Tzeltal of Chiapas and on Gougeon's unpublished data on the Yucatec community of Xculoc, Campeche (data obtained, respectively, in the 1980s and 1970s). Neither estimate includes independent granaries, but both include the surface area of kitchens, given that ethnographic research shows that some individuals slept in the kitchen (Redfield and Villa Rojas 1934). I therefore applied Gougeon and Breton's figures to all residential and nonresidential structures except pyramidal shrines (easily recognized given their location to the east or at the center of the patios; Becker 1982, 2003; Chase and Chase 2014:9). For vaulted structures, I used the 3:1 ratio of mound to roofed surface obtained from the complete excavation of Residential Unit 5N6 (Goudiaby 2018), which is also the ratio obtained by Lemonnier (2009) at La Joyanca, Guatemala. For nonvaulted structures, I used Lemonnier's estimate from La Joyanca, of 1.5:1.

Step 2: Calculation of the Average Number of Inhabitants per Type of Patio in Its Mature State

I used the four inhabitant factors to obtain a range for each patio in its mature state and used this range to calculate the range of the average number of inhabitants per type of patio (Supplemental Table 1).

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Table 2. Patio Typology and Criteria.

Patio Class	Criteria	Patio Type	Tested	Growth between Early and Late Classic Periods
P1	Isolated structure	P1A	No	
		P1B	Yes	Vertical possible
		P1C	Yes	Vertical theoretically possible
P2	Single-patio residential units	P2A	Yes	Vertical possible
		P2B	Yes	Major change, horizontal and vertical
P3	Multi-patio residential units	P3A	Yes	Vertical possible
		P3B	Yes	Change, horizontal and vertical
		P3C	Yes	Major change, horizontal and vertical

Step 3: Calculation of the Average Number of Inhabitants per Type of Patio in Its Early Classic State

For each type of patio, I inferred the average number of residences and approximate roofed area (minus shrines) for its Early Classic stage from models of the growth of patios and residential units; I then assigned a range of inhabitants following the combined approach of inhabitants per residential structure and the square meters of roofing space per person. The range for the Early Classic period relies on two assumptions: the average maximal number of inhabitants per residential structure was lower (5 instead of 5.6), and residential structures were fewer than in the Late Classic period (Table 3).

Step 4: Calculation of the Total Number of Inhabitants at the End of Each Subphase of the Early Classic Period

Finally, I multiplied the inhabitant factor per patio type by the number of occupied patios of this type at the end of each subphase of the sequence. I obtained the number of occupied patios from a program of test pitting of Naachtun's residential area (Hiquet 2020). Along with full excavation of an entire residential unit, 5N6 (Goudiaby 2018), this program enabled us to build a robust, high-resolution occupational sequence (Figures 2 and 3; see Supplemental Text 4). The 98 1.5×1.5 m test pits covered 46% of the residential units (55/119) and 40% of the patios (89/226). Supplemental Table 3 summarizes the rate of occupation of each patio type during each subphase. Because a test pit does not capture all occupations, I decided to increase the number of patios occupied during each subphase by 5% (Supplemental Text 4), except in those cases where the typologies of growth suggest an absence of occupation for a given period. I also made corrections to the raw figures (given in Supplemental Table 3) for invisibility and contemporaneity (see Supplemental Text 3).

Modeling Occupational History

Although the Late Preclassic population remains particularly difficult to assess, I extended the methodology into this period to contextualize the Early Classic rise of Naachtun. I estimate that at the end of the Late Preclassic period, the site numbered between 183 and 289 inhabitants (Figure 5). During the Early Classic period, the population of the residential area never exceeded 1,300 inhabitants. The low estimate sees growth from 665 to 745 inhabitants between the end of Balam 1 (AD 300) and the end of the Early Classic (AD 550). The high estimate sees growth from 1,004 to 1,276 inhabitants. I consider the high estimate more likely, because the lower bound sometimes gives a result of less than one person per building in a patio. The maximal Early Classic population was about half the size of the Late Classic apex population (AD 800), which I estimate at 1,642 to 2,491 inhabitants.

Discussion

Contrary to expectations, Early Classic residential units are proportionately more numerous at Naachtun than at many other Petén sites. The major Early Classic cities of El Zotz (Garrison et al.

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Table 3. Number of Inhabitants per Patio of Each Type for Each Subphase.

		Kutz'		Balam 1		Balam 2		Balam 3		Ma'ax 3	
Residential Unit Type	Patio Type	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
A1	P1A	—	—	—	—	—	—	—	—	—	—
A2	P1B	2	5	2	5	2	5	2	6	2	6
	P1C	4	5	4	5	4	5	4	6	4	6
B1	P2A	5	7	5	7	5	7	5	8	5	8
	P2B	4	10	4	10	4	10	4	11	4	11
B2	P2A	6	9	6	9	6	9	6	10	6	10
	P2B	7	10	7	10	7	10	12	21	12	21
C1	P3A	0	0	0	0	0	0	3	6	3	6
C2 Main patio	P3A	5	10	5	10	5	10	6	11	6	11
	P3B	5	12	5	12	5	12	6	14	6	14
	P3C	11	15	11	15	11	15	14	22	14	22
C2 Secondary patio	P3A	0	0	0	0	0	0	2	4	2	4
	P3B	0	0	0	0	0	0	8	13	8	13
C3	P3A	4	7	4	7	4	7	4	8	4	8
	P3B	7	10	7	10	7	10	8	14	8	14
	P3C	12	15	12	15	12	15	16	25	16	25
D1	P3A	0	0	0	0	0	0	3	6	3	6
	P3B	0	0	0	0	0	0	9	13	9	13
	P3C	0	0	0	0	0	0	12	17	12	17
D2	P3A	3	6	3	6	3	6	3	6	3	6
	P3B	8	10	8	10	8	10	9	13	9	13
	P3C	15	19	15	19	15	19	16	22	16	22

2019) and Yaxha (Gámez 2011) lack Early Classic residential units, which aggregate in specific sectors. At Naachtun, at least 55 (61.8%) and up to 70 (78.7%) of the 89 tested patios—a difference owing to uncertainty in the dating, as assessed in Supplemental Text 4—were founded before the Late Classic. None was proven to have been definitively abandoned before the Late Classic period, although sometimes no Late Classic construction stage was identified in the test pit for some patios. At least 41 (74.5%) and up to 51 (92.7%) of the 55 residential units were founded before the Late Classic and logically were not abandoned before the Late Classic period. The difference in the proportion of Early Classic occupation of patios and residential units demonstrates the growth of the latter between the Early and Late Classic periods.

Several moments in the sequence are of particular interest. The demographic rise between the Late Preclassic and Balam 1—an average annual rate of 0.8% over 150 years (Hiquet 2020)—is unlikely to have resulted from natural growth alone, given accepted trends for the period AD 150–300 (Ortega-Muñoz et al. 2018; Turner 1990; Wingard 2013). Immigration as an explanation would fit with (1) the regional upheavals occurring after the Preclassic collapse and abandonment of El Mirador; with (2) data from other sites with short-distance population shifts, namely San Bartolo-Xultun (Garrison and Dunning 2009) and El Palmar-El Zotz (Garrison et al. 2019); and with (3) data from preliminary excavations at Kunal, discovered by lidar survey less than 4 km east of Naachtun (Morales Aguilar et al. 2018), which suggest that this site, which was imposing in the Preclassic, had an Early Classic hiatus before a Late Classic revival. An Early Classic transfer of population from Kunal to Naachtun, early in this period—although impossible to prove for the moment—would fit with the two sites' sequences and with regional trends and would thereby explain Naachtun's demographic increase.

The steady growth later in the Early Classic is well within the few contemporary regional estimates (Fry 1990:292; Turner 1990:310; Webster 2018:43). Nevertheless, for the late Early Classic subphase (Balam 3), I hypothesize that the housing system may be closer to Late than to Early Classic patterns. At Naachtun, a shift in the mode of dwelling may have occurred sometime during the fifth or early sixth century, when more permanent, vaulted structures started to appear. A change in settlement patterns at the end of the Early Classic has already been noted at other Lowland sites, such as Caracol (Chase and Chase 2005:20, 2011:14) and peripheral Tikal (Fry 1990:292–293). It is possible that at the end of Balam 3, we should be applying the inhabitant factors of Late Classic period patios. The oldest standing structures in the residential area of Naachtun date to Balam 3, whereas only one structure, a shrine, dates to Balam 2 (Figure 6). The first vaulted structures may appear during Balam 3. Most pre-Balam 3 structures are covered by later architecture and have a very different orientation from the mounds in their mature version. This is why the "mature" states of the patio types are applied to Balam 3.

The number of occupied residential units and patios decreases in Balam 3, regardless of which of my proposed corrections for insufficient dating, contemporaneity, and invisibility issues are applied (Figure 7; Supplemental Texts 3 and 4). Yet the corresponding number of inhabitants increases if I use mature state figures of inhabitants per patio for Balam 3 and immature state figures for Balam 2. The number of inhabitants decreases slightly if I use Early Classic immature state figures for Balam 2 and Balam 3 and, more markedly, when using mature state figures for all subphases, which is incompatible with the excavation data.

This raises the question: How much does taking into account the difference in the number of inhabitants per patio between the Early and the Late Classic period, rather than just the rate of occupancy, affect the population estimates? The archaeological data clearly show that a marked morphological change occurred between the Early and Late Classic periods in many residential units of all sizes. Nevertheless, as a control exercise, I also calculated the Early Classic population using only the index of inhabitants obtained for the mature state of the patios (as in Supplemental Table 1). Results are on average 10% higher for the minimal and 20% higher for the maximal estimate. Although population estimates in general have a high margin of error, the change using this method is substantial. Leaving aside questions of scale and focusing instead on the direction of change (Houston et al. 2003:212), we see that applying a different average number of inhabitants per patio according to the phase modifies the direction of the demographic curve. The Balam 3 figures exemplify this.

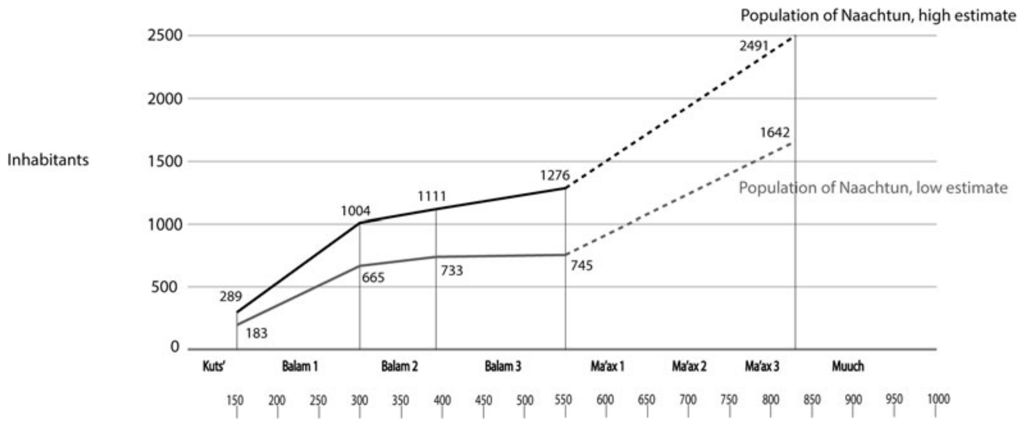

Figure 5. Estimated population of Naachtun at the end of the Kutz'; Balam 1, 2, 3; and Ma'ax 3 phases. The Late Classic curve is dashed to represent that in Ma'ax 1 and 2; the population of the growing Group B has not been taken into account. Ma'ax 3 figures include the population of Group B calculated with a different method (Hiquet 2020:288–290).

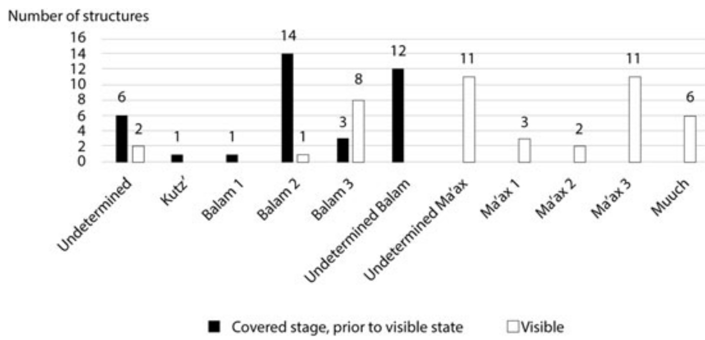

Figure 6. Construction date of 81 structures from Naachtun's residential area.

Conclusions

Although outnumbered and covered over by later constructions, Early Classic remains are omnipresent in the residential area of Naachtun. The historical and stratigraphic depth of residential units was often greater than expected: most residential units, whether complex or simple, were founded during the Early Classic period.

No easy, straightforward way exists to calculate the Early Classic, pre–demographic apex Maya population. Culbert and colleagues (1990:112) suggested that the "estimate of Early Classic population at Tikal is unusually dependent on factors that are poorly controlled" (see also Fry 1990:292). With most Early Classic residential structures being invisible at the surface, modeling from a more knowable state of the occupation is the only option. This approach involves a high margin of error and relies on various assumptions, including that social unit size was smaller during the Early Classic period than in later periods. Nevertheless, it is worthwhile to attempt to calculate the Early Classic population, because Early Classic residential units differ in morphology and size from their Late Classic counterparts. Significant differences between the Early and Late Classic periods exist both in the scale of residential groups and in the housing system. Early Classic residential units had fewer patios, and many patios served fewer structures than their Late Classic counterparts.

Residential dynamics do not suggest monolithic growth from the Early Classic foundation to the Late Classic climax. Tourtellot (1988) rightly assesses that, at any given time, there were residential units at every possible point in the developmental cycle and that, already during the Early Classic period, some residential units had reached their mature state or were in decline. However, at Naachtun, the large number of long-lived residential units, many of which become multi-patio clusters, suggests some continued growth for most of the residential area.

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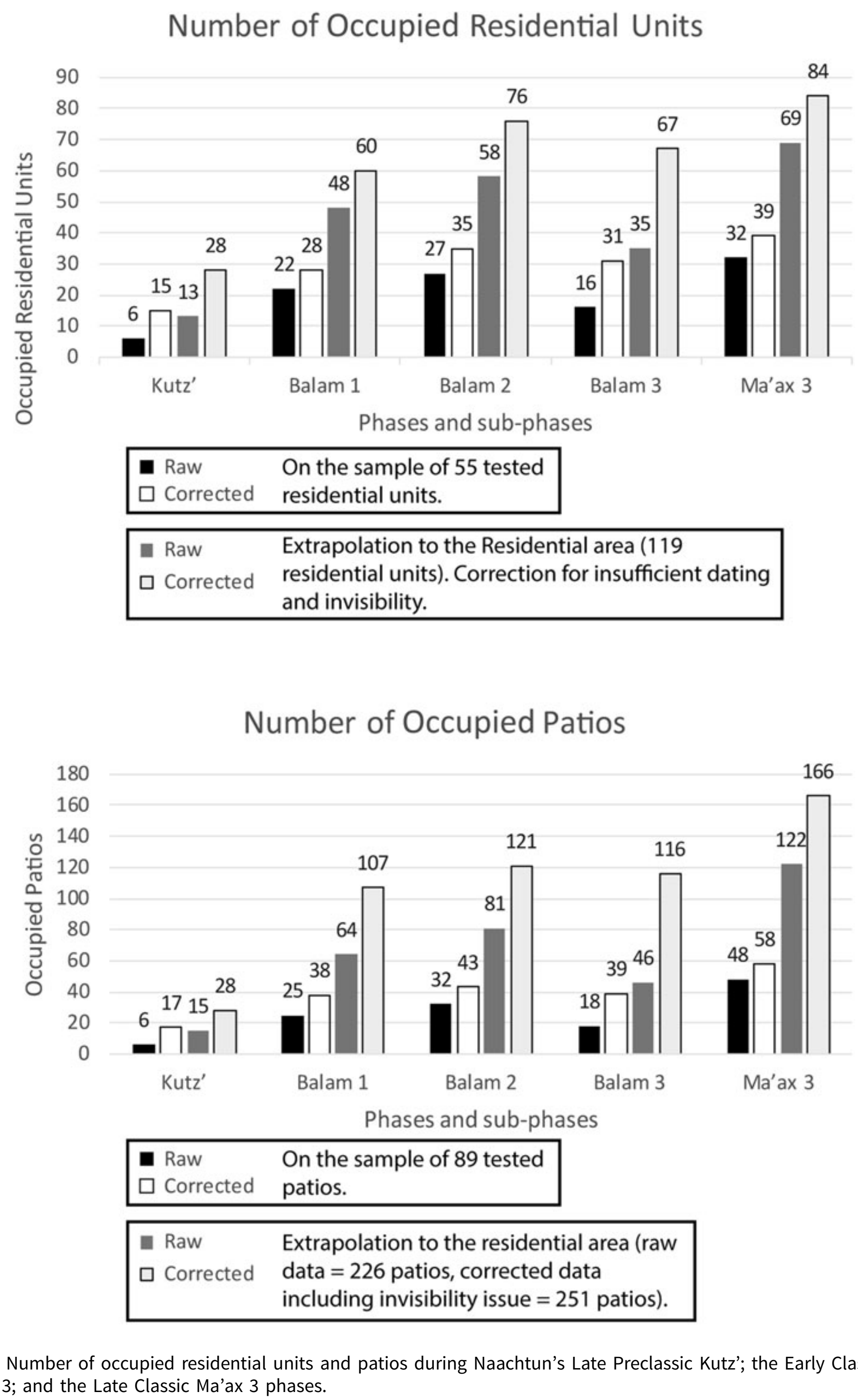

Figure 7. Number of occupied residential units and patios during Naachtun's Late Preclassic Kutz'; the Early Classic Balam 1, 2, and 3; and the Late Classic Ma'ax 3 phases.

For a site such as Naachtun with so much formal diversity in residential unit size, population estimates using residential units as the unit of calculation (to be multiplied by an index of inhabitants) would merge very different residential units and, hence, yield unrealistic results. This is why I consider the patio the more appropriate scale.

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However, because the varied types of residential groupings grew differently in the Early and Late Classic periods, I provide typologies at the scale of the patio and of the residential unit. Results reveal that the overall rate of occupation of residential units (i.e., without breaking them down by unit type) is not always a good indicator of trends in the number of inhabitants, because one multi-patio unit may contain more inhabitants than several single-patio residential units. In addition, using a specific index of inhabitants per patio for each period affects the population curve, causing it to differ from one based on extrapolation from the rate of occupancy.

Finally, it seems that Early Classic capitals, such as Naachtun, although endowed with prestigious regal dynasties that built monumental epicenters and engaged in long-distance trade and diplomacy, were home to only a small number of inhabitants: fewer than 1,300 in Naachtun's urban core, 1,185–1,750 in Waka's core (Marken 2011:238), and 3,861–5,372 in the urban core of Tikal (Webster 2018:41). Naachtun's core population would have sufficed to rapidly build most of the site's monumental architecture. However, to build the main pyramid, the city leaders had to draw labor from the hinterland of the recently founded capital (Hiquet 2020). To fully understand the scope of the power claimed by Suutz's kings on the stela of the region and the pyramids erected in their capital, the next step is to measure the extent of Naachtun's Early Classic territory and its hinterland population.

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Supplemental Material. For supplemental material accompanying this article, visit https://doi.org/10.1017/laq.2023.2.

Supplemental Text 1. The controversy over Copán's Early Classic population and its role in the development of methods to assess Early Classic population.

Supplemental Text 2. Details on the typologies of residential units and patios.

Supplemental Text 3. Corrections for contemporaneity and invisibility issues.

Supplemental Text 4. Methodological issues around dating.

Supplemental Table 1. Average Number of Inhabitants per Type of Patio according to the Four Factors of Inhabitants, Mature State.

Supplemental Table 2 [Referenced in Supplemental Text 4]. Proportion of Structures Identified for Each Phase at Tikal, by Type of Excavation (after Culbert et al. 1990:107–108).

Supplemental Table 3. Rate of Occupation of Each Type of Patio during Each Phase.

Supplemental Figure 1 [Referenced in Supplemental Text 2]. Profiles of Type C2 residential units where both patios were tested.

Supplemental Figure 2 [Referenced in Supplemental Text 2]. Profiles of Type C3 residential units where both patios were tested.

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