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Archaeological Population Studies in Mesoamerica

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Mesoamerica—located in the modern countries of Belize, Guatemala, Mexico, and parts of El Salvador and Honduras (figure 1.1)—is one of the few areas of the world that gave rise to a series of complex human societies over the course of some four thousand years, the best known of which are the Olmec, the Maya, and the Aztec. Although difficult to assess, knowing how many people lived at various ancient settlements is important for understanding and modeling these past human societies. Thus the need for this book.

Our last attempts to broadly estimate and compare ancient populations across sites in both the Maya area and central Mexico were undertaken more than three decades ago, using methodologies established by Kolb (1985) for central Mexico and by Culbert and Rice (1990) for the Maya area. Because of differences in how populations were estimated in these two regions, and because only limited archaeological samples existed, full comparison across the various regions of Mesoamerica proved exceedingly difficult. Much has happened since 1990, however, in on-the-ground archaeological fieldwork and in interpretations about the structure, organization, and economies of ancient sites throughout Mesoamerica (e.g., A. F. Chase and D. Z. Chase 2016a; Masson, Freidel, and Demarest 2020; Sabloff 2019), making a reevaluation timely.

Perhaps the most important reason for revisiting ancient population estimates is new technology. By providing information on settlement at a much larger scale, lidar (light detecting and ranging) has provided us with a view of ancient landscape use and modification that was not possible in the twentieth century (particularly within areas that have dense forest cover; see A. F. Chase et al. 2012). For example, lidar has provided data that show how large ancient Maya settlements could be, helping to end the debate on whether the ancient Maya were complex and had true

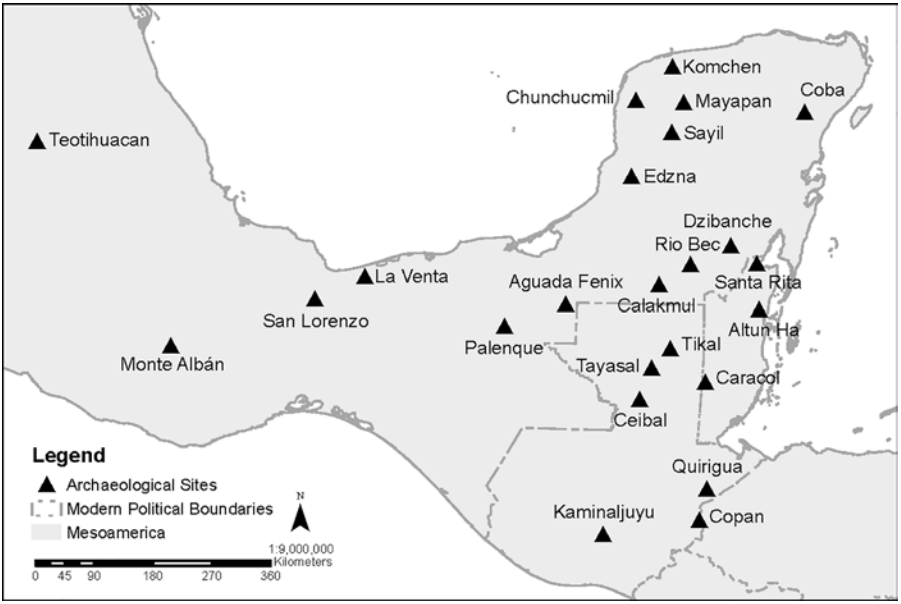

Figure 1.1 Map of Mesoamerica, showing boundaries of modern countries and a selection of the hundreds of settlements that cover this landscape. The original settlements and areas included in the 1990 volume by Culbert and Rice included sites mostly in the Maya area (Copan, Quirigua, Seibal, Tikal, Tayasal, Yaxha, upper Belize Valley, Nohmul, Santa Rita Corozal, Sayil, and Komchen), as well as brief commentaries on the Basin of Mexico, the Valley of Oaxaca, and trends over time. The current volume includes in-depth coverage of the Basin of Mexico, the Valley of Oaxaca, and the Gulf Coast area of Mexico, as well as new coverage in the Maya area (Chunchucmil, Puuc region, Coba, Rio Bec region, Peten of Guatemala, Caracol, Palenque, and Kaminaljuyu).

cities—and pushing us instead to understand their forms of urbanism and development within the context of other ancient communities (D. Z. Chase et al. 2023). Other technologies, as well, complement our understanding of ancient populations: isotopic analysis helps reconstruct population movement and migration (e.g., Arnauld, Beekman, and Pereira 2021); and ancient DNA analysis permits exploration of family and social relationships (e.g., Smith and Non 2022). Thus now, more than ever, we are clearly in a better position to estimate ancient population histories and relationships across Mesoamerica.

It is our hope that providing detailed considerations of ancient population histories for Mesoamerican sites will result in a comparable base for additional study. Population histories are fundamental to establishing the kinds of social, political, and economic systems that operated in the past as well as for making comparisons within and among regions. Using newer tools and methodologies for determining population numbers in ancient Mesoamerican settlements provides better data for modeling, interpreting, and understanding the past. This chapter provides background to ways in which population histories have been generated for ancient Mesoamerica and examines some of the issues that should be considered when calculating archaeological population estimates.

BACKGROUND

A key factor for almost any archaeological study is the reconstruction of ancient population. Population size and density are particularly important for considerations of societal complexity. Yet, no consensus exists about how best to derive such estimates, making solid comparisons among sites and regions almost impossible. Because of this lack of agreement, as well as because of the difficulties involved in such an exercise, many Mesoamerican researchers have not attempted to provide estimates of the number of people who once lived in their cities and settlements at particular points in the past. Mesoamerica is one of a half dozen areas of the world that witnessed the independent development of complex state-level societies (A. F. Chase et al. 2009; Flannery 1972; Spencer and Redmond 2004; Zeitlin 2000). Determining Mesoamerican population history is necessary both for understanding this trajectory and for cross-cultural comparison with other regions of the world. Developing common definitions and methodologies is a necessary prerequisite to these discussions, especially if our goal is to allow for comparative analysis.

While archaeologists have long made cursory estimates of the size of ancient settlements, population reconstruction became of greater interest in archaeology with a resurgence of theoretical proposals that population pressure was a major factor in the intensification of agriculture, changes in agricultural strategies, and the development of complexity (e.g., Boserup 1965; Carneiro 1970), something first articulated by Thomas Malthus (1826) on the issue of population growth outstripping food production at the onset of the nineteenth century. Not all researchers have viewed population as the dominant factor in driving change and growth, however, with some arguing instead that past societies grew and transformed for any variety of reasons apart from simple numerical increase (see Bender 1978; Bronson 1975; Cowgill 1975; Hassan 1974; Weiss 1976; and Wright and Johnson 1975).

Concern with establishing appropriate methodology for creating population estimates was expressed openly by early practitioners of processual archaeology (Binford 1968; Flannery 1969), precisely because of attempts to assess the role of population pressure as a major causal factor—as opposed to consequence of—social change (see Cohen 1977; P. E. L. Smith 1972; and Spooner 1972). While more recent approaches parse out different factors that can account for increase (e.g., Feinman 2013; Fogarty and Creanza 2017), they also support suggestions that population growth and organizational complexity are conjoined (Carneiro 1967; Sandeford 2018). Some societies, however, are incredibly complex even though they have fewer people (e.g., Vaesen et al. 2016). Yet, whether or not causal, the relationship between population size and organizational complexity (e.g., agglomeration) is also evident in urban scaling in both ancient and modern contexts (Lobo et al. 2020).

Much of the basic knowledge relating to the methods for reconstructing populations was established half a decade ago and summarized with the publication of Fekri Hassan's 1981 book *Demographic Archaeology*. Hassan detailed the ways in which archaeologists have estimated population, focusing on evidence from a cross-section of societies ranging from hunters and gatherers to complex state systems. He also examined the relationship between food production and population density in more recent and past societies, critiquing population pressure as being the only driver of change. He further detailed a paleodemographic approach to ancient populations, noting that researchers should consider mortality, fertility, and methods of population control (something now attempted in the Maya area; see Tiesler 2020).

Hassan's (1981) volume led to extended discussion over the use of paleodemographic methods in archaeology (e.g., Bocquet-Appel and Masset 1982; Chamberlain 2006; Gowland and Knüsel 2006; Hassan 2007). Since its publication, bioarchaeology has become a major field in anthropology, in which skeletal analysis of past populations has a bearing on population considerations, such as genetic relationships among individuals, place of origin for different individuals, and differences in diet among segments of a population. It remains unclear, however, how the samples of interments discovered by archaeologists relate to total population numbers, with the distinct possibility that remains uncovered by researchers represent only a small segment of any ancient society (see D. Z. Chase 1997, 26); thus, only infrequently has bioarchaeological data been used to estimate population numbers and histories in ancient Mesoamerica (but see D. Z. Chase 1990, 207, table 10.3; and chapter 3, this volume).

CALCULATING MESOAMERICAN POPULATIONS: BACKGROUND AND APPROACHES

Population studies in Mesoamerica not only have developed differently based on the environmental setting of a given center, but also have been influenced by assumptions prevalent in the earlier history of archaeology about the relative complexity of highland and lowland populations (see Sanders and Price 1968). The highlands were portrayed as being more complex, benefiting from extensive ethnohistoric literature related to the Aztec empire, its large-scale sociopolitical organization and long-distance trade connections. The tropical lowlands were viewed as not suitable for the internal development of large and dense populations or sociopolitical complexity (Meggers 1954). Any complexity seen in the tropical lowlands was viewed as having been introduced to the region from elsewhere, meaning that Maya researchers were forced not only to counter "received" knowledge (e.g., Coe 1957) but also to document early in situ complexity in the Maya area (Coe 1965). This set the stage for continued arguments over the overall levels of complexity reached by the ancient Maya (e.g., D. Z. Chase and Chase 1992, 2017; Ek 2020; Fox et al. 1996), in contrast to what was already assumed for central Mexico (Sanders and Price 1968). As stated by Rice and Culbert (1990, 7), "It is within the context of simplistic models of environmental productivity, subsistence adaptation, and societal organization that Mayanists first pursued settlement studies and demographic reconstructions in the Maya lowlands. As a result, characteristics of agricultural systems and their carrying capacities, and discussions of societal complexity have been inextricably associated with estimates of population size and density" in the Maya area.

Whereas intensive agriculture in the form of chinampas was ethnohistorically recorded in highland Mexico (Sanders and Price 1968), the ancient Maya were initially positioned in terms of twentieth-century agricultural practices, based on slash-and-burn subsistence farming, leading early researchers (e.g., Sanders 1962, 1963) to posit the past existence of a less complex society with local, agriculturally limited population levels. The agricultural basis for such interpretations was eventually recognized as being fundamentally flawed, as more intensive forms of agriculture were recorded (A. F. Chase and Chase 1998; Harrison and Turner 1978; Turner 1974, 1983; Turner and Harrison 1983). Newer remote sensing technologies have firmly demonstrated the use of intensive agriculture (e.g., Beach et al. 2019; A. F. Chase et al. 2011), as well as the long-standing sociopolitical complexity of the ancient Maya peoples (Canuto et al. 2018; A. F. Chase et al. 2014a; Hansen et al. 2023; Inomata et al. 2018, 2020).

For ancient Mesoamerica, many of the basic precepts of demographic archaeology were codified in an article by Kolb (1985, 582), who reviewed methods of estimating prehistoric populations, grouping them into six categories: "(1) skeletal and other mortuary remains . . . ; (2) artifacts assemblages and subassemblages related to food preparation, storage, and consumption . . . ; (3) food remains . . . ; (4) surface refuse or ceramic (sherd) densities . . . ; (5) architectural features such as roofed over space . . . ; or (6) calculations of mean family size." Kolb (1985, 582) further noted that Mesoamerican archaeologists tended to focus on the last three methods and that such methods "of estimating archaeological populations are ultimately based on ethnographic analogies and/or archival or ethnohistoric research." Foundational to these reconstructions is the size of family and household units. Thus, the archaeological literature contains extended discussions about family units, with the goal of establishing an average family number that can be applied to all archaeological contexts. Similar discussions exist regarding what constitutes and determines a household (e.g., Wilk and Rathje 1982). In practice, mean family size and architectural features (Kolb's fifth and sixth categories) traditionally have been conjoined as a single method of evaluating archaeological population size, meaning that only two general methods are broadly used in the field (surface refuse or family size relative to architecture).

Identifying a common family size for ancient residences remains difficult. Within the Maya area, the family-size number focused on is 5 people per residential unit (defined as a single dwelling capable of supporting a nuclear family), based on researchers' (Haviland 1972, 138; Ricketson and Ricketson 1937, 16; Willey et al. 1965, 576) interpretation of ethnographic data provided by Steggerda (1941) and Wauchope (1938). In central Mexico, a figure of 5.5 people per household is generally used, based on Kolb's (1985) and other researchers' (Charlton 1970; Diehl 1970) calculations, but occasionally other numbers are also considered. For instance, for the Mexican site of Teotihuacan, Michael E. Smith and colleagues (2019, 414) adopt the 5.5 figure but also use higher figures, of 7.4 and 9.7 (assuming the presence of extended families), based on ethnographic data about household size provided by Carrasco (1976). Haviland (1972, 137), however, cautioned that "it seems risky to assume that aboriginal household size and composition were the same as in the twentieth century." Indeed, there are indications that household sizes at the time of contact may have been substantially larger than the 5.5 figure, ranging from 7.3 to 25 persons in either multiple nuclear or extended families that resided in the same dwelling (e.g., Calnek 1972, 111; Culbert and Rice 1990, 18; Haviland 1972, 138). Therefore, simple assumptions of family or household size can be problematic even across a single site or region.

Not only is family size important, but so too are the physical manifestations of houses and households on the ground. Of paramount significance is the definition and identification of what is considered to be a "house" by a given researcher. Some researchers suggest that individual structures represent individual houses and households, while others focus on larger groupings or units of multiple structures with varied uses as representing a single household. For instance, at Teotihuacan, the groupings of spatial units within apartment compounds are used as a proxy for family units, which can then be translated into population numbers (e.g., M. E. Smith et al. 2019). In the Maya area, archaeologists generally have focused on mounded and raised constructions to estimate the size of general site populations.

Bench space within Maya palaces has also been used to assist in estimating population, as the benches are considered to represent sleeping space. The total sleeping area is then used to calculate the elite population, who resided in stone buildings, as was done for Uaxactun, Guatemala (R. E. W. Adams 1974, 292). The size of a general population has sometimes then been inferred based on assumptions about the ratio of elite and nonelite living at a site (for Uaxactun, this was 184 elite out of a total estimated population of 8,849 [the elite were viewed as being approximately 2 percent of the population], a figure supported with inferences about agricultural carrying capacity). Millon (1970, 1080) also initially calculated sleeping space based on room types in apartment compounds to estimate population at Teotihuacan but ultimately transposed an average sleeping space onto the areas of apartment compounds to estimate a total population of 125,000 people for that city, later revised to between 150,000 to 200,000 people (Millon 1974, 355). More recent estimates of the overall population of Teotihuacan have been between 85,000 to 100,000 (Cowgill 2015, 141–43) or from 56,591 to 146,878 based on architectural form (M. E. Smith et al. 2019, 415). Architectural living space can similarly be calculated from lidar data and translated into population estimates (see chapter 3, this volume).

Besides considerations of mean family size or household size to determine a factor that can be applied to archaeological house remains, Mesoamerican researchers have also focused on Kolb's (1985) fourth category—surface refuse and sherd density. This method has been applied predominantly in areas where surface remains are more visible (due to lack of vegetation), such as in the Mesoamerican highlands around the Basin of Mexico and the Valley of Oaxaca (see Kowalewski et al. 2009; and Ortman et al. 2014). This approach was largely modeled on earlier endeavors to estimate archaeological populations using sherd scatter and area outside Mesoamerica, specifically in ancient Mesopotamia, where the area of archaeological sites was multiplied by a set figure—usually around 200 people per hectare.

The number used in Mesopotamia was derived from modern population data (R. McC. Adams 1965). Further archaeological work in Mesopotamia carried out by Kramer (1980), however, suggested that the number being used as a multiplier was too high (also a possibility for current Mesoamerican estimates), and Hassan (1981, 67) expressly noted "that correlations between site area and population drawn from modern contexts cannot be applied to archaeological contexts without reservation." Yet, because of the ease of application, the ability to cross-compare, and the lack of mounded structures, this methodology was widely adopted in the Mesoamerican highlands. In the lowland Maya area, however, when surface survey has been employed, it generally has been used not to generate population estimates but rather to gain clues about basic periods for which a given site was occupied (e.g., Killion et al. 1989; Smyth, Dore, and Dunning 1995).

Ceramic materials have also been used in Mesoamerica in attempts to derive family size through the total numbers of ceramic vessels in use by any given household (Inomata and Triadan 2010; Plunket and Uruñuela 1998; Sheets 2002; Straight 2017). This approach to determining family size is based on ethnographically recorded numbers of ceramic vessels that were used in modern households in both Mesoamerica (Kirkpatrick 1977; Deal 1998) and elsewhere (David 1972). A major limiting factor in using such an approach, however, is that in situ ceramic vessels associated with archaeologically recovered households are only rarely encountered, thus making this approach difficult to apply widely.

Other techniques have been used to derive population estimates. One approach involved determining carrying capacity and subsistence areas, as was done by Sanders, Parsons, and Santley (1979), in conjunction with surface surveys to generate population estimates for the Basin of Mexico. This approach has been infrequently used in the Maya region, being employed for both Uaxactun (Adams 1974, 292) and Tikal (Dickson 1980; Lentz et al. 2014; Webster 2018) as a secondary method to help support or validate estimates developed by other means. Carrying capacity, in combination with population estimates, has also been used to suggest that food needed to be imported at major Maya cities like Tikal and Calakmul during the Late Classic period (Dahlin and Chase 2012); similar projections at Chunchucmil, Mexico, also strongly suggested that food was imported into that city (Dahlin et al. 2005). While carrying capacity highlights limitations on population based on local food supply, some foodstuffs could be exchanged for up to 275 kilometers by foot (Drennan 1984, 28–29) and even farther by canoe (Laporte, Adánez, and Mejía 2008).

A recent analysis of the foods and nutrition available to ancient Maya populations concluded that "essential dietary needs of ancient Mayas could have been met on the basis of available locally-produced (procured) foods" (Wong, Rebeiro, and Gomes 2017, 414). While asserting that this could constitute an alternative way to derive population estimates, especially when human waste is considered (Wong 2018), this analysis did not consider consumption of freshwater fish or trade in foodstuffs for generating population estimates. Carrying capacity, like other methodological approaches, is not without its issues for establishing population size. Hayden (1975) was very critical of applying the concept of carrying capacity to human beings because of the difficulty in linking potential food with a given population and its resource environment. Carrying capacity methods likely provide only a floor for establishing population numbers and not a ceiling because of the interconnectedness of ancient communities and environmentally external factors such as ancient trade and exchange.

Drennan, Berrey, and Peterson (2015, 12–14) note the use of simple counts of radiocarbon dates as a way of generating population estimates for mobile Neolithic populations. In the Maya area, an early variant of this approach was attempted by Sidrys and Berger (1979) to examine the ebbs and flows of population at the time of the Maya collapse; subsequent researchers generally did not employ these methods because of the potential sampling bias inherent in decisions to run Maya radiocarbon samples. A premise of this method is that the carbon samples selected for analysis match the amount of burning in the past; however, different research designs, sampling strategies, and project excavation and budgetary decisions about which samples to run make this method less reliable for actual population estimates across research sites and projects (see also Carleton and Groucutt 2021). When they have been used, however, it has been noted that radiocarbon "plateaus" can also skew such dating (e.g., Hoggarth et al. 2014).

A more recent approach to using C14 dates to estimate population reexamined the data from Tikal, Guatemala, suggesting that the results matched the excavated data (Price et al. 2021). This conclusion is not surprising, however, given that the radiocarbon dates were preselected by the archaeological excavators for publication in the articles used by the later researchers. In fact, the archaeological excavators rejected some 25 percent of the overall Tikal date sample (n = 23), and these were not included in the later analysis. The full suite of dates, however, is published in the site report (Coe 1990, 807–11), which also notes that nearly 40 percent of the C14 dates at Tikal did not match their stratigraphically dated contexts (out of eighty-nine dates).

In summary, there has been no lack of innovative attempts to derive meaningful population estimates in Mesoamerica. In practice, however, we have settled into two basic techniques with a few variations. We describe these in greater detail below and then use these approaches as springboards to look at next steps that can be taken to better incorporate advances in archaeological method and modern technologies. Remote sensing techniques, such as lidar, now provide greater and better coverage of ancient landscapes, resulting in much larger population estimates for many Maya sites and simultaneously forcing a reanalysis of our current methodologies for estimating ancient population.

ESTIMATING POPULATION FOR ANCIENT MESOAMERICAN SETTLEMENTS

While multiple measures for estimating ancient populations have been proposed, as noted above, in practice the actual determinations of such counts in the Mesoamerican archaeological record have generally been established using two methodologies that were crystallized some forty years ago. In the highland regions of Mesoamerica and other areas that were drier, where remains were less obscured by dense tropical vegetation, and where the reconnaissance of large areas was often possible, surface ceramic (and artifact) distribution and density was used to produce both estimated population numbers and site size. In limited cases, when appropriate archaeological data were available, considerations of roofed space (and unroofed space in *plazuelas* or patio groups) were incorporated. Recovered surface materials have also been used to discuss craft production and markets (Feinman and Nichols 2021).

The approaches used in the highlands were different from those put into practice in the wet and canopy-covered lowlands, where it was more difficult to undertake large-scale survey and mapping and where surface sherd materials were lacking because of the build-up of decomposing leaf litter over the centuries. Thus, in the lowlands, population estimates tended to be derived from structure counts in partially mapped and sampled areas of sites combined with temporal estimates of occupation largely gained from test pits.

Both of these methods have strengths and weaknesses.

METHODOLOGY 1: LOWLANDS

The equation of individual mounds with family houses can be traced back to at least 1886, when Edward Thompson used the "principle of abundance" in the northern Maya lowlands to identify mounds as residences (Ashmore and Willey 1981, 6). These mounded structures could be counted, defined as a particular kind of settlement unit, and used to generate an estimate of past population. This technique was particularly useful in the Maya lowlands, where most structures were raised or mounded and had little related artifactual material visible on the surface. After the mounded structures were counted, factors were applied for function and contemporaneity, with the remainder being multiplied by projected size of the occupying family. This method was first firmly established for Tikal, Guatemala, by William Haviland (1969, 1972) and then refined and widely adopted by other Mayanists (e.g., Culbert and Rice 1990; see Webster 2018 for a critical review). The categorized method focused on the equation of a single mound with a single residence, but with the important caveats that not every mound may have been a house mound, meaning that some correction factors needed to be applied for contemporaneous occupation, and that not all structures were continuously occupied across time. Rice and Culbert (1990, 14–18) saw the issues involved in using this method as being compounded by the following factors: (1) nonplatform and hidden structures; (2) nonresidential structures; (3) establishment of contemporaneity; (4) disuse of a structure; and (5) estimated family size. Subsequent research has considered, but not resolved, these issues.

Settlement research in the Maya area demonstrated that many house mounds were organized into what were termed "*plazuela* groups": "The typical Classic Maya household was made up of not one but from two to five houses—single, small, isolated buildings assumed to have been residences of single nuclear or biological families (Willey 1981:388–389)—arranged around the edges of a small plaza" (Haviland 1988, 121). Thus, counting these individual mounds, excluding some for being nonresidential or disused, and multiplying the number of mounds by a set factor of family size was viewed as being able to yield population estimates. Two main difficulties in employing this technique were site size and temporality. Before the advent of lidar, the full areal extent of sites was often difficult to ascertain because of the jungle conditions. Site size was usually determined by means of narrow survey transects that extended out from monumental architecture to enable projections of structure density and population drop-off (A. F. Chase 1988; Puleston 1983; see also Ford 1986). Temporality was generally gained through the placement of small test pits into the plazas (or sometimes structures) of given *plazuela* groups, then categorizing the recovered sherd material by phase (e.g., A. F. Chase 1990; Culbert 1973; Culbert et al. 1990). Assuming that this was done in a systematic way and with a large enough sample, it was believed that population change over time could then be estimated and compared across sites (e.g., Culbert and Rice 1990).

This method was operationalized by involving settlement pattern researchers in a 1985 SAA session that resulted in a published volume summarizing population trends for the entire Maya area (Rice and Culbert 1990, 12–13). This group operated on the premise that equivalently surveying sites for size provided the opportunity for cross-site comparisons. Yet, comparably surveyed samples were not always available. Since the 1990 volume was published, Maya researchers have generated much more information on ancient Maya settlements, enabling more robust cross-site comparisons.

METHODOLOGY 2: HIGHLANDS

The second method used for population estimation in Mesoamerica derived from measures of sherd density over a delimited area, using these measures to provide an estimate of population per hectare, and then incorporating the surveyed area to provide numbers of hectares occupied by a given settlement. As outlined by Santley (1990, 335), several assumptions lay behind the sherds-equal-people method: (1) "all time periods from which the materials derive must be of equal duration"; (2) there is "little change in the generic composition of ceramic assemblage from one time period to the next"; (3) "postdepositional processes should not obscure surface deposits"; and (4) "garbage disposal must involve discard near residences" because "the lower the population density, the greater the likelihood that there will be vacant space available for trash middens near the residence," as in "the Gulf Coast" and "the Maya lowlands."

The surface survey population reconstruction methodology was established in the regional surveys of the Texcoco and Ixtapalapa areas by Jeffrey R. Parsons (1971; Parsons, Kintigh, and Gregg 1983) and Richard Blanton (1972). The Basin of Mexico population numbers were established in 1979 (Sanders et al. 1979), and since then, these projections have received only minor updates (see Ortman et al. 2014 for a summary of population estimates in the Valley of Mexico; see also Gorenflo, Robertson, and Nichols, this volume). Similar methods and synthetic statements were also put into place in Oaxaca (e.g., Blanton et al. 1982, 1999; Fish and Kowalewski 1990; Kowalewski et al. 1989, 2009; see also Feinman, this volume), even though researchers in the Valley of Oaxaca and the Basin of Mexico had rather heated arguments with each other over the interpretation of settlement patterns and basic archaeological data (e.g., Blanton, in his commentary on Sanders and Nichols 1988, 52: "It is difficult to know where to start a commentary on such a convoluted mess of illogic, misinformation, and epistemological crudity"; compare also Blanton et al. 1999 with Marcus and Flannery 1996; Zeitlin 2000). For the most part, the techniques used to estimate populations relied on the surface density and areal extent of sherd materials with only slight modifications being made for residential household counting where such a tabulation could be undertaken (Santley 1990).

Within the survey method, population estimates were based on sherd counts per square meter, categorized as ranging from very light ("one to two sherds may be present every few meters" indicating "2–5 persons per ha.") to heavy ("a randomly placed 1-m square might produce 400–800 pieces of pottery" indicating "50–100 persons per ha."); Ortman et al. 2014, 4; see also Drennan, Berrey, and Peterson 2015, 34). Santley (1990, 334) earlier categorized the thought behind this as follows: "The amount of refuse discarded at a settlement varies in direct relation to site population"; thus, "occupational density" can be used "as a measure of the number of persons inhabiting sites"; "twice as many people deposit twice as much garbage;" and therefore, "density of surface remains, mainly pottery, is likely to be twice as high also." Drennan and his colleagues (2015, 34–35) provide the temporal component: "A higher value for the area-density index thus corresponds to more intensive utilization of the place during the period the sherds pertain to." But there are problems with these assumptions.

LIMITATIONS OF USING INDIVIDUAL STRUCTURES AND SURFACE SHERDS

The basic methodologies involved in population estimations were put into place some half century ago—before we had more analytical sophistication in interpreting the archaeological record and before the development of new geospatial techniques and technologies. When the methodology for population estimations was established in the Mesoamerican area, Michael B. Schiffer's (1987) book *Formation Processes of the Archaeological Record* had not yet appeared. Few archaeologists in Mesoamerica pondered the full formulation of archaeological contexts (but see Sheets 1974, 1978; and A. F. Chase 1983, 44–45). Most were not using laser theodolites for mapping. Earlier synthetic statements on archaeological method and theory did not deal with the hermeneutics involved in interpreting the archaeological record (e.g., Willey and Phillips 1958), and Mesoamerican archaeologists were noted for being highly traditional and not theoretical, as parodied by Kent V. Flannery (1976) in *The Early Mesoamerican Village*. In hindsight, we now need to reconsider several basic assumptions that form the basis for reconstructing population estimates in ancient Mesoamerica. For the highland regions, we need to ask: How can population estimates be directly linked to surface sherd density? And for the lowland Maya area, we need to query: Are mounds the unit we should be using for calculating populations? In both cases we need to consider the difficulty of assessing change over time, the number of individuals in a household or in a unit of space, and the full extent of any settlement.

While we believe that focusing on the architectural remains of houses for interpretation has great merit throughout Mesoamerica, there are actually very serious issues in estimating population counts based solely on individual, usually unexcavated, house mounds and in assessing the rise and fall of population levels over time based on limited testing of structures or structure groups. Although this technique has had application throughout Mesoamerica, it is primarily used in the Maya area. A key question is whether the mounds that compose a Maya residential *plazuela* group were each occupied by individual nuclear families, as Haviland (1988) originally suggested, or whether the entire residential group—with all of its structures—was used by a single extended family.

While on the surface these options appear similar, the latter premise would provide lower estimates than the former.

Early research by Sanders (1962, 98), building on that by Bullard (1960) in the Peten of Guatemala argued for the use of residential units focused on an extended family comprising approximately ten individuals in both highland Mexico and in the Maya area. Possibly because of his previous work at Barton Ramie, which had focused on larger platforms, Bullard (1960, 359) explicitly noted that he considered each residential plaza group—and not the two or more structures associated with the group—to be "an individual house." Other researchers, especially those undertaking settlement work at Tikal, Guatemala (Haviland 1963, 1965; Puleston 1973, 1983), instead focused on the individual structures or platforms as each being a house supporting a nuclear family. And this definition still largely persists.

In-depth research into the structures in Maya residential groups or *plazuela* units shows great diversity in how these units are composed. Becker (1982, 2003) categorized the *plazuela* groups at Tikal according to plans, arguing that function and other information from excavated plaza groups can be projected onto similar unexcavated architectural assemblages; his categorizations cover both public and residential architecture. Becker (1982; 2014, 308) speculated that the multiple structures in each residential group functioned like the rooms of a single house, contrary to the more general interpretation of residential groups at Tikal as being composed of multiple nuclear families each living within their own structure (Haviland 1988). As noted by Rice and Culbert (1990, 15), however, not all structures within *plazuela* or house mound groups were residential, something shown explicitly for Caracol residential groups, where eastern structures are generally ritual units (A. F. Chase and Chase 2014). A perusal of both Becker's (1999) and Haviland's (1985, 2014a, 2014b, 2015) published monographs on Tikal residential groups reveals a series of different building plans and purposes for the edifices included within these groups. The variability in the excavated structures that make up any Maya *plazuela* group makes it more likely that these groups contained more nonresidential structures than generally believed (partially conforming with ethnographic studies of modern Maya residential compounds showing that specific buildings had different purposes, such as for bathing, eating, sleeping, and storage [Killion 1990; see also Marcus

2004]). Thus, a focus on the residential group or patio group around a central plaza, taken as a whole, may be more appropriate for estimating population. These larger rectilinear patio groups are also more visible in lidar than many of the smaller individual structures supported on their surfaces (e.g., A. F. Chase, Chase, and Chase 2024; Hutson et al. 2016; Prufer, Thompson, and Kennett 2015; Ringle et al. 2021; Stanton et al. 2020; Yaeger, Brown, and Cap 2016).

Besides enhancing our interpretations of settlements with regard to dating, scale, and composition, current archaeological technologies and conceptual advances also highlight issues related to sampling. Most residential groups exhibit significant time depth in terms of their length of use (e.g., Becker 1999; A. F. Chase 1990; A. F. Chase and Chase 2013; Haviland 1985, 2014a, 2014b, 2015) and in how they physically developed over time. As such, it is difficult, but important, to assess this when reconstructing population histories. Dating of occupation can be difficult, even with excavation, especially if investigations sampled only a small part of any given residential group. Different residential plaza buildings or parts of the same plaza can produce variable temporal sequences and inconsistent pottery remains—something not always, or easily, garnered from a test pit in a residential plaza to gain a basic ceramic sample for dating. We demonstrated the issues with such sampling relative to the identification of Early Classic remains at Caracol (A. F. Chase and Chase 2018) and relative to Terminal Classic materials at both Caracol (A. F. Chase and Chase 2004) and Tikal (A. F. Chase and Chase 2008), where different ceramics were in use in different parts of the site at the same time, making assessments difficult without substantial excavation and cross-correlation across the site. While sampling can provide a meaningful idea of what was present in a given area in the past—so that statistical calculations can be made (Mueller 1975; Orton 2000; Plog 1978)—inferences become more problematic when the archaeological record is not largely homogeneous across temporal and spatial contexts and where there is variability in the form of status, wealth, and sociopolitical practices that can skew interpretation of recovered archaeological assemblages (e.g., A. F. Chase and Chase 2004, 2009; M. E. Smith 1987; see also Schiffer 1987). Thus, the impact of archaeological sampling needs to be addressed in any population history reconstruction.

Dating and sampling issues within the archaeological record have become even more important—and difficult—with the advent of lidar for recording ancient settlements in Mesoamerica (A. F. Chase et al. 2010, 2012), in that large areas of anthropogenic landscape are visible—areas much larger than can be easily assessed for temporality and function by limited excavation. Geospatial technologies like lidar are appropriately helping us to reevaluate what it means to be a single settlement. This is particularly acute in situations where sites, a basic building block for earlier archaeological surveys (e.g., McCoy 2020), now merge into one another within the lidar data. It also means that "our theories of culture change must account for the variation in settlement patterns over successively larger spatial scales or be discarded" (Balkansky 2006, 77). Yet, with these new remote sensing techniques, archaeologists have gained relative spatial control over vast areas of landscape (Canuto et al. 2018; A. F. Chase et al. 2014b; Hansen et al. 2023). Although these areas still need to be ground checked for lower, less visible remains, which have been referred to as "vacant terrain" and "nonplatform structures" (e.g., D. Z. Chase 1990; Rice and Culbert 1990, 14–15; Pyburn 1990), as well as archaeologically tested for temporal control (A. F. Chase et al. 2011, 393), the large areas of landscape coverage are permitting a much more complete view of ancient anthropogenic landscape modifications—and, importantly, better population estimations.

Another assumption that should be evaluated rather than assumed was that refuse is generally left to build up near houses. Following this premise, sherds or other artifactual remains found close to households have been used to date occupation. Yet, most ancient Mesoamerican settlements are multiphase and had long-standing occupation over a sizable temporal period; if refuse was moved, then careful analysis of context is necessary to indicate use during a contemporary timeframe. Although early settlement researchers in the Maya area felt that residential trash was deposited and left in the immediate vicinity of residential groups (Fry 1969; Haviland 1963; Puleston 1973; see also discussion and critique provided by Newman 2015 and Pendergast 2004, 242–43), this can no longer be assumed to be the case (e.g., A. F. Chase and Chase 2015, 19; Culbert and Kosakowsky 2019, 2). What is often described as debris on the ground in modern contexts (see an example provided by Drennan, Berrey, and Peterson 2015, 29) may be representative of what Schiffer

(1987, 65) calls "provisional trash" that was awaiting eventual recycling to some other location, but it could also have resulted from any number of archaeological formation processes.

Complex urban environments, like those that existed throughout ancient Mesoamerica, practiced garbage collection and movement of both trash and human waste, some deposited locally and some deposited at a distance from where it was produced (e.g., A. F. Chase and Chase 2015). The complexity of garbage deposition has been similarly noted in contexts outside of Mesoamerica (Needham and Spence 1997; Wilkinson 1982). Another issue is scale. While smaller, isolated residential groups may place some trash just outside their living areas, in more heavily populated societies, trash usually neither is left where it falls nor remains where it is originally left. Most ethnographic models for household trash deposition in Mesoamerica (e.g., Hayden and Cannon 1983; Killion 1990) are not based on urban contexts, but even here they point to detailed considerations of where trash is initially used and ultimately deposited. In areas of concentrated ancient Mesoamerican settlement, especially those that were occupied for any extended period, not only is the landscape extensively modified (A. F. Chase and Chase 2016b), but trash was likely similarly manipulated.

Residential garbage was being recycled into Maya agricultural fields along with night soil (A. F. Chase and Chase 1998); similar to ancient Near East cities (Wilkinson 1982). Trash was also being recycled into the fill for buildings, platforms, and construction efforts at any given Maya site (A. F. Chase and Chase 2015). Just as soil could be moved by the Maya over long distances (Turner 1978, 170), so too could trash. The Maya (and probably other Mesoamerican peoples) recycled items long before this process was adopted by the modern world, and trash disposal and reuse is certainly related to both sanitation and population pressures. Importantly, if trash was relocated, there can be no simple one-to-one correlation between amounts of trash and numbers of people in the Maya area—or probably elsewhere in Mesoamerica.

The heavy accumulation of sherds in a given location may indicate latest use (e.g., A. F. Chase and Chase 2020) or that a large amount of sherd material had been recycled into construction fill and had eroded to the surface—rather than representing the size of population at that locale or the temporality of the occupation. It may also not be representative of the duration of occupation. For instance, at Santa Rita Corozal, Belize, the extensive earlier remains were rarely represented on the ground surface (D. Z. Chase 1990), and structures sometimes contained extensive sherd fill that dated to an earlier time than the construction and use of the building and that could not be correlated with any constructions in the immediate area (D. Z. Chase and Chase 1988, 18).

Thus, the dating of occupation should explicitly consider whether artifacts derive from primary deposits or use-related materials left within or near a construction or whether they relate to earlier fill materials. Santley (1990, 335) explicitly noted this for Teotihuacan: "Where there should be little spatial congruity between location of use and location of discard is at sites such as Teotihuacan, where structures were built directly adjacent to one another." Santley (1990, 35) also noted that the methodology used in the Mexican highlands was dependent on occupation conditions that are "single-phase, short-term, and not deflated," combined with "archaeological and/or ethnohistoric controls on refuse disposal, specialized ceramic production, and population" that were met in the Basin of Mexico only "during the Late Aztec Period," thus further recognizing the precariousness of broad use of this methodology in other contexts.

Many of the same issues found in the Maya area regarding the use of residential groups and trash deposition in estimating population histories are also apparent in the archaeology of central Mexico. At Teotihuacan, patio groups located within apartment compounds are viewed as containing one or more houses, all occupied by nuclear families (e.g., M. E. Smith et al. 1989, 196). Calnek (1972, 111), in analyzing Aztec house and field complexes in Tenochtitlan, noted multiple buildings in the same compound and argued that they were occupied by "a bilateral joint family" consisting of an average of "10 to 15 individuals of all ages per site" (i.e., extended family units). Again, where and how refuse enters the archaeological record is important, and its categorization or labeling is often imprecise, making interpretation problematic (e.g., Newman 2019, 806). In some cases, it is called "midden," implying relatively pristine trash that has been directly incorporated into construction levels (Hare and Smith 1996). At other Aztec-era sites, actual garbage pits have been found directly associated with Aztec residences (Charlton et al. 2000; Nichols and Charlton 1996), but it is unclear if such garbage pits are found in truly urban contexts like Teotihuacan. Pristine garbage pits, like those recorded for central Mexico, are not common in the Maya archaeological record, except for the rapid dumping of very early refuse materials into bedrock depressions (Garber et al. 2004) or chultuns (Culbert and Kosakowsky 2019, 2, 14). Rather, as noted above, earlier trash was moved about and incorporated into later building episodes.

CONCLUSION

Settlement pattern survey data have been crucial in advancing Mesoamerican archaeology (Sabloff and Ashmore 2001), and the data derived from the newer remote sensing technologies that cover entire landscapes continue a long tradition of research in advancing the field of Mesoamerican studies (A. F. Chase et al. 2012, 2014a). Our conceptions of how large Classic Maya sites and settlements were has completely changed in the last forty years. One thing that this recent research has especially emphasized is that there are differences in settlement patterns throughout the various parts of Mesoamerica. Balkansky (2006, 76) noted that recent surveys throughout Mexico have shown, "It is simply not possible to project the settlement patterns from any given region onto another, even for adjacent survey regions." This is also true for the Maya region, where Classic period landscape data demonstrate that cities and settlements were organized in very different ways. There also are distinct density differences; many northern lowland Maya settlements are far denser than those in the southern lowlands, probably because of differences in agricultural practice in terms of infield versus outfield urbanism (A. S. Z. Chase 2021; A. F. Chase and Chase 2016a; Fisher 2014). Social and cultural differences are also likely among the neighboring groups of Maya that once populated the lowlands. There were multiple adaptations to Mesoamerican landscapes by multiple linguistic and ethnic groups over time and not a single template for urban form.

Despite the past predilection to see societal development in the highlands and lowlands as very different in terms of overall complexity and population levels, what the accumulated data demonstrate were quite similar developments in population levels during the Preclassic (ca. 1000 BCE–200 CE) and Classic (200–900 CE) periods, only diverging significantly during the Postclassic period (900 CE to 1519/1697). As Turner (1990a, 312; 1990b) has shown, for the Maya area, the density figures before 300 CE "did not exceed 15 people/km^2"; between 300 and 600 CE, "the figure rose to the mid-40 to 50 range"; by 800 CE, it was approximately "145 people/km^2"; this density fell "to the low-40 range" by 1000 CE; after 1500, "the figure was below one person/km^2." For comparison to the Maya, Turner (1990a, 312) pointed out that Sanders and his colleagues (1979, 217–18) had found very similar levels in the Basin of Mexico: "The average populations per km^2 for the Basin of Mexico for 330 B.C., A.D. 650, and A.D. 1500 were 11.3, 37.6, and 180.4, respectively" (M. E. Smith 2008 provides an estimate of 157 people per ha. for the Aztec capital of Tenochtitlan). At least in the lowland Maya area, both accumulated archaeological investigations and newer lidar data permit researchers to refine these densities, providing ranges that are constrained by other defined parameters.

To move population studies forward, we need a better sense of scale and data for all parts of Mesoamerica to ensure comparability. The new digital technologies are capable of providing the total extent of population areas on the landscape and the density of occupation, both of which are key factors in deriving population numbers. Population size, density, and extent (area) are all important factors in characterizing and interpreting past change in the archaeological record. Developing agreed-on best practices in estimating population histories, using available technologies like lidar, and being explicit about underlying assumptions and methods will move our considerations of ancient Mesoamerican complexity forward successfully. The papers in this volume are a first step in that direction.

More rigorous population estimates should result in a better understanding of the archaeological past, in the ability to construct more accurate models of how societies were organized and developed, and in cross-cultural comparisons that may shed light on broader social processes. Many of the issues in Mesoamerican settlement archaeology derive from past practice and techniques as well as assumptions about past lifeways that may or may not have been correct. Currently, archaeologists can employ different technologies and methodologies within the context of an expanded history of archaeological investigations. Population size, the scale of settlement, and how people are distributed over a given landscape provide important clues for interpreting relationships within the social, political, economic, and even religious realms. Population estimates are key to analyzing social order, complexity, and power. Thus, reexamining ancient Mesoamerican demography and population history in terms of how they are derived from the archaeological record and how they foster broader interpretations will advance the field. While differences remain among researchers in the methodologies used, the subsequent chapters are all clear about the constructs and procedures used to make interpretations, with particular attention being paid to dating, contemporaneity, and household size and composition in combination with the potential impact that ground survey, excavation technique, and new technologies can have on interpretations.

The chapters that follow in this book provide valuable information from across Mesoamerica that can inform current considerations and research on urbanism, urban form and function, sustainability, and landscape use. Together, these studies also should help advance the analysis of Mesoamerican population estimations and provide new insights into past societies in this part of the world. Finally, we hope our discussions will inspire a new generation of researchers to continue to consider not only rigorous production of population estimates, but also the value of contextualizing population and settlement history both locally and across space and time.

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REFERENCES

Adams, Richard E. W. 1974. "A Trial Estimation of Classic Maya Palace Populations at Uaxactun." In *Mesoamerican Archaeology: New Approaches*, edited by Norman Hammond, 285–96. Austin: University of Texas Press.

Adams, Robert McC. 1965. *Land Behind Baghdad: A History of Settlement on the Diyala Plain*. Chicago: University of Chicago Press.

Arnauld, M. Charlotte, Christopher Beekman, and Grégory Pereira, eds. 2021. *Mobility and Migration in Ancient Mesoamerican Cities*. Louisville: University Press of Colorado.

Ashmore, Wendy, and Gordon R. Willey. 1981. "A Historical Introduction to the Study of Lowland Maya Settlement Patterns." In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, 3–18. Albuquerque: University of New Mexico Press.

Balkansky, Andrew K. 2006. "Surveys and Mesoamerican Archaeology: The Emerging Macroregional Paradigm." *Journal of Archaeological Research* 14 (1): 53–95.

Beach, Timothy P., Sheryl Luzzadder-Beach, Samantha Krause, Tom Guderjan, Fred Valdez Jr., Juan Carlos Fernandez-Diaz, Sara Eshleman, and Colin Doyle. 2019. "Ancient Maya Wetland Fields Revealed Under Tropical Forest Canopy from Laser Scanning and Multiproxy Evidence." *Proceedings of the National Academy of Sciences* 116 (43): 21469–77.

Becker, Marshall J. 1982. "Ancient Maya Houses and Their Identification: An Evaluation of Architectural Groups at Tikal and Inferences Regarding Their Functions." *Revista Española de Antropología Americana* 12:111–29.

Becker, Marshall J. 1999. *Excavations in Residential Areas of Tikal: Groups with Shrines*. Tikal Report 21. University Museum Monograph 104. Philadelphia: University Museum, University of Pennsylvania.

Becker, Marshall J. 2003. "Plaza Plans at Tikal." In *Tikal: Dynasties, Foreigners, and Affairs of State*, edited by J. A. Sabloff, 253–80. Santa Fe, N.Mex.: School of American Research Press.

Becker, Marshall J. 2014. "Plaza Plans and Settlement Patterns: Regional and Temporal Distributions as Indicators of Cultural Interactions in the Maya Lowlands." *Revista Española de Antropología Americana* 44 (2): 305–36.

Bender, Barbara. 1978. Review of Mark Nathan Cohen, *The Food Crisis in Prehistory*. *Antiquity* 52:77–78.

Binford, Lewis R. 1968. "Post-Pleistocene Adaptations." In *New Perspectives in Archaeology*, edited by Sally R. Binford and Lewis R. Binford, 313–41. Chicago: Aldine.

Blanton, Richard E. 1972. *Prehispanic Settlement Patterns of the Ixtapalapa Peninsula Region, Mexico*. Occasional Papers in Anthropology 6. University Park: Museum of Anthropology, Pennsylvania State University.

Blanton, Richard E., Gary M. Feinman, Stephen A. Kowalewski, and Linda M. Nicholas. 1999. *Ancient Oaxaca: The Monte Albán State*. Cambridge: Cambridge University Press.

Blanton, Richard E., Stephen A. Kowalewski, Gary M. Feinman, and Jill Appel. 1982. *Monte Alban's Hinterland, Part I: The Prehispanic Settlement Patterns of the Central and Southern Parts of the Valley of Oaxaca, Mexico*. Memoirs 15. Ann Arbor: Museum of Anthropology, University of Michigan.

Bocquet-Appel, J.-P., and C. Masset. 1982. "Farewell to Paleodemography." *Journal of Human Evolution* 11 (4): 321–33.

Boserup, Ester. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure*. Chicago: Aldine.

Bronson, Bennet. 1975. "The Earliest Farming Demography as Cause and Consequence." In *Population, Ecology, and Social Evolution*, edited by Steven Polgar, 53–78. The Hague: Mouton.

Bullard, William R., Jr. 1960. "Maya Settlement Patterns in Northeastern Peten, Guatemala." *American Antiquity* 25 (3): 355–72.

Calnek, Edward E. 1972. "Settlement Pattern and Chinampa Agriculture at Tenochtitlan." *American Antiquity* 37 (1): 104–15.

Canuto, Marcello A., Francisco Estrada-Belli, Thomas G. Garrison, Stephen D. Houston, Mary Jane Acuña, Milan Kováč, Damien Marken, et al. 2018. "Ancient Lowland Maya Complexity as Revealed by Airborne Laser Scanning of Northern Guatemala." *Science* 361 (6409): eaau0137. https://doi.org/10.1126/science.aau0137.

Carleton, W. Christopher, and Huw S. Groucutt. 2021. "Sum Things Are Not What They Seem: Problems with Point-Wise Interpretations and Quantitative Analyses of Proxies Based on Aggregated Radiocarbon Dates." *Holocene* 31 (4): 630–43.

Carneiro, Robert L. 1967. "On the Relationship Between Size of Population and Complexity of Social Organization." *Southwestern Journal of Anthropology* 23 (3): 234–43.

Carneiro, Robert L. 1970. "A Theory of the Origin of the State." *Science* 169: 733–38.

Carrasco, Pedro. 1976. "The Joint Family in Ancient Mexico: The Case of Molotla." In *Essays in Mexican Kinship*, edited by H. G. Nutini, P. Carrasco, and J. M. Taggert, 45–64. Pittsburgh, Pa.: University of Pittsburgh Press.

Chamberlain, Andrew. 2006. *Demography in Archaeology*. New York: Cambridge University Press.

Charlton, Thomas H. 1970. "Contemporary Settlement Patterns: The Cerro Gordo, North Slope, and Upper Valley Areas." In *The Natural Environment, Contemporary Occupation, and 16th Century Population of the Valley*, vol. 1 of *The Teotihuacan Valley Project Final Report*, edited by William T. Sanders, Anton Kovar, Thomas H. Charlton, and Richard A. Diehl, 181–252. Occasional Paper in Anthropology 3. University Park: Pennsylvania State University.

Charlton, Thomas H., Deborah L. Nichols, and Cynthia L. Otis Charlton. 2000. "Otumba and Its Neighbors: Ex Oriente Lux." *Ancient Mesoamerica* 11 (2): 247–65.

Chase, Adrian S. Z. 2021. "Urban Life at Caracol, Belize: Neighborhoods, Inequality, Infrastructure, and Governance." PhD diss., School of Human Evolution and Social Change, Arizona State University, Tempe.

Chase, Arlen F. 1983. "A Contextual Consideration of the Tayasal-Paxcaman Zone, El Peten, Guatemala." PhD diss., Department of Anthropology, University of Pennsylvania, Philadelphia. University Microfilms International No. 8406652.

Chase, Arlen F. 1988. "Jungle Surveying: Mapping the Archaeological Site of Caracol, Belize." *P.O.B. (Point of Beginning)* 13 (3): 10–24.

Chase, Arlen F. 1990. "Maya Archaeology and Population Estimates in the Tayasal-Paxcaman Zone, Peten, Guatemala." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 149–66. Albuquerque: University of New Mexico Press.

Chase, Arlen F., and Diane Z. Chase. 1998. "Scale and Intensity in Classic Period Maya Agriculture: Terracing and Settlement at the 'Garden City' of Caracol, Belize." *Culture and Agriculture* 20 (2–3): 60–77.

Chase, Arlen F., and Diane Z. Chase. 2004. "Terminal Classic Status-Linked Ceramics and the Maya 'Collapse': De Facto Refuse at Caracol, Belize." In *The Terminal Classic in the Maya Lowlands: Collapse, Transition, and Transformation*, edited by Arthur A. Demarest, P. M. Rice, and Don S. Rice, 342–66. Boulder: University Press of Colorado.

Chase, Arlen F., and Diane Z. Chase. 2008. "Methodological Issues in the Archaeological Identification of the Terminal Classic and Postclassic Transition in the Maya Area." *Research Reports in Belizean Archaeology* 5:23–36.

Chase, Arlen F., and Diane Z. Chase. 2009. "Symbolic Egalitarianism and Homogenized Distributions in the Archaeological Record at Caracol, Belize: Method, Theory, and Complexity." *Research Reports in Belizean Archaeology* 6:15–24.

Chase, Arlen F., and Diane Z. Chase. 2013. "Temporal Cycles in the Archaeology of Maya Residential Groups from Caracol, Belize." *Research Reports in Belizean Archaeology* 10:13–23.

Chase, Arlen F., and Diane Z. Chase. 2014. "Ancient Maya Houses, Households, and Residential Groups at Caracol, Belize." *Research Reports in Belizean Archaeology* 11:3–17.

Chase, Arlen F., and Diane Z. Chase. 2015. "The Domestic Economy of Caracol, Belize: Articulating with the Institutional Economy in an Ancient Maya Urban Setting." *Research Reports in Belizean Archaeology* 12:15–23.

Chase, Arlen F., and Diane Z. Chase. 2016a. "The Ancient Maya City: Anthropogenic Landscapes, Settlement Archaeology, and Caracol, Belize." *Research Reports in Belizean Archaeology* 13:3–14.

Chase, Arlen F., and Diane Z. Chase. 2016b. "Urbanism and Anthropogenic Landscapes." *Annual Review of Anthropology* 45:361–76.

Chase, Arlen F., and Diane Z. Chase. 2018. "Sampling and Timeframes: Contextualizing the Protoclassic and Early Classic Periods at Caracol, Belize." *Research Reports in Belizean Archaeology* 15:3–15.

Chase, Arlen F., and Diane Z. Chase. 2020. "Final Moments: Contextualizing On-Floor Archaeological Materials from Caracol, Belize." *Ancient Mesoamerica* 31 (1): 77–87.

Chase, Arlen F., Diane Z. Chase, Jaime J. Awe, John F. Weishampel, Gyles Iannone, Holley Moyes, Jason Yaeger, and M. Kathryn Brown. 2014a. "The

Use of LiDAR in Understanding the Ancient Maya Landscape: Caracol and Western Belize." *Advances in Archaeological Practice* 2 (3): 208–21.
Chase, Arlen F., Diane Z. Chase, Jaime J. Awe, John F. Weishampel, Gyles Iannone, Holley Moyes, Jason Yaeger, M. Kathryn Brown, Ramesh L. Shrestha, William E. Carter, and Juan Carlos Fernandez-Diaz. 2014b. "Ancient Maya Regional Settlement and Inter-Site Analysis: The 2013 West-Central Belize LiDAR Survey." *Remote Sensing* 6 (9): 8671–95.
Chase, Arlen F., Diane Z. Chase, and Adrian S. Z. Chase. 2024. "A Decade Later: The Impact of Caracol LiDAR Surveys on Archaeological Interpretation in the Maya Area." In *Lowland Maya Settlement Patterns in the Age of Lidar*, edited by Marcello Canuto and Francisco Estrada-Belli. Publication 74. New Orleans, La.: Middle American Research Institute.
Chase, Arlen F., Diane Z. Chase, Christopher T. Fisher, Stephen J. Leisz, and John F. Weishampel. 2012. "Geospatial Revolution and Remote Sensing LiDAR in Mesoamerican Archaeology." *Proceedings of the National Academy of Sciences* 109 (32): 12916–21.
Chase, Arlen F., Diane Z. Chase, and Michael E. Smith. 2009. "States and Empires in Ancient Mesoamerica." *Ancient Mesoamerica* 20 (2): 175–82.
Chase, Arlen F., Diane Z. Chase, and John F. Weishampel. 2010. "Lasers in the Jungle: Airborne Sensors Reveal a Vast Maya Landscape." *Archaeology* 63 (4): 27–29.
Chase, Arlen F., Diane Z. Chase, John F. Weishampel, Jason B. Drake, Ramesh L. Shrestha, K. Clint Slatton, Jaime J. Awe, and William E. Carter. 2011. "Airborne LiDAR, Archaeology, and the Ancient Maya Landscape at Caracol, Belize." *Journal of Archaeological Science* 38 (2): 387–98.
Chase, Diane Z. 1990. "The Invisible Maya: Population History and Archaeology at Santa Rita Corozal." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 199–213. Albuquerque: University of New Mexico Press.
Chase, Diane Z. 1997. "Southern Lowland Maya Archaeology and Human Skeletal Remains: Interpretations from Caracol (Belize), Santa Rita Corozal (Belize), and Tayasal (Guatemala)." In *Bones of the Maya: Studies of Ancient Skeletons*, edited by S. L. Whittington and D. M. Reed, 15–27. Washington, D.C.: Smithsonian Institution Press.
Chase, Diane Z., and Arlen F. Chase. 1988. *A Postclassic Perspective: Excavations at the Maya Site of Santa Rita Corozal, Belize*. Monograph 4. San Francisco, Calif.: Pre-Columbian Art Research Institute.
Chase, Diane Z., and Arlen F. Chase, eds. 1992. *Mesoamerican Elites: An Archaeological Assessment*. Norman: University of Oklahoma Press.
Chase, Diane Z., and Arlen F. Chase. 2017. "Caracol, Belize, and Changing Perceptions of Ancient Maya Society." *Journal of Archaeological Research* 25 (3): 185–249.
Chase, Diane Z., José Lobo, Gary M. Feinman, David M. Carballo, Arlen F. Chase, Adrian S. Z. Chase, Scott R. Hutson, Alanna Ossa, Marcello Canuto,

Travis W. Stanton, L. J. Gorenflo, Christopher A. Pool, Bárbara Arroyo, Rodrigo Liendo Stuardo, and Deborah L. Nichols. 2023. "Mesoamerican Urbanism Revisited: Environmental Change, Adaptation, Resilience, Persistence, and Collapse." *Proceedings of the National Academy of Sciences* 120 (31): e2211558120.

Coe, William R. 1957. "Environmental Limitation on Maya Culture: A Reexamination." *American Anthropologist* 59:328–35.

Coe, William R. 1965. "Tikal, Guatemala, and Emergent Maya Civilization." *Science* 147:1401–19.

Coe, William R. 1990. *Excavations in the Great Plaza, North Terrace, and North Acropolis of Tikal*. 6 vols. Tikal Report 14. Philadelphia: University of Pennsylvania Museum.

Cohen, Mark N. 1977. *The Food Crisis in Prehistory*. New Haven, Conn.: Yale University Press.

Cowgill, George L. 1975. "On Causes and Consequences of Ancient and Modern Population Changes." *American Anthropologist* 77 (3): 505–25.

Cowgill, George L. 2015. *Ancient Teotihuacan: Early Urbanism in Central Mexico*. Cambridge: Cambridge University Press.

Culbert, T. Patrick. 1973. "The Maya Downfall at Tikal." In *The Classic Maya Collapse*, edited by T. Patrick Culbert, 63–92. Albuquerque: University of New Mexico Press.

Culbert, T. Patrick, and Laura J. Kosakowsky. 2019. *The Ceramic Sequence of Tikal*. Tikal Report 25B. University Museum Monograph 152. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Culbert, T. Patrick, Laura J. Kosakowsky, Robert E. Fry, and William A. Haviland. 1990. "The Population of Tikal, Guatemala." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 103–22. Albuquerque: University of New Mexico Press.

Culbert, T. Patrick, and Don S. Rice, eds. 1990. *Precolumbian Population History in the Maya Lowlands*. Albuquerque: University of New Mexico Press.

Dahlin, Bruce H., Timothy Beach, Sheryl Luzzadder-Beach, David Hixson, Scott R. Hutson, Aline Magnoni, Eugenia B. Mansell, and Daniel E. Mazeau. 2005. "Reconstructing Agricultural Self-Sufficiency at Chunchucmil, Yucatan, Mexico." *Ancient Mesoamerica* 16:229–47.

Dahlin, Bruce H., and Arlen F. Chase. 2014. "A Tale of Three Cities: Effects of the AD 536 Event in the Lowland Maya Heartland." In *The Great Maya Droughts in Cultural Context: Case Studies in Resilience and Vulnerability*, edited by G. Iannone, 127–55. Boulder: University Press of Colorado.

David, Nicholas. 1972. *The Ethnography of Pottery: A Fulani Case Seen in Archaeological Perspective*. McCaleb Module in Anthropology 21. Reading, Mass.: Addison-Wesley.

Deal, Michael. 1998. *Pottery Ethnoarchaeology in the Central Maya Highlands*. Salt Lake City: University of Utah Press.

Dickson, D. Bruce. 1980. "Ancient Agriculture and Population at Tikal, Guatemala: An Application of Linear Programming to the Simulation of an Archaeological Problem." *American Antiquity* 45 (4): 697–712.

Diehl, Richard A. 1970. "Contemporary Settlement Patterns: An Overview." In *The Natural Environment, Contemporary Occupation, and 16th Century Population of the Valley*, vol. 1 of *The Teotihuacan Valley Project Final Report*, edited by William T. Sanders, Anton Kovar, Thomas H. Charlton, and Richard A. Diehl, 103–80. Occasional Paper in Anthropology 3. University Park: Pennsylvania State University.

Drennan, Robert D. 1984. "Long-Distance Movement of Goods in the Mesoamerican Formative and Classic." *American Antiquity* 49 (1): 27–43.

Drennan, Robert D., C. Adam Berrey, and Christian E. Peterson. 2015. *Regional Settlement Demography in Archaeology*. Clinton Corners, N.Y.: Eliot Werner.

Ek, Jerald D. 2020. "The Inertia of Old Ideas: A Historical Overview of Theoretical and Methodological Challenges in the Study of Classic Maya Political Organization." *Journal of Archaeological Research* 28:241–87.

Feinman, Gary M. 2013. "The Emergence of Social Complexity: Why More than Population Size Matters." In *Cooperation and Collective Action: Archaeological Perspectives*, edited by David M. Carballo, 35–56. Boulder: University Press of Colorado.

Feinman, Gary M., and Linda M. Nichols. 2021. "Marketplaces and Market Exchanges in the Pre-colonial Americas." In *Multidisciplinary Approaches to Ancient Societies: Interpreting Ancient Egypt*, edited by Juan Carlos Moreno García, 35–52. Oxford: Oxbow.

Fish, Suzanne K., and Stephen A. Kowalewski, eds. 1990. *The Archaeology of Regions: The Case for Full-Coverage Survey*. Washington, D.C.: Smithsonian Institution Press.

Fisher, Chelsea. 2014. "The Role of Infield Agriculture in Maya Cities." *Journal of Anthropological Archaeology* 36:196–210.

Flannery, Kent V. 1969. "Origins and Ecological Effects of Early Domestication in Iran and the Near East." In *The Domestication and Exploitation of Plants and Animals*, edited by Peter J. Ucko and George W. Dimbleby, 73–100. Chicago: Aldine.

Flannery, Kent V. 1972. "The Cultural Evolution of Civilizations." *Annual Review of Ecology and Systematics* 3:399–426.

Flannery, Kent V., ed. 1976. *The Early Mesoamerican Village*. New York: Academic Press.

Fogarty, Laurel, and Nicole Creanza. 2017. "The Niche Construction Cultural Complexity: Interactions Between Innovations, Population Size and the Environment." *Philosophical Transactions of the Royal Society B* 372:20160428. https://doi.org/10.1098/rstb.2016.0428.

Ford, Anabel. 1986. *Population Growth and Social Complexity: An Examination of Settlement and Environment in the Central Maya Lowlands*. Anthropological Research Paper 35. Tempe: Arizona State University.

Fox, John W., Garrett W. Cook, Arlen F. Chase, and Diane Z. Chase. 1996. "Questions of Political and Economic Integration: Segmentary versus Centralized States Among the Ancient Maya." *Current Anthropology* 37 (5): 795–801.

Fry, Robert E. 1969. "Ceramics and Settlement in the Periphery of Tikal, Guatemala." PhD diss., Department of Anthropology, University of Arizona, Tucson.

Garber, James F., M. Kathryn Brown, Jaime J. Awe, and Christopher J. Hartman. 2004. "Middle Formative Prehistory of the Central Belize Valley: An Examination of Architecture, Material Culture, and Sociopolitical Change at Blackman Eddy." In *The Ancient Maya of the Belize Valley*, edited by James F. Garber, 25–47. Gainesville: University Press of Florida.

Gowland, Rebecca, and Christopher Knüsel, eds. 2006. *The Social Archaeology of Funerary Remains*. Oxford: Oxbow.

Hansen, Richard D., Carlos Morales-Aguilar, Josephine Thompson, Ross Ensley, Enrique Hernández, Thomas Schreiner, Edgar Suyuc-Ley, and Gustavo Martínez. 2023. "LiDAR Analyses in the Contiguous Mirador-Calakmul Karst Basin, Guatemala: An Introduction to New Perspectives on Regional Early Maya Socioeconomic and Political Organization." *Ancient Mesoamerica* 34 (2): 1–40. https://doi.org/10.1017/S0956536122000244.

Hare, Timothy S., and Michael E. Smith. 1996. "A New Postclassic Chronology for Yautepec, Morelos." *Ancient Mesoamerica* 7:281–97.

Harrison, Peter D., and Billie L. Turner II, eds. 1978. *Pre-Hispanic Maya Agriculture*. Albuquerque: University of New Mexico Press.

Hassan, Fekri A. 1974. "Population Growth and Cultural Evolution." *Reviews in Anthropology* 1:205–12.

Hassan, Fekri A. 1981. *Demographic Archaeology*. New York: Academic Press.

Hassan, Fekri A. 2007. "Review Essay: Demography and Archaeology." *Journal of Anthropological Research* 63:563–67.

Haviland, William A. 1963. "Excavation of Small Structures in the Northeast Quadrant of Tikal, Guatemala." PhD diss., Department of Anthropology, University of Pennsylvania, Philadelphia.

Haviland, William A. 1965. "Prehistoric Settlement at Tikal, Guatemala." *Expedition* 7 (3): 14–23.

Haviland, William A. 1969. "A New Population Estimate for Tikal, Guatemala." *American Antiquity* 34 (4): 429–33.

Haviland, William A. 1972. "Family Size, Prehistoric Population Estimates, and the Ancient Maya." *American Antiquity* 37 (1): 135–39.

Haviland, William A. 1985. *Excavations in Small Residential Groups of Tikal: Groups 4F-1 and 4F-2*. Tikal Report 19. Monograph 58. Philadelphia: University Museum, University of Pennsylvania.

Haviland, William A. 1988. "Musical Hammocks at Tikal: Problems with Reconstructing Household Composition." In *Household and Community in the*

Mesoamerican Past, edited by Richard R. Wilk and Wendy Ashmore, 121–34. Albuquerque: University of New Mexico Press.

Haviland, William A. 2014a. *Excavations in Residential Areas of Tikal: Non-Elite Groups Without Shrines*. Vol. 1, *The Excavations*. Tikal Report 20A. Monograph 139. Philadelphia: University of Pennsylvania Museum.

Haviland, William A. 2014b. *Excavations in Residential Areas of Tikal: Non-Elite Groups Without Shrines*. Vol. 2, *Analysis and Conclusions*. Tikal Report 20B. Monograph 140. Philadelphia: University of Pennsylvania Museum.

Haviland, William A. 2015. *Excavations in Residential Areas of Tikal: Group 7F-1*. Tikal Report 22. Monograph 141. Philadelphia: University of Pennsylvania Museum.

Hayden, Brian. 1975. "The Carrying Capacity Dilemma: An Alternate Approach." *Memoirs of the Society for American Archaeology*, no. 30, 11–21.

Hayden, Brian, and Aubrey Cannon. 1983. "Where the Garbage Goes: Refuse Disposal in the Maya Highlands." *Journal of Anthropological Archaeology* 2 (2): 117–63.

Hoggarth, Julie A., Brendan J. Culleton, Jaime J. Awe, and Douglas J. Kennett. 2014. "Questioning Postclassic Continuity at Baking Pot, Belize, Using Direct AMS ^{14}C Dating of Human Burials." *Radiocarbon* 56 (3): 1057–75.

Hutson, Scott R., Barry Kidder, Céline Lamb, Daniel Vallejo-Cáliz, and Jacob Welch. 2016. "Small Buildings and Small Budgets: Making Lidar Work in Northern Yucatan, Mexico." *Advances in Archaeological Practice* 4 (3): 268–83.

Inomata, Takeshi, and Daniela Triadan, eds. 2010. *Burned Palaces and Elite Residences of Aguateca: Excavations and Ceramics*. Monographs of the Aguateca Archaeological Project First Phase, vol. 1. Salt Lake City: University of Utah Press.

Inomata, Takeshi, Daniela Triadan, Flory Pinzón, Melissa Burham, José Luis Ranchos, Kazuo Aoyama, and Tsuyoshi Haraguchi. 2018. "Archaeological Application of Airborne LiDAR to Examine Social Changes in the Ceibal Region of the Maya Lowlands." *PLOS ONE* 13 (2): e0191619.

Inomata, Takeshi, Daniela Triadan, Verónica A. Vásquez López, Juan Carlos Fernandez-Diaz, Takayuki Omori, María Belén Méndez Bauer, Melina García Hernández, et al. 2020. "Monumental Architecture at Aguada Fénix and the Rise of Maya Civilization." *Nature* 582 (7813): 530–33. https://doi.org/10.1038/s41586-020-2343-4.

Killion, Thomas W. 1990. "Cultivation Intensity and Residential Site Structure: An Ethnoarchaeological Examination of Peasant Agriculture in the Sierra de los Tuxtlas, Veracruz, Mexico." *Latin American Antiquity* 1 (3): 191–215.

Killion, Thomas W., Jeremy A. Sabloff, Gair Tourtellot, and Nicholas P. Dunning. 1989. "Intensive Surface Collection of Residential Clusters at Terminal Classic Sayil, Yucatan, Mexico." *Journal of Field Archaeology* 16 (3): 273–94.

Kirkpatrick, Muriel. 1977. "The Application of the Type-Variety Method of Ceramic Analysis to a Collection of Contemporary Pottery from Metepec, Mexico." Master's thesis, Department of Anthropology, Temple University, Philadelphia.

Kolb, Charles C. 1985. "Demographic Estimates in Archaeology: Contributions from Ethnoarchaeology on Mesoamerican Peasants." *Current Anthropology* 26 (5): 581–99.

Kowalewski, Stephen A., Andrew K. Balkansky, Laura R. Stiver Walsh, Thomas J. Pluckhahn, John F. Chamblee, Verónica Pérez Rodríguez, Verenice Y. Heredia Espinoza, and Charlotte A. Smith. 2009. *Origins of the Ñuu: Archaeology in the Mixteca Alta, Mexico*. Boulder: University Press of Colorado.

Kowalewski, Stephen A., Gary M. Feinman, Laura Finsten, Richard E. Blanton, and Linda M. Nicholas. 1989. *Monte Albán's Hinterland, Part II: Prehispanic Settlement Patterns in Tlacolula, Etla, and Ocotlan, the Valley of Oaxaca, Mexico*. 2 vols. Memoirs 23. Ann Arbor: Museum of Anthropology, University of Michigan.

Kramer, Carol. 1980. "Estimating Prehistoric Populations: An Ethnoarchaeological Approach." In *L'archeologie de l'Iraq*, edited by M. T. Barrelet, 315–34. Paris: Centre national de la Recherche Scientifique.

Laporte, Juan Pedro, Jesús Adánez, and Héctor E. Mejía. 2008. "Entre cayucos y caites: Una ruta de interacción entre el mar Caribe y el río Pasión." *Simposio de Investigaciones Arqueológicas en Guatemala, 2007* 21:744–69.

Lentz, David L., Nicholas P. Dunning, Vernon L. Scarborough, Kevin S. Magee, Kim M. Thompson, Eric Weaver, Christopher Carr, et al. 2014. "Forests, Fields, and the Edge of Sustainability at the Ancient Maya City of Tikal." *Proceedings of the National Academy of Sciences* 111 (52): 18513–18.

Lobo, José, Luís M. A. Bettencourt, Michael E. Smith, and Scott Ortman. 2020. "Settlement Scaling Theory: Bridging the Study of Ancient and Contemporary Urban Systems." *Urban Studies* 57 (4): 731–47.

Malthus, Thomas R. 1826. *An Essay on the Principle of Population*. 6th edition. London. First published 1798.

Marcus, Joyce. 2004. "Maya Commoners: The Stereotype and the Reality." In *Ancient Maya Commoners*, edited by Jon C. Lohse and Fred Valdez Jr., 255–84. Austin: University of Texas Press.

Marcus, Joyce, and Kent V. Flannery. 1996. *Zapotec Civilization: How Urban Society Evolved in Mexico's Oaxaca Valley*. New York: Thames and Hudson.

Masson, Marilyn A., David A. Freidel, and Arthur A. Demarest, eds. 2020. *The Real Business of Ancient Maya Economies: From Farmers' Fields to Rulers' Realms*. Gainesville: University Press of Florida.

McCoy, Mark D. 2020. "The Site Problem: A Critical Review of the Site Concept in Archaeology in the Digital Age." *Journal of Field Archaeology* 45 (S1): S18–S26.

Meggers, Betty J. 1954. "Environmental Limitation on the Development of Culture." *American Anthropologist* 56:801–24.

Millon, René. 1970. "Teotihuacan: Completion of Map of Giant Ancient City in the Valley of Mexico." *Science* 170 (3962): 1077–82.

Millon, René. 1974. "The Study of Urbanism at Teotihuacan, Mexico." In *Mesoamerican Archaeology: New Approaches*, edited by Norman Hammond, 335–62. Austin: University of Texas Press.

Mueller, James W. 1975. *Sampling in Archaeology*. Tucson: University of Arizona Press.

Needham, Stuart, and Tony Spence. 1997. "Refuse and the Formation of Middens." *Antiquity* 71 (271): 77–90.

Newman, Sarah E. 2015. "Rethinking Refuse: A History of Maya Trash." PhD diss., Department of Anthropology, Brown University, Providence, R.I.

Newman, Sarah E. 2019. "Rubbish, Reuse, and Ritual in the Ancient Maya Site of El Zotz, Guatemala." *Journal of Archaeological Method and Theory* 26:806–43.

Nichols, Deborah L., and Thomas H. Charlton. 1996. "The Postclassic Occupation at Otumba: A Chronological Assessment." *Ancient Mesoamerica* 7 (2): 231–44.

Ortman, Scott G., Andrew H. F. Cabaniss, Jennie O. Sturm, and Luís M. A. Bettencourt. 2014. "The Pre-History of Urban Scaling." *PLOS ONE* 9 (2): e87902.

Orton, Clive. 2000. *Sampling in Archaeology*. Cambridge: Cambridge University Press.

Parsons, Jeffrey R. 1971. *Prehistoric Settlement Patterns in the Texcoco Region, Mexico*. Memoirs 3. Ann Arbor: Museum of Anthropology, University of Michigan.

Parsons, Jeffrey R., Keith W. Kintigh, and Susan A. Gregg. 1983. *Archaeological Settlement Pattern Data from the Chalco, Xochimilco, Ixtapalapa, Texcoco, and Zumpango Regions, Mexico*. Technical Report 14. Ann Arbor: Museum of Anthropology, University of Michigan.

Pendergast, David M. 2004. "Where's the Meat? Maya Zooarchaeology from an Archaeological Perspective." In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by Kitty F. Emery, 239–48. Monographs 51. Los Angeles: Cotsen Institute of Archaeology, University of California.

Plog, Stephen. 1978. "Sampling in Archaeological Surveys: A Critique." *American Antiquity* 43 (2): 280–85.

Plunket, Patricia, and Gabriella Uruñuela. 1998. "Preclassic Household Patterns Preserved Under Volcanic Ash at Tetimpa, Puebla, Mexico." *Latin American Antiquity* 9 (4): 287–309.

Price, Michael H., José M. Capriles, Julie A. Hoggarth, R. Kyle Bocinsky, Claire E. Ebert, James H. Jones. 2021. "End-to-End Bayesian Analysis for Summarizing Sets of Radiocarbon Dates." *Journal of Archaeological Science* 135 (2021): 105473.

Prufer, Keith M., Amy E. Thompson, and Douglas J. Kennett. 2015. "Evaluating Airborne LiDAR for Detecting Settlements and Modified Landscapes in Disturbed Tropical Environments at Uxbenká, Belize." *Journal of Archaeological Science* 57:1–13.

Puleston, Dennis E. 1973. "Ancient Maya Settlement Patterns and Environment at Tikal, Guatemala: Implications for Subsistence Models." PhD diss., Department of Anthropology, University of Pennsylvania, Philadelphia.

Puleston, Dennis E. 1983. *The Settlement Survey of Tikal*. Tikal Report 13. Monograph 48. Philadelphia: University Museum, University of Pennsylvania.

Pyburn, K. Anne. 1990. "Settlement Patterns at Nohmul: Preliminary Results of Four Excavation Seasons." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 183–97. Albuquerque: University of New Mexico Press.

Rice, Don S., and T. Patrick Culbert. 1990. "Historical Contexts for Population Reconstruction in the Maya Lowlands." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 1–36. Albuquerque: University of New Mexico Press.

Ricketson, Oliver G., and Edith B. Ricketson. 1937. *Uaxactun, Guatemala, Group E: 1926–1931*. Publication 477. Washington, D.C.: Carnegie Institution of Washington.

Ringle, William M., Tomás Gallereta Negrón, Rossana May Ciau, Kenneth E. Seligson, Juan C. Fernandez-Diaz, David Ortegón Zapata. 2021. "Lidar Survey of Ancient Maya Settlement in the Puuc Region of Yucatan, Mexico." *PLOS ONE* 16 (4): e0249314. https://doi.org/10.1371/journal.pone.0249314.

Sabloff, Jeremy A. 2019. "How Maya Archaeologists Discovered the 99% Through the Study of Settlement Patterns." *Annual Review of Anthropology* 48:1–16.

Sabloff, Jeremy A., and Wendy Ashmore. 2001. "An Aspect of Archaeology's Recent Past and Its Relevance in the New Millenium." In *Archaeology at the Millennium: A Sourcebook*, edited by Gary M. Feinman and T. Douglas Price, 11–32. New York: Plenum.

Sandeford, David S. 2018. "Organizational Complexity and Demographic Scale in Primary States." *Royal Society Open Science* 5:171137.

Sanders, William T. 1962. "Cultural Ecology of the Maya Lowlands." *Estudios de Cultura Maya* 2:79–121.

Sanders, William T. 1963. "Cultural Ecology of the Maya Lowlands." *Estudios de Cultura Maya* 3:203–41.

Sanders, William T., and Deborah L. Nichols. 1988. "Ecological Theory and Cultural Evolution in the Valley of Oaxaca." *Current Anthropology* 29 (1): 33–80.

Sanders, William T., Jeffrey R. Parsons, and Robert S. Santley. 1979. *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization*. New York: Academic Press.

Sanders, William T., and Barbara J. Price. 1968. *Mesoamerica: The Evolution of a Civilization*. New York: Random House.

Santley, Robert S. 1990. "Demographic Archaeology in the Maya Lowlands." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 325–43. Albuquerque: University of New Mexico Press.

Schiffer, Michael B. 1983. "Toward the Identification of Formation Processes." *American Antiquity* 48 (4): 675–706.

Schiffer, Michael B. 1987. *Formation Processes of the Archaeological Record*. Albuquerque: University of New Mexico Press.

Sheets, Payson D. 1974. "Differential Change among the Precolumbian Artifacts of Chalchuapa, El Salvador." PhD diss., Department of Anthropology, University of Pennsylvania, Philadelphia.

Sheets, Payson D. 1978. *Artifacts and Figurines*. Vol. 2 of *The Prehistory of Chalchuapa, El Salvador*. Robert J. Sharer, general editor. Philadelphia: University of Pennsylvania Press.

Sheets, Payson D. 2002. *The Ceren Site: A Prehistoric Village Buried by Volcanic Ash in Central America*. Belmont, Calif.: Wadsworth.

Sidrys, Raymond, and Rainer Berger. 1979. "Lowland Maya Radiocarbon Dates and the Classic Maya Collapse." *Nature* 277:269–74.

Smith, Michael E. 1987. "Household Possessions and Wealth in Agrarian States: Implications for Archaeology." *Journal of Anthropological Archaeology* 6 (4): 297–335.

Smith, Michael E. 2008. *Aztec City-State Capitals*. Gainesville: University Press of Florida.

Smith, Michael E., Patricia Aguirre, Cynthia Heath-Smith, Kathryn Hirst, Scott O'Mack, and Jeffrey Price. 1989. "Architectural Patterns at Three Aztec-Period Sites in Morelos, Mexico." *Journal of Field Archaeology* 16 (2): 185–203.

Smith, Michael E., Abhishek Chatterjee, Angela C. Huster, Sierra Stewart, and Marion Forest. 2019. "Apartment Compounds, Households, and Population in the Ancient City of Teotihuacan, Mexico." *Ancient Mesoamerica* 30 (3): 399–418.

Smith, Philip E. L. 1972. "Changes in Population Pressure in Archaeological Explanation." *World Archaeology* 4 (1): 5–18.

Smith, Rick W. A., and Amy L. Non. 2022. "Assessing the Achievements and Uncertain Future of Paleoepigenomics." *Epigenomics* 14 (4): 167–73.

Smyth, Michael P., Christopher D. Dore, and Nicholas P. Dunning. 1995. "Interpreting Prehistoric Settlement Patterns: Lessons from the Maya Center of Sayil, Yucatan." *Journal of Field Archaeology* 22 (3): 321–47.

Spencer, Charles S., and Elsa M. Redmond. 2004. "Primary State Formation in Mesoamerica." *Annual Review of Anthropology* 33:173–99.

Spooner, Brian, ed. 1972. *Population Growth: Anthropological Implications*. Cambridge, Mass.: MIT Press.

Stanton, Travis W., Traci Ardren, Nicolas C. Barth, Juan C. Fernandez-Diaz, Patrick Rohrer, Dominique Meyer, Stephanie J. Miller, Aline Magnoni, and Manuel Pérez. 2020. "'Structure' Density, Area, and Volume as Complementary Tools to Understand Maya Settlement: An Analysis of Lidar Data Along the Great Road Between Coba and Yaxuna." *Journal of Archaeological Science: Reports* 29:102178. https://doi.org/10.1016/j.jasrep.2019.102178.

Steggerda, Morris. 1941. *Maya Indians of Yucatan*. Publication 531. Washington, D.C.: Carnegie Institution of Washington.

Straight, Kirk D. 2017. "A Houseful of Pots: Applying Ethnoarchaeological Data to Estimate Annual Ceramic Vessel Consumption Rates of Classic Maya Households." *Ancient Mesoamerica* 28 (1): 95–117.

Tiesler, Vera. 2020. "Maya Bioarchaeology." In *The Maya World*, edited by Scott R. Hutson and Traci Ardren, 107–27. London: Routledge.

Turner, Billie L., II. 1974. "Prehistoric Intensive Agriculture in the Mayan Lowlands: Examination of Relic Terraces and Raised Fields Indicates that the Río Bec Maya Were Sophisticated Cultivators." *Science* 185 (4146): 118–24.

Turner, Billie L., II. 1978. "Ancient Agricultural Land Use in the Central Maya Lowlands." In *Pre-Hispanic Maya Agriculture*, edited by Peter D. Harrison and Billie L. Turner II, 163–83. Albuquerque: University of New Mexico Press.

Turner, Billie L., II. 1983. *Once Beneath the Forest: Prehistoric Terracing in the Río Bec Region of the Maya Lowlands*. Boulder, Colo.: Westview Press.

Turner, Billie L., II. 1990a. "Population Reconstruction for the Central Maya Lowlands: 1000 BC to AD 500." In *Precolumbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, 301–24. Albuquerque: University of New Mexico Press.

Turner, Billie L., II. 1990b. "The Rise and Fall of Population and Agriculture in the Central Maya Lowlands: 300 BC to Present." In *Hunger and History: Food Shortages, Poverty, and Deprivation*, edited by Lucile F. Newman, 178–211. Oxford: Basil Blackwell.

Turner, Billie L., II, and Peter D. Harrison. 1983. *Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize*. Austin: University of Texas Press.

Vaesen, Krist, Mark Collard, Richard Cosgrove, and Wil Roebroeks. 2016. "Population Size Does Not Explain Past Changes in Cultural Complexity." *Proceedings of the National Academy of Sciences* 113 (16): E2241–47.

Wauchope, Robert. 1938. *Modern Maya Houses: A Study of Their Archaeological Significance*. Publication 502. Washington, D.C.: Carnegie Institution of Washington.

Webster, David. 2018. *The Population of Tikal: Implications for Maya Demography*. Paris Monographs in American Archaeology 49. Oxford: Archaeopress.

Weiss, Kenneth M. 1976. "Demographic Theory and Anthropological Inference." *Annual Review of Anthropology* 5:351–81.

Wilk, Richard R., and William L. Rathje. 1982. "Household Archaeology." *American Behavioral Scientist* 25 (6): 617–39.

Wilkinson, Tony J. 1982. "The Definition of Ancient Manured Zones by Means of Extensive Sherd-Sampling Techniques." *Journal of Field Archaeology* 9 (3): 323–33.

Willey, Gordon R. 1981. "Lowland Maya Settlement Patterns: A Summary Review." In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, 385–415. Albuquerque: University of New Mexico Press.

Willey, Gordon R., William R. Bullard Jr., John B. Glass, and James C. Gifford. 1965. *Prehistoric Maya Settlements in the Belize Valley*. Papers of the Peabody Museum of Archaeology and Ethnology 54. Cambridge, Mass.: Harvard University.

Willey, Gordon R., and Philip Phillips. 1958. *Method and Theory in American Archaeology*. Chicago: University of Chicago Press.

Wong, Alfred. 2018. "Impact of Human Waste Management on the Estimation of Ancient Maya Population." *Estudios de Cultura Maya* 51:111–28.

Wong, Alfred, Christine Rebeiro, and Roxanne Gomes. 2017. "Estimation of Ancient Maya Population: Basic Human Nutritional Needs for Sustenance." *Journal of Archaeological Science: Reports* 13:435–54.

Wright, Henry T., and Gregory A. Johnson. 1975. "Population, Exchange, and Early State Formation in Southwestern Iran." *American Anthropologist* 77: 267–89.

Yaeger, Jason, M. Kathyrn Brown, and Bernadette Cap. 2016. "Locating and Dating Sites Using Lidar Survey in a Mosaic Landscape in Western Belize." *Advances in Archaeological Practice* 4 (3): 339–56.

Zeitlin, Robert N. 2000. "Two Perspectives on the Rise of Civilization in Mesoamerica's Oaxaca Valley." *Latin American Antiquity* 11 (1): 87–89.