

ARTICLE

Repositioning Altar de Sacrificios on the Ancient Maya Landscape: UAS Settlement Survey of the Upper Usumacinta Confluence Zone

Jessica Munson¹ , Andrés G. Mejía Ramón² , Jill Onken³  and Lorena Paiz⁴

¹Department of Anthropology-Sociology, Lycoming College, Williamsport, PA, USA; ²Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Catalunya, Spain; ³Department of Geosciences, University of Arizona, Tucson, AZ, USA and ⁴Proyecto Arqueológico Altar de Sacrificios, Guatemala

Corresponding author: Jessica Munson; Email: munson@lycoming.edu

(Received 10 September 2024 UTC; revised 2 November 2025 UTC; accepted 2 November 2025 UTC)

Abstract

Despite its record among early twentieth-century explorers and being one of the first sites excavated in southwestern Petén, Guatemala, Altar de Sacrificios has eluded Maya scholarship for much of the last half-century. This article aims to redefine Altar's position on the ancient Maya geopolitical landscape and reconsider its role in socioeconomic exchange during the Classic period (ca. AD 200–900). We report new findings from a unmanned aerial system survey of the Upper Usumacinta Confluence Zone, contextualizing our results with other remote sensing surveys across the Maya lowlands. By examining the size, form, and distribution of settlement across this fluvial landscape, we characterize variable patterns of settlement density and organization in relation to shifting river channels and potential land use practices associated with Altar's Classic period occupation. Synthesizing these patterns and population estimates with data from other well-documented settlements across the Maya lowlands, this study highlights the diversity of this ancient urban tradition and contributes to broader discussions on Maya urbanization—especially the connections between cities and more rural zones of human habitation.

Resumen

A pesar de haber sido uno de los primeros sitios del Petén guatemalteco suroeste en ser documentado y excavado por arqueólogos, Altar de Sacrificios ha permanecido al margen de los estudios mayas durante gran parte del último medio siglo. Este artículo redefine la posición de Altar en el antiguo ámbito geopolítico maya y reconsidera su papel en los intercambios socioeconómicos durante el periodo Clásico (ca. 200-900 aC). Reportamos nuevos descubrimientos hechos a través de un recorrido aéreo no tripulado sobre la zona de confluencias del Usumacinta Superior, contextualizando nuestros resultados con otros recorridos de teledetección de las tierras bajas mayas. Examinando el tamaño, la forma, y la distribución de los asentamientos a lo largo de este paisaje fluvial, caracterizamos patrones variables de densidad y organización habitacional en torno a los ríos locales y sus causas cambiantes. Asimismo, proponemos prácticas de uso de suelo que potencialmente se pueden asociar con la ocupación clásica del sitio. Al sintetizar estos patrones y estimaciones de población con aquellos de otros sitios bien documentados de las tierras bajas, destacamos la diversidad de una tradición urbana antigua, fomentando debates más amplios sobre la urbanización maya, especialmente respecto a la conexión entre ciudades y zonas más rurales de ocupación humana.

Keywords: Maya; settlement archaeology; urbanism; population estimates; remote sensing

Palabras clave: Maya; arqueología de los asentamientos; urbanismo; estimaciones de población; teledetección

The ancient Maya site of Altar de Sacrificios (hereafter Altar) was originally described as an elusive “principal center” by Gordon Willey (1973:6–7), who also once declared that the lowland Maya were a “civilization without cities” (Willey 1962:96). Such ambiguous and discordant terminology reflects interpretative challenges in reconciling the seemingly contradictory patterns of dispersed urban settlement recorded at the time (Bullard 1960; Puleston 1974; Rice 1976; Willey 1965; Willey and Leventhal 1979; Willey and Smith 1969). While most scholars now accept that ancient Maya cities not only existed but also were large, spatially expansive agro-urban settlements (Chase and Chase 2016; Fletcher 2009; Isendahl 2012), particular questions about the size and extent of Altar’s settlement and its connection with broader processes of lowland Maya urbanization have not been addressed. This article repositions Altar on the ancient Maya landscape by contextualizing results from our recent unmanned aerial system (UAS) settlement survey of the Upper Usumacinta Confluence Zone (UUCZ) with other remote sensing surveys across the Maya lowlands. By examining the size, form, and distribution of settlement across this fluvial landscape, we characterize variable patterns of settlement density and organization in relation to shifting river channels and potential land use practices associated with Altar’s Classic period (ca. AD 250–900) occupation. Synthesizing these patterns and population estimates with data from other well-documented settlements across the Maya lowlands, this study highlights the diversity of this ancient urban tradition and contributes to broader discussions on Maya urbanization—especially the connections between cities and more rural zones.

Over the last two decades, interpretative models in Maya archaeology have coalesced around the notion of the lowland Maya as a fully urbanized premodern society. Building on traditional settlement surveys and aided by more recent lidar technology, archaeologists have documented numerous ancient cities across the Maya lowlands that exhibit urban planning, markets, specialized functions, and agricultural infrastructure that helped sustain large populations (e.g., Chase and Chase 1998; Dahlin et al. 2005; Ford and Nigh 2009; Hutson et al. 2008). Often, urban centers were also local seats of power or capitals of regional polities attested by their epigraphic history and built environments including temple pyramids, royal tombs, palaces, and public spaces where administrative and ceremonial functions were conducted (e.g., Fash 2001; Houk 2015; Martin 2001). Preclassic (ca. 400 BC–AD 200) and Classic (ca. AD 200–900) cities of substantial size and complexity within eastern Mesoamerica’s lowland tropical forests were once considered implausible (Sanders and Price 1968; Sanders and Webster 1988)—inconsistent with models of other ancient urban societies (Childe 1950)—but are now widely characterized as a unique form of low-density agrarian urbanism (Chase and Chase 1998; Fletcher 2009; Graham 1999; Isendahl 2012). While this categorization facilitates global comparisons between the Maya and other ancient and contemporary societies (Chase et al. 2023; Fletcher 2012; Isendahl and Smith 2013; Isendahl et al. 2025; Lucero et al. 2015; Smith et al. 2021), empirical observations defy easy classification. Given the immense variety of architectural forms and different scales and sizes of settlements documented across the Maya lowlands, this category may be of limited utility for characterizing the internal variation of a uniquely Mesoamerican urban tradition.

Herein, it is important to emphasize that urbanism is a feature of *societies* rather than a particular attribute of individual cities, towns, or other types of settlements (for recent discussions, see Marken and Arnould 2023; Raja and Sindbæk 2022; Smith 2023:10–25). As Smith (2020) points out, “city” and “urban” are theoretical concepts as opposed to empirical realities; definitions of these terms will vary given different contexts and specific research questions. While some use particular attribute lists or thresholds to define these categories (Hutson 2016; Smith 2006), other approaches consider the nature, degree, and effects of social interaction within spatially defined centers of population concentration (Bettencourt 2013; Lobo et al. 2020; Smith 2019). Archaeologists may debate whether demographic or functional definitions of cities are more appropriate (q.v., Marken and Arnould 2023:8–13; Raja and Sindbæk 2023; Smith 2020), but almost all empirical studies of ancient urbanism focus on settlements as the primary unit of analysis.

In this article, we recognize ancient Maya urbanism as an expansive, multiscale concept that includes large and small nucleated settlements alongside more dispersed communities. Crucially, however, the relationships between these spatially defined populations—the political alliances, social interactions, economic exchanges, and historical ties—define this urban tradition. Ultimately, we are interested in

connections between settlements traditionally described as “urban” and “rural” as well as the organization of sociopolitical interaction within and between these different contexts. As Marken and Arnauld (2023:11) note, “Cities do not exist in isolation; they are part of large settlement systems that also include towns, villages, and hamlets, as well as vast tracks of agricultural lands and other resources.” From this perspective, urban and rural are not opposed but are conceptually interconnected and elements of larger, integrated political systems deserving equal treatment (Ek 2020; Lamb 2020; Marken and Arnauld 2023; Smith 2023:19). However, to examine these connections we need to move beyond localized analyses of individual sites and begin synthesizing the numerous datasets that Maya archaeology has produced over the last century. While this ambitious goal is beyond the scope of the current article, we contribute to these efforts by contextualizing results from our recent survey with findings from previous investigations to redefine Altar’s position on the ancient Maya geopolitical landscape and reconsider its role in socioeconomic exchange during the Classic period.

Dimensions of Maya (R)urbanism

Despite the growing acceptance of ancient Maya urbanism, research has generally focused on localized analyses of cities, often imbuing greater significance to urban contexts than their rural counterparts. In part this might be explained by the urban prestige effect (Smith 2023:7–8) but could also result from Maya archaeology’s reluctance to engage in comparative, synthetic analysis (Ek 2020). Such trends, however, do not negate the extensive body of scholarship that focuses on rural life and hinterland communities in ancient Maya society (e.g., Hutson et al. 2021; Iannone and Connell 2003; Lamb 2022; Lemonnier and Arnauld 2022; Lohse and Valdez 2004; Robin 2012; Scarborough et al. 2003; Yaeger and Robin 2004). Much of this research stems from foundational fieldwork involving intersite surveys and household archaeology conducted by an earlier generation of scholars (e.g., Fedick 1988; Ford 1981; Puleston 1974; Wilk and Ashmore 1988). Increasing numbers of recent large-scale lidar studies further reveal variable patterns of settlement density over much broader areas (Canuto et al. 2018; Chase et al. 2014; Estrada-Belli et al. 2025; Golden et al. 2021; Inomata et al. 2018; Ringle et al. 2021; Schroder et al. 2020). While there is clearly no lack of empirical record, there is little agreement over what models of urban-rural settlement organization are most appropriate for the lowland Maya.

Traditional interpretations tend to emphasize one configuration over the other, viewing urban and rural as distinct and separate entities. For example, some argue that ancient Maya cities were discrete centers of attraction for more distant rural populations (e.g., Hutson 2016) whereas others interpret rural settlements as independent—largely disconnected from the centralized administration of urban centers (Arnauld et al. 2013; Lemonnier and Vannière 2013; Nondédéo et al. 2013). In contrast, Marken’s (2015) delineation of settlement zones at El Perú-Waka’ calls for greater attention to urban-rural interactions within Classic Maya polities. Similarly, Garrison and colleagues introduce the concept of “conurbation” to emphasize a continuous social landscape wherein urban and rural populations were fully integrated and “part of a comprehensive, interpretable system built on landesque investment and a high degree of political coordination” (2019:135). Still others contend that alternative categories such as “town” should be employed to differentiate settlements that exhibit urban functions in otherwise rural landscapes (Eppich and Ball 2024; Nondédéo et al. 2023). Although recent approaches eschew binary frameworks (Lamb 2022; Marken and Arnauld 2023), the pervasive usage of urban and rural perpetuates categorical thinking that may not accurately reflect indigenous distinctions (Hirth 2003; Marcus 1983). An alternative term that may prove beneficial is the blended concept “rurban,” referring to a mix of large rural and small urban areas with multiple land use functions linked or nested within broader geopolitical systems (Cyriac et al. 2022). While we agree that Maya archaeology must reckon with its conceptual terminology and models of urban-rural settlement (see also Garrison 2023), such efforts require a unified analytical framework to systematically compare and synthesize these different datasets before new terms and models are adopted.

Smith (2020) defines several key dimensions of urbanism that establish empirical criteria for the analysis of ancient cities. Expanding on these dimensions to accommodate the rural-urban continuum of lowland Maya settlement, Marken and Arnauld (2023:13–21) offer a revised framework that organizes

Table 1. Analytical Framework of Urban Dimensions for Maya Archaeology based on Marken and Arnauld (2023) and Smith (2020).

Dimension	Definition	Approaches
Urban function	Activities and institutions within a settlement that have an effect beyond the borders of the urban-rural community	Regional studies, distributional analyses
Urban meaning	Cosmic and religious symbolism; messages of identity, status, and power; built environment's impact on individual thought and behavior	Monumental archaeology, iconography, epigraphy
Urban life and society	Social complexity and variation; top-down and bottom-up processes	Household archaeology
Urban form and settlement size	Architecture, form, layout, planning, housing, population, area, density	Settlement and landscape archaeology

these analytical categories (urban form, life, meaning, and function) according to their archaeological accessibility, emphasizing the recursive relationship between urban dimensions (Table 1). We find this approach promising for promoting synthesis research in Maya archaeology and examining this unique “rurban” tradition. Thus, our study focuses on two basic aspects: (1) settlement size, including spatial extent, demographic estimates, and approximations of population density; and (2) urban form, comprised of architectural features, site layout, and settlement planning in relation to the natural landscape. We first introduce the study area and summarize findings from previous investigations at Altar, highlighting the urban features found in the site core. We then describe our UAS survey and the broader settlement patterns of the UUCZ according to the analytical dimensions outlined in the preceding text. Contextualizing our results with settlement data from other remote sensing surveys allows us to examine organizational aspects of past urban life at Altar and reevaluate the function of this “principal center” in relation to other Classic Maya cities. We conclude with a discussion of broader implications for studying ancient Maya urbanism, focusing on the connection between cities and more rural settlements.

Historical and Environmental Context

The UUCZ encompasses the region where the Pasión and Salinas-Chixoy Rivers join to form the Río Usumacinta in the western Maya lowlands along the modern-day border of Guatemala and Mexico (Figure 1). The landscape is dominated by meandering river system landforms including seasonally flooded lagoons, oxbow lakes, and infilled cut-off channel remnants in low-lying floodplains flanked by slightly elevated terraces. Unlike the narrow, bedrock channels of the Pasión and lower reaches of the Usumacinta (Aliphat 1994), the UUCZ is defined by alluvial reaches with wide floodplains and frequent channel migration, resulting in a dynamic fluvial landscape that changed dramatically during the Holocene. While these riparian environments offered vital resources to sustain early human populations (Sharpe et al. 2024) and rich alluvial soils suitable for nonintensive agriculture (Horseman et al. 2024), they also posed significant risks due to flooding (Schroder et al. 2021) as recently observed in our study area after back-to-back hurricanes in 2020.

Altar—the largest recorded site in the UUCZ—has been the focus of multiple investigations since the late nineteenth century. Among the early explorers were Maudslay, Maler, and Morley who each visited on separate occasions to record the carved monuments—including the one for which the site is (mis)named—and to produce sketch maps of some of the largest structures in the epicenter (Willey and Smith 1969:4–7). A 1937 expedition sponsored by the Carnegie Institution of Washington made more systematic efforts to map the site, later published alongside a summary of the hieroglyphic inscriptions (Morley 1938:309–340). These early documentary efforts provided an important basis for the first large-scale excavation project in southwest Petén conducted by the Peabody Museum of Harvard University between 1958 and 1963.

Not surprisingly, questions about settlement patterns and site location were central to this new project as project director Gordon Willey had just completed the Belize Valley survey (Willey 1973:6). Based on

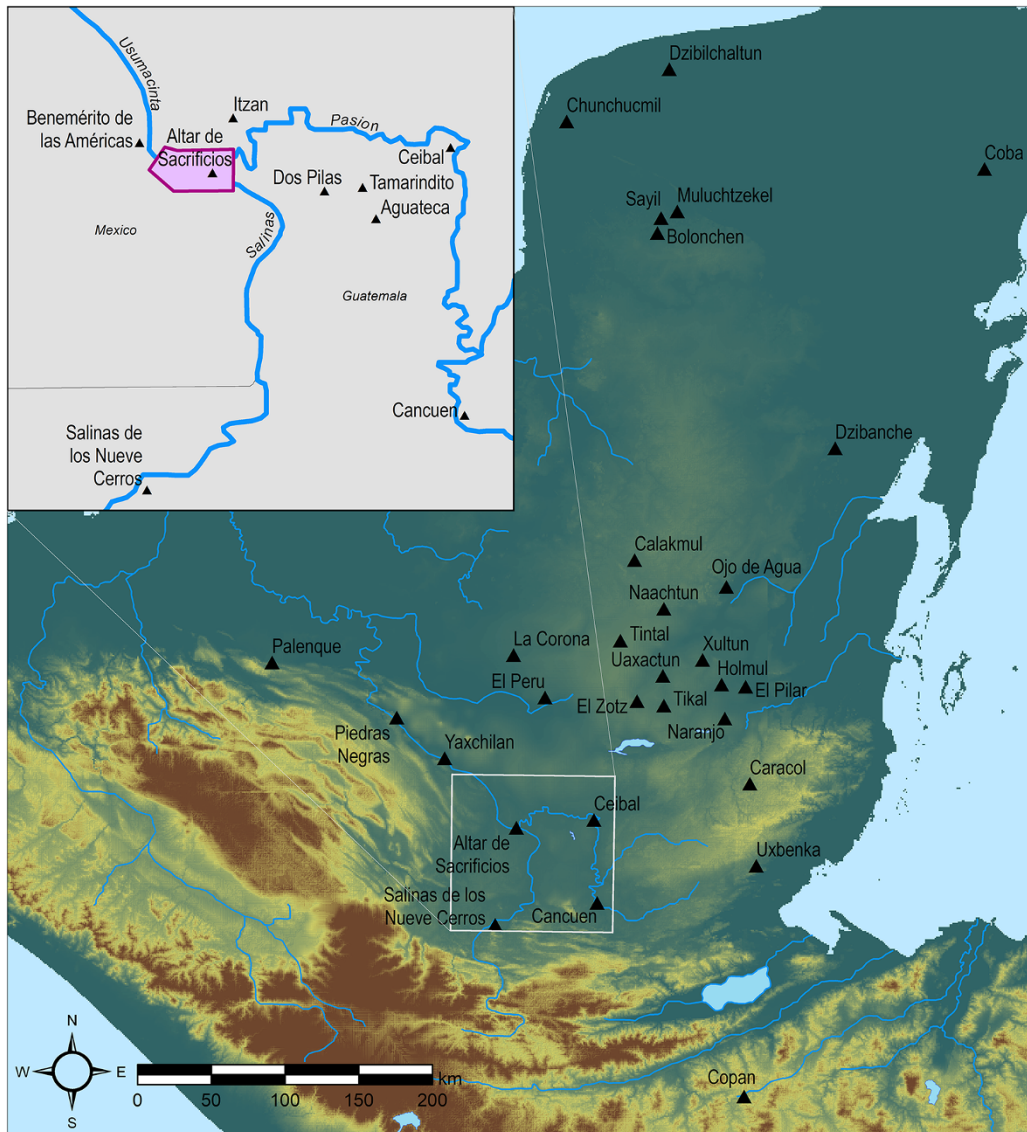


Figure 1. Overview map of the Maya region with sites mentioned in the text. Inset map shows the location of Altar de Sacrificios and the UUCZ study area shaded in purple. (Color online)

Altar's location at the junction of two major rivers that conjoin to form the Usumacinta, it was hypothesized that the site could be a potential crossroads for highland-lowland exchange (Willey et al. 1960). However, the Harvard team never capitalized on this line of inquiry due to insufficient comparative data (Willey 1973:11). Moreover, questions about trade and exchange were not major research topics for American archaeology at the time. Instead, the Harvard project pursued a more traditional culture-historical research program, documenting the site chronology through an intensive excavation program, architectural investigations, and ceramic analysis (Adams 1971; Smith 1972). William Bullard prepared a more detailed map of the site core and adjacent settlement during the first season (Figure 2), which helped guide the excavation strategy (Smith 1972). Altar's epicenter contains a number of monumental buildings, including temple pyramids and ceremonial platforms, plazas of various sizes, carved stone monuments, a ballcourt, and two palace complexes—architectural features that are now considered typical of urban areas in other Maya cities. These buildings are separated into two main architectural groups

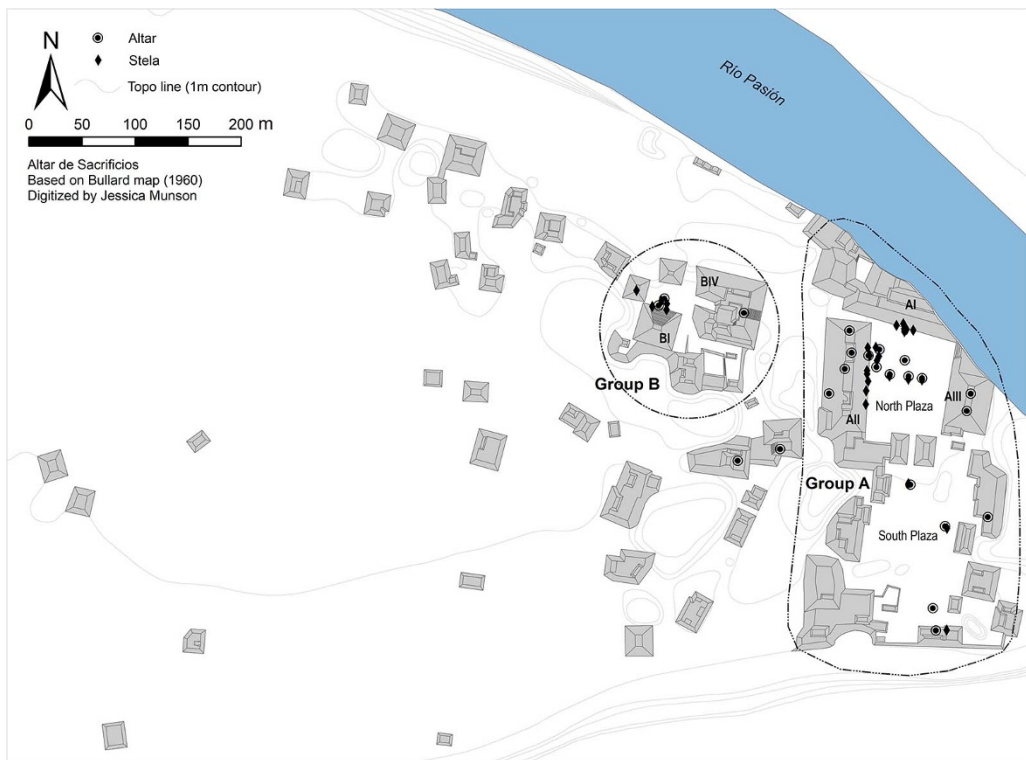


Figure 2. Digitized map of Altar de Sacrificios site core including urban architectural features in Groups A and B (source: Bullard map published in Willey and Smith 1969).

(A and B) that have distinct forms, layouts, and construction histories as described in Smith (1972) and summarized in the following text.

Group B forms a small and compact architectural complex that was the center of localized ritual and ceremonial activity from the Middle Preclassic to the Early Classic period. Buildings are arranged around a small rectangular plaza measuring about 50 m² and faced with a locally available red “sandstone” block¹ in its final architectural phase dated to the Protoclassic Salinas phase (AD 100–450). Str. BI, the tallest building at the site, is a temple pyramid located on the south side of the plaza that was gradually built up over seven construction episodes beginning in the Middle Preclassic San Felix phase (600–300 BC). Early platforms were raised from packed earth later covered with *almeja* clamshells procured from the local rivers and set into clay mortar. In its final form, Str. BI rose 13 m above the plaza level in multiple terraces where several inscribed stelae and altars carved from the same red “sandstone” material were placed along with dozens of ceramic vessel cache offerings. Structures BII and BIII, on the west and north sides of the plaza, respectively, are smaller temple pyramids with a similar construction history. Enclosing the eastern edge of the plaza is Str. BIV, a broad and low palace complex with a terraced upper platform and court arrangements that yielded a similar stratigraphy as the other Group B buildings. Notably, the area to the east of Group B seems to have been retained as an open space throughout the Preclassic and may have served as an informal plaza or gathering place along the river, at least until construction began in Group A.

Less than 200 m eastward, Group A is more than twice the size of Group B measuring about 350 × 150 m and is divided into North and South Plazas of about equal size. In contrast to the early establishment of Group B, the buildings in Group A mostly date to the Late Classic period (AD 600–900) with the earliest monument (Stela 8) dedicated on 9.9.15.0.0 (AD 628). Departing from earlier architectural traditions, most of the buildings in Group A were constructed with a rubble core and faced with limestone blocks and a plaster finish in the standard central Petén style. The North Plaza is delineated

by Str. AI—a large palace complex with terraced platforms that had largely been destroyed by riverbank erosion prior to Harvard’s investigations—and Strs. AII and AIII. The latter was a 10 m high funerary temple on the east side of the plaza that contained multiple graves including the remains of Burial 128, a royal woman who was accompanied with the most elaborate grave goods recovered by the Harvard project including the famous Altar vase (Haviland 1971; Smith 1972:266–268). Three large circular altars were found atop Str. AII, a range structure measuring 110 m long, 40 m wide, and 10 m tall that forms the west side of the North Plaza. The South Plaza is slightly larger but less formally defined with various platforms of different sizes and shapes that may have been the foundations for elite residences surrounding the plaza area. Although no standing walls, vaulted structures, or roomed buildings were documented in Group A, many of these structures likely supported perishable dwellings constructed from wattle and daub similar to those found in the outlying areas. A ballcourt separating the North and South Plazas was a focal point for ceremonial activity in Group A. Although access to the Group A plazas was restricted, the layout of monuments and buildings suggests that rituals, ballgames, and other royal performances likely provided formal contexts for periodic communal gatherings in Altar’s urban core during the Late Classic.

While Bullard’s original map remains remarkably accurate, Harvard’s limited explorations beyond Groups A and B documented a sparse distribution of small earthen mounds presumed to be the remains of residential dwellings called “house mounds” in the original report (Smith 1972:128–129). Although test pits were placed in all 41 house mounds, the goal was to recover ceramics for the purpose of developing a site chronology rather than an expansive household study. Despite the relatively small number and size of structures documented outside the site core, Altar was originally interpreted as a “principal center” based primarily on the ceremonial architecture, hieroglyphic monuments, and elaborate cache deposits and burial goods recovered from Groups A and B—features similar to those found at other nearby major ruins (Willey 1973:6–7).

Subsequent publications make only passing reference to the original Altar reports. Drennan’s (1988) study of residential density across Mesoamerica is one of the only comparative analyses to use Altar’s original survey data, which helped confirm the dispersed settlement patterns of the lowland Maya—a point we return to in the following text. Despite limited decipherment of its poorly preserved inscriptions, Altar has featured in a handful of other accounts related to Maya political organization. Based on its hieroglyphic details and archaeological context, Mathews and Willey (1991) describe Altar as an independent polity that emerged early and maintained its position by existing on the margins and between more powerful polities like Dos Pilas and Yaxchilan. In another case, Altar is identified as a secondary center with local rulers who were never under the sway of a regional power but consolidated their communal authority through water and agricultural rituals (Lucero 2006). Still, in other studies, Altar has been left out of political interaction models altogether (Martin and Grube 2008). To reevaluate Altar’s position on the geopolitical landscape, we must understand how its urban core articulates with the surrounding settlement and landscape.

UAS Survey in the Upper Usumacinta Confluence Zone

The true situation as regards the distribution of dwellings along the Río Pasión and their relation to the ceremonial center [Altar de Sacrificios] can only be ascertained by systematic exploration over large stretches of terrain. The principal difficulties in such exploration are the lack of sizable clearings and the fact that most of the river is bordered by areas of swamp [Willey et al. 1960:114].

This statement characterizes the archaeological situation around Altar during the mid-twentieth century, but the same cannot be said for the region today. The dense canopy and thick patches of bamboo that once enclosed this landscape have largely been replaced by plowed agricultural fields and pastures used for grazing cattle (Figure 3), though remnant river channels and low-lying areas still flood during the rainy season. Such vast deforested landscapes document the alarming rate of change within this tropical ecosystem, but at the same time offer fortuitous opportunities for archaeologists to systematically inventory large stretches of terrain using relatively inexpensive and efficient remote sensing methods (Munson et al. 2019).



Figure 3. Photograph of the modern UUCZ landscape showing the junction of the Salinas-Chixoy (top left), Pasión (bottom left), and Usumacinta (right) rivers, looking west from Guatemala into Mexico. Photograph courtesy of Jessica Munson. (Color online)

The Proyecto Arqueológico Altar de Sacrificios (PAALS) began in 2016 with the goal of understanding the history of human occupation and landscape change in the UUCZ through extensive settlement survey, geoarchaeological research, and household investigations. From 2017 to 2019, PAALS conducted a series of UAS surveys that generated high-resolution topographic models to identify cultural features and natural landforms (Mejía Ramón 2019; Munson et al. 2019). Additionally, geoarchaeological investigations of floodplain deposits exposed in riverbanks and sediment cores along with geomorphic mapping of floodplain landforms have aided in the reconstruction of river channel migration across the study area (Onken 2023; Figure 4). This work, combined with ongoing analyses from household excavations, provides an important foundation for understanding the social contexts and natural landscapes in which people pursued diverse livelihoods throughout the Preclassic and Classic periods (Munson and Scholnick 2022).

Over three field seasons, PAALS surveyed a total of 54 km² on both sides of the Guatemala-Mexico border using a DJI Phantom 3 Professional quadcopter with a 12-megapixel camera and gimbal stabilization. We collected 26,000+ images that were processed using Structure-from-Motion (SfM)-based photogrammetry to generate high-resolution (≤ 15 cm/pixel) digital elevation models (DEMs) of the UUCZ landscape. To generate the DEMs, photographs were taken with the UAS controlled using an iPad Mini 2 running the iOS application Map Pilot versions 2.5–2.6. The UAS was flown at 15 m/s at an elevation of 85 m the first year (to maximize resolution) above the main peninsula, and at the maximum then-allowable elevation in years thereafter to maximize total areal coverage (150 m the second year in Guatemala and 120 m the third year in Mexico). Routes and photographic intervals were programmed such that there would be a 75% front and side overlap ensuring that every ground point would be visible in at least nine images from different angles.

Photogrammetric reconstructions were generated twice—once in the field at a high resolution (~ 30 cm depending on the sector), and again at the conclusion of fieldwork with the highest resolution (~ 15 cm)—using Agisoft Metashape versions 1.3.2–1.5.2. Given the scale of the area surveyed, the ground conditions in parts of the survey region, and the limited amount of time available for mapping, it was not feasible to produce ground control points. As such, the resulting DEMs suffer from significant barrel distortion given the UAS's truncated fisheye-style camera. To correct these aberrations, we assumed that SRTM-based elevations are distributed about the true elevation if at a lower scale. Thus, we resampled

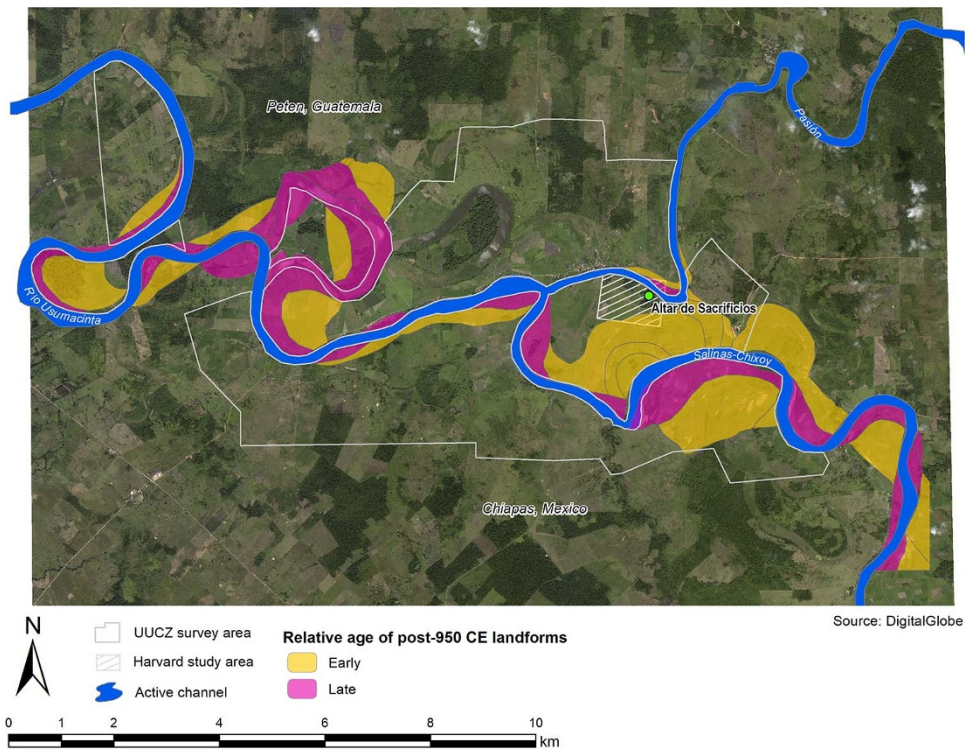


Figure 4. Relative age of geomorphological surfaces in the UUCZ. Because the estimated age of these landforms post-date site abandonment, these areas were excluded from the structure density estimates and definition of district boundaries. (Color online)

the SfM-based DEM to 30 m and subtracted that from the SRTM-based DEM. From these differences we regressed a twelfth-order polynomial raster, producing a topographic distortion error model. This error model was resampled to the SfM model's original resolution, and subtracted from the raw elevations producing the corrected raster used for identification and analysis.

Archaeological features were detected and digitized by the first two authors—relying on hill-shaded elevation rasters (and detrended versions thereof)—in separate analyses to ensure replicability and were later ground verified by the PAALS team. In total, 430 mounds were recorded including 352 new structures that were not previously documented (Figure 5). Some architectural clusters, however, were noted during earlier explorations and appear on several published maps of the broader region (Tourtellot 1988; Tovalín and Ortiz 2005; Willey and Smith 1969). Morley (1938:310–314), for example, noted a small group of mounds and one inscribed monument along the south bank of the Usumacinta about 3 km downstream from Altar at a site he called El Pabellón. In addition, Bullard visited ruins near Laguna Ixcoche during the early years of the Harvard project, describing “eight to 12 mounds forming a small ceremonial group . . . substantially larger than El Pabellón” although no monuments were observed (Willey and Smith 1969:35). Another group of mounds located at the opposite end of Laguna Ixcoche was also reported to the Harvard team but went unvisited. The descriptions of these mound locations are consistent with features observed in our survey, so we retain these names to reference the settlement clusters as described in the following text and indicated on Figure 5. In general, mounds are dispersed across the fluvial landscape, in many cases aligned with relict channels. However, the river courses have shifted considerably throughout the Holocene, dramatically changing the landscape and damaging or obliterating an unknown number of archaeological features, thus complicating analysis and interpretation of ancient settlement systems (Munson et al. 2023). We attempt to account for some of these factors in our population estimates and interpretations of the settlement patterns.

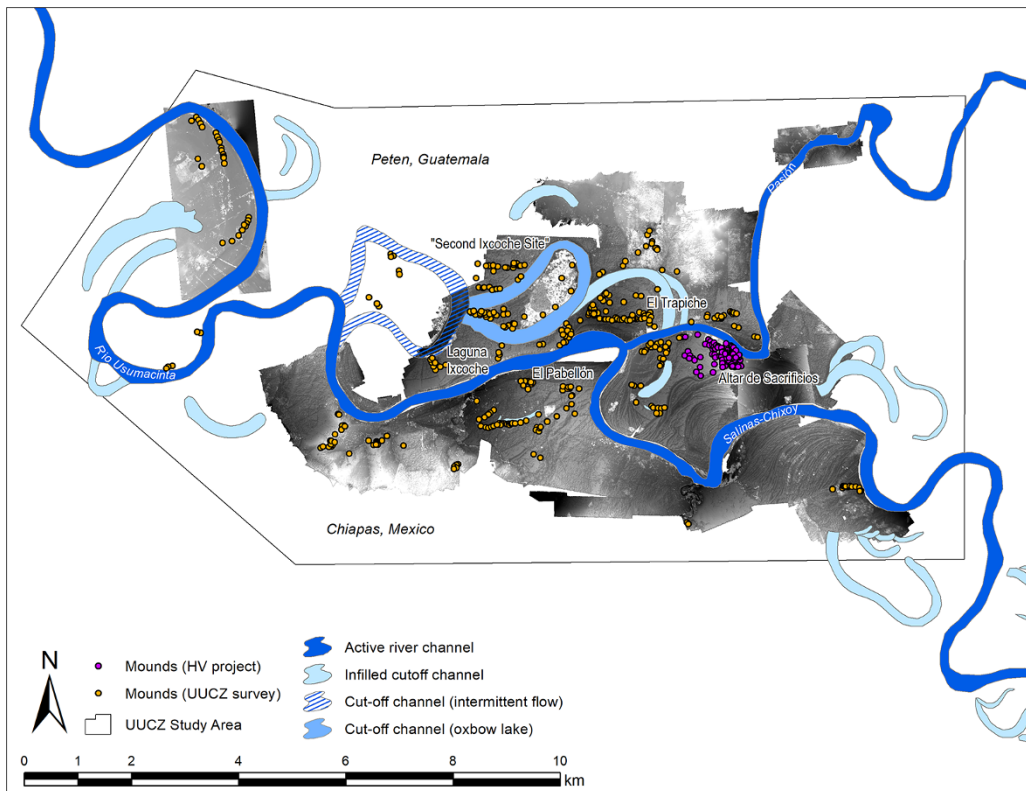


Figure 5. Settlement map showing the location of identified mounds and UAS-surveyed areas in the UUCZ study region with site names based on earlier investigations. (Color online)

Settlement Size: Area, Density, and Population Estimates

The UUCZ survey area is relatively small (54 km²) compared to other remote sensing surveys in the Maya lowlands (Table 2; $\mu = 214$ km²), but many were acquired with airborne lidar that can cover much larger tracts than our drone-mounted system. Nonetheless, we can still make systematic comparisons between regions using common methods. Different approaches, however, have been employed by Maya archaeologists to calculate population estimates, a nontrivial exercise that has generated significant debate (for selected reviews, see Chase et al. 2024; Culbert et al. 1990; Webster 2018). Here we use individual structure count—a representation of a single-family unit—for the basis of our population estimates, following methods described in Canuto et al. (2018) to facilitate regional comparison. This technique multiplies the total number of structures in the study area by a population index (PopIndex) that takes into account variation in the average number of household occupants, contemporaneity, and structure function, among other factors (see Canuto et al. 2018:Table 5). In this case, we report population as a range using the low (2.55) and high (3.97) PopIndex values recognizing the inherent imprecision in estimating the size of past populations. While most of the comparative cases in Table 2 derive from the Pacunam Lidar Initiative (PLI), structure density and population estimates for other regions are also reported as ranges according to the publications cited.

Population estimates for the UUCZ also consider local landscape changes associated with river channel migration that have compromised archaeological visibility. We calculated the density of structures excluding post-AD 950 landforms (see Figure 4), using this value (10.8 structures/km²) to estimate the number of mounds that may have been obliterated ($n_i \approx 153$) in the study area. We then use this extrapolated structure count ($n_{\text{tot}} = 583$) to calculate the regional population estimates employing the method described in the preceding text. Accounting for taphonomic processes yields a more realistic population

Table 2. Population Estimates and Settlement Density Comparison of Selected Remotely Sensed Archaeological Surveys in the Maya Lowlands.

Region/Site	Area (km ²)	Structures	Structure Density (str/km ²)	Pop. Est. Low	Pop. Est. High	Pop. Density Low (people/km ²)	Pop. Density High (people/km ²)	Source
Caracol	240.0	n/a	n/a	74,109	121,728	308.8	507.2	Chase et al. 2024
El Pilar	15.5	1,444	93.2	3,806	—	245.5	—	Horn et al. 2023
Bolonchén/Muluchtzekel	237.0	19,200	81.0	56,000	84,000	236.3	354.4	Ringle et al. 2021
Naachtun	135.0	11,979	88.7	30,546	47,557	226.3	352.3	Canuto et al. 2018
Tikal	147.0	12,341	84.0	31,470	48,994	214.1	333.3	Canuto et al. 2018
Peru	91.0	4,096	45.0	10,445	16,261	114.8	178.7	Canuto et al. 2018
Xultun	124.0	5,513	44.5	14,058	21,887	113.4	176.5	Canuto et al. 2018
Zotz	144.0	6,254	44.0	15,948	24,828	110.7	172.4	Canuto et al. 2018
Tintal	97.0	4,130	42.6	10,532	16,396	108.6	169.0	Canuto et al. 2018
Uaxactun	163.0	5,075	31.1	12,941	20,148	79.4	123.6	Canuto et al. 2018
Ceibal	470.0	15,985	34.0	33,637	51,841	71.6	110.3	Inomata et al. 2018
Holmul	309.0	7,207	23.3	18,378	28,612	59.5	92.6	Canuto et al. 2018
Usumacinta-Lacanja	331.0	5,220	15.8	13,311	20,723	40.2	62.6	Golden et al. 2021
UUCZ (incl. est. # destroyed mounds)	54.0	583	10.8	1,487	2,315	27.5	42.9	This article
UUCZ (excl. post-950 AD landforms)	40.0	430	10.8	1,097	1,707	27.4	42.7	This article
Corona	432.0	3,629	8.4	9,254	14,407	21.4	33.3	Canuto et al. 2018
Yala	172.0	740	4.3	1,887	2,938	11.0	17.1	Canuto et al. 2018
Env 2	146.0	254	1.7	648	1,008	4.4	6.9	Canuto et al. 2018
Env 1	184.0	307	1.7	783	1,219	4.3	6.6	Canuto et al. 2018

estimate for the UUCZ than if one assumes a static landscape. Thus, estimates for the Late Classic population in the UUCZ range from about 1,500 to 2,300—orders of magnitude less than other regions (see Table 2).

Although the UUCZ's low population estimates may be a function of the smaller area surveyed in comparison to larger regional lidar surveys, population densities for the UUCZ are comparable to macro-settlement densities in the Corona-Achiotal region of northwestern Petén. However, comparisons between neighboring regions reveal that population density in the UUCZ is substantially lower than Ceibal (~40%; Inomata et al. 2018) and the Usumacinta-Lacanja (~60%; Golden et al. 2021), suggesting that this was not a major hub for permanent population despite its hypothesized importance as a crossroads for exchange. It is possible though that this region experienced large numbers of passers-by who may have made short stops along the way. Such transient encounters, however, would have left ephemeral settlement traces—a point we discuss further below.

At the macro-settlement scale, cluster analysis of the PLI survey blocks indicates that these can be grouped into three urbanization classes with Corona-Achiotal and the three “control” regions (Yala, Env 1, Env 2) classified as rural based on their low overall density and limited political integration (Canuto et al. 2018:7–8). Accordingly, the sparsely settled UUCZ would also fall into this rural category. However, populations were not evenly distributed across any of these landscapes, so we must examine patterns of variation at different scales and in relation to other topographic and environmental factors to better understand density continua and their implications for urbanization processes (Canuto and Auld-Thomas 2021).

We generated a settlement density map for the UUCZ (Figure 6) following the same kernel density protocols used by Canuto et al. (2018) ensuring consistency in classificatory schemes. Settlement distribution in the UUCZ is indeed sparse with most settled areas classified as “rural” based on the criterion of 10 to 60 structures/km². Notably, areas designated as rural are more sparsely occupied zones on the alluvial plain with settlement located close to previously active river channels. This rural pattern, however, is discontinuous with large “vacant” zones of settlement interspersed across the landscape. Such local variability is similar to the patchy settlement patterns observed in the Corona-Achiotal region (Canuto and Auld-Thomas 2021), although we recognize that some of these areas may have housed a small number of ephemeral structures that left minimal traces on the landscape (Johnston 2004). Crop stains identified in multispectral imagery obtained by the PAALS survey may be consistent with such non-mounded, perishable structures (Munson et al. 2019). Although we were unable to further test these features, we tentatively interpret them as temporary-use structures or other possible campsites that may have been used intermittently by transient populations.

The eastern part of the survey area surrounding Groups A and B has a slightly higher occupation density than other parts of the settlement. Another such small area is found a few kilometers to the west on the north side of the Usumacinta River near the current location of the Pasi n-Salinas confluence. These areas of elevated density would be defined as “periurban” according to the classes defined by Canuto and colleagues (2018; 61–150 structures per km²); however, this term usually refers to the urban fringe surrounding more densely settled cities (Simon 2008). All the PLI survey blocks with known archaeological sites have sizable “urban” areas and many have even higher density “urban cores” with true periurban zones surrounding them (Canuto et al. 2018:Figure 7; see also Simon 2008:171–172). Because there is no high-density epicenter in the UUCZ, we employ the term “rurban” to describe this macro-settlement pattern that combines traditionally urban and rural characteristics paralleling other frontier settlements and anomalous cases that do not easily fit into dichotomous classifications (Cyriac et al. 2022; Raja and Sindb k 2022).

Architectural Form, Function, and Spatial Organization

Size, layout, and distribution of residential and public architecture offer important descriptive attributes to characterize urban form and settlement planning (Marken and Arnould 2023:16–18). For the UUCZ, we examine these aspects of the built environment and undefined open space to consider potential land use activities carried out in the rural zones—and how these relate to Altar's urban function and life in the countryside.

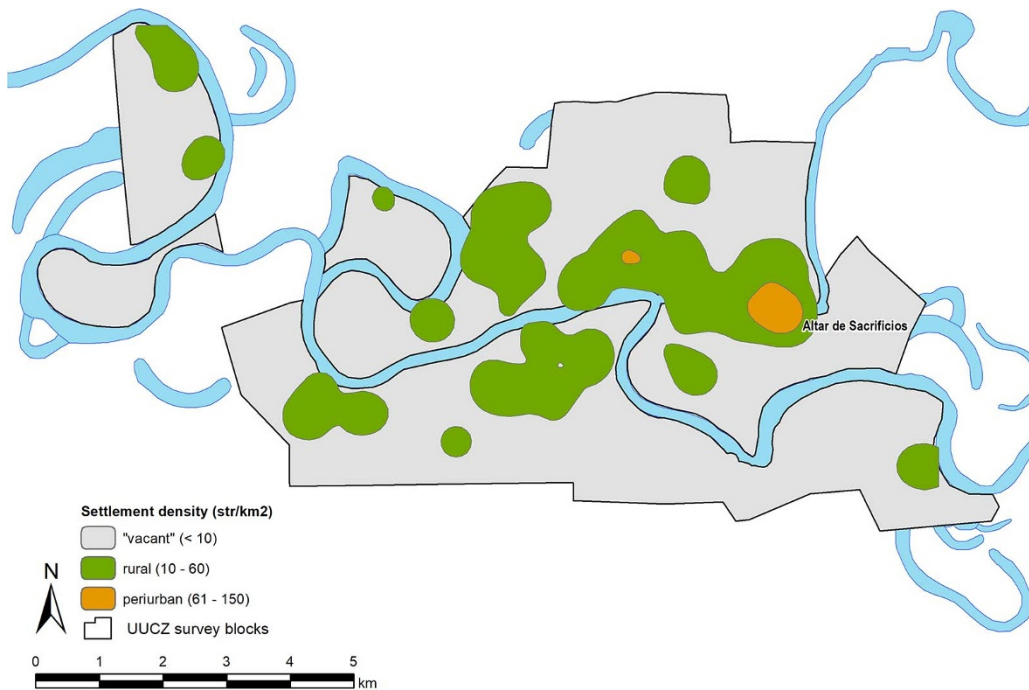


Figure 6. Kernel density settlement map with values expressed as structures/km². (Color online)

We classified structures into two categories based on criteria established by Bullard (1960) and the original Harvard project (Smith 1972). Residential structures are generally low earthen mounds whereas nonresidential “special structures” are nearly twice as tall and more massive architectural complexes with different forms (Table 3). Bullard’s original survey identified the former as “house mounds” based on their simple form, relatively small size, and dissociation from Groups A and B. The latter are more similar to Bullard’s (1960) description of minor ceremonial centers, but we recognize these buildings may have more diverse and overlapping functions. Most of the mounds that were ground-verified by our team yield little to no evidence of masonry construction, unlike the monumental buildings in Groups A and B and some of the “special structures” documented in the rural zones. Most mounds identified in our survey are classified as residential ($n = 390$; 90.7%) and likely served some domestic function (Figure 7). These low earthen platforms offered an elevated, level surface for the construction of perishable buildings generally above the flood zone. Alluvial clay and mud deposits along with bamboo growing nearby offered ample, easily accessible materials for the construction of wattle-and-daub dwellings. Although Harvard’s investigations recorded few details of the domestic architecture, the PAALS excavations have documented the remains of walls, postholes, clay floors, and pit features associated with refuse consistent with domestic activities (Paiz and Munson 2023; Viñals and Munson 2024). Unlike the *plazuela* configuration typical of other lowland Maya settlements, residential platforms in the UUCZ are single, solitary features that generally align with the contours of previous river channels. Depending on their size, most mounds probably could have accommodated two to four perishable structures. Therefore, we consider each mound equivalent to a household unit for the purpose of estimating population and calculating household wealth inequality (Munson et al. 2023).

A total of 27 mounds (6.3%) were classified as “non-residential special structures” in our survey. Of these, 14 are buildings in Groups A and B that were previously identified as temple pyramids, ball-courts, administrative buildings, or dedicated funerary mounds. The remaining “special structures” in the outlying rural zone are large platforms or pyramid-shaped structures more than 6 m tall—greater than the height of most residential mounds. Notably, all “special structures” in the peripheral zone are within 400 m of water sources, and most are situated along paleochannels, which provided access to

Table 3. Mound Classification and Size Attributes.

Mound Type	Total Mounds	Avg. Height (m)	Avg. Base Area (m ²)	Avg. Volume (m ³)
Residential	390	2.4	929.8	1,449.3
“Special” Nonresidential	27	4.9	2,801.4	13,159.5
<i>Focal Nodes</i>	13	7.9	4,704.6	17,290.2
Unclassified	13	—	—	—

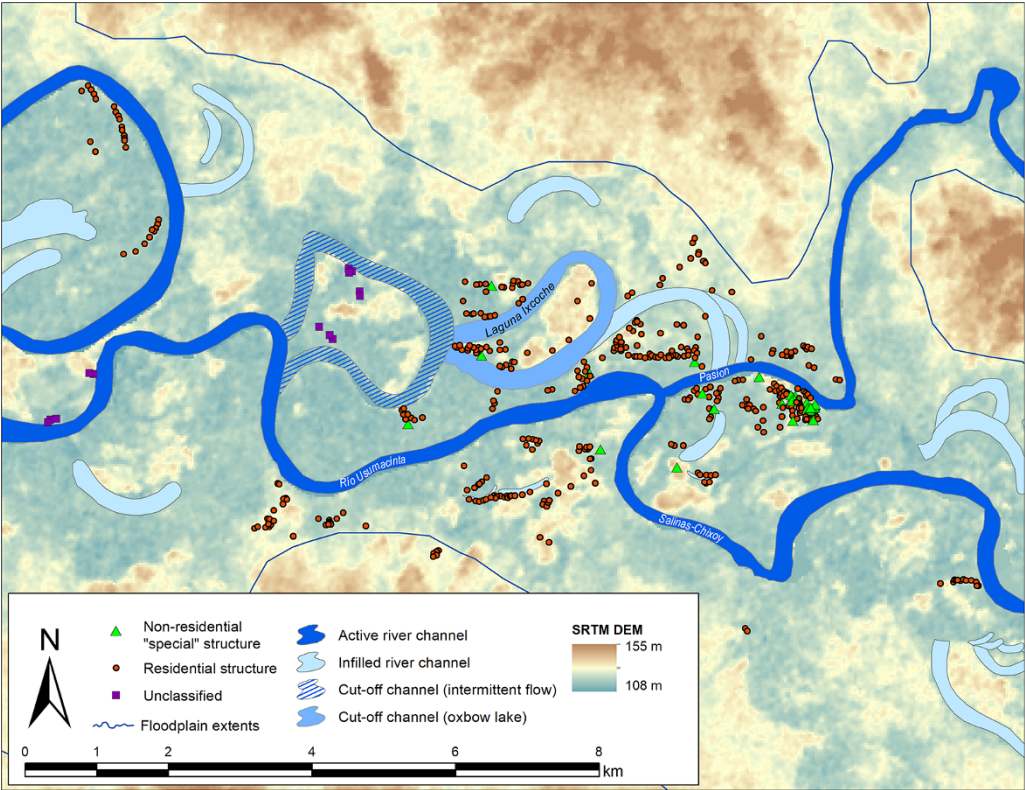


Figure 7. Regional settlement pattern in the UUCZ relative to existing topographic and hydrologic features showing the location of mounds classified as residential and “special structures.” (Color online).

riparian resources and transportation corridors yet avoided riverbanks prone to flooding (see also Ford et al. 2009). Many are also part of small architectural clusters. Although we have not yet excavated any “special structures” in the rural zones, we recovered numerous figurine whistles and several small plain whistles from surface collections on Strs. 38 and 67. The acoustic properties of these objects may have served important roles in ceremonies and/or as more mundane communication devices. The location of these prominent structures in an otherwise sparsely occupied landscape may have provided important interregional functions controlling navigation along these waterways, although we do not exclude the possibility that these structures also served additional organizing functions for the resident population. Future investigations will help clarify these points, but for now we interpret the “special structures” in the rural zone, along with the principal temple and palace in Groups A and B, as focal nodes.

Focal nodes have been identified at a number of Maya settlements and are interpreted as integrating features for rural or dispersed populations (Burham et al. 2020; Hutson 2016; Ingalls and Yaeger 2022; Lemonnier 2012; Peuramaki-Brown 2013; Walden et al. 2019). Although this term embraces a wide range of variation, we use it broadly to refer to built spaces that facilitated social interaction and

Table 4. Size and Architectural Form Attributes for Focal Nodes in the UUCZ.

District	Str. ID	Height (m)	Basal Area (m ²)	Volume (m ³)	Focal Node Form (Function)
ALS	AI	10.0	—	—	platform (Late Classic palace)
	AII	10.2	4,686.7	—	range structure
	BI	13.0	1,369.2	—	temple pyramid
	BIV	7.7	3,917.7	—	platform (Preclassic-Early Classic palace)
GF	38	7.0	5,431.3	17,880.4	pyramid
GF2	50	6.2	5,534.9	15,145.9	platform
	67	7.7	4,379.9	17,670.5	pyramid
IX	182	6.0	6,946.2	22,117.1	platform
IX2	201	7.6	5,601.0	20,180.0	platform
IX3	220	6.7	7,037.3	22,809.5	platform
PB	226	3.3	5,267.5	11,485.8	platform
TP	100	9.5	1,940.9	—	pyramid
TP2	163	9.8	3,244.4	11,032.5	pyramid

organization across this rural landscape (Ashmore 1981; Hutson 2016). In this study, the “special structures” we identify as focal nodes are evenly distributed, proximal to water sources, and associated with architectural clusters that we identify as districts (Table 4).

Districts are defined as residential zones that have some kind of administrative function and/or particular social identity that is distinct from other sectors of a settlement (Smith 2010). According to this definition, districts tend to be larger than neighborhoods and may include public architecture and spaces for social gathering absent within more private settings. Although we previously defined neighborhoods for the UUCZ as a convenient unit for comparative analysis (Thompson et al. 2022, 2025), we introduce districts in this article as a means to analyze intrasettlement patterns and social organization. District boundaries were delineated based on the settlement density map, distribution of focal nodes, geomorphological reconstructions, and consideration of the contours of relic river channels and oxbow lakes that may have formed natural boundaries in the past. While the actual boundaries are probably fuzzier and more fluid than those conveyed in Figure 8, the social scale of districts provides a more appropriate unit of analysis to examine aspects of urban function than neighborhoods given the region's sparse occupation. Table 5 lists the size, structure counts, and population estimates for each district including the estimated number of obliterated mounds. As expected, districts with periurban zones (Altar de Sacrificios and El Trapiche) have the highest population estimates within the UUCZ. However, with only ~200 people per district they are very small communities. The most sparsely occupied districts (Ixcoche III and Grupo Frontera) had only a few dozen inhabitants, but these are adjacent to landforms that postdate AD 950 and may include obliterated mounds, so populations may have been higher in the past. Overall, the small size of these districts suggests that most members probably were familiar with each other given the natural community size of many human social networks (Hill and Dunbar 2003). In contrast to “urban” settings, these districts would have been populated by people who had a high degree of social familiarity but lower intensity of face-to-face interactions than those generated by the effects of energized crowding in city centers (Lamb 2020; Smith 2023). Therefore, we propose that focal nodes in these rural districts may have helped formalize and regularize social interactions through labor organization, communal ceremony, and other activities.

Rurban Function and Agrarian Land Use

Lastly, we shift our attention to the “vacant” spaces in between these sparsely settled areas to consider potential agrarian activities in the countryside. Frequent floods in the UUCZ deposit rich alluvial soils across this broad plain, making it well-suited to cultivation (Horseman et al. 2024). However, such low populations would not have placed great demand for intensive agriculture as in other parts of the Maya

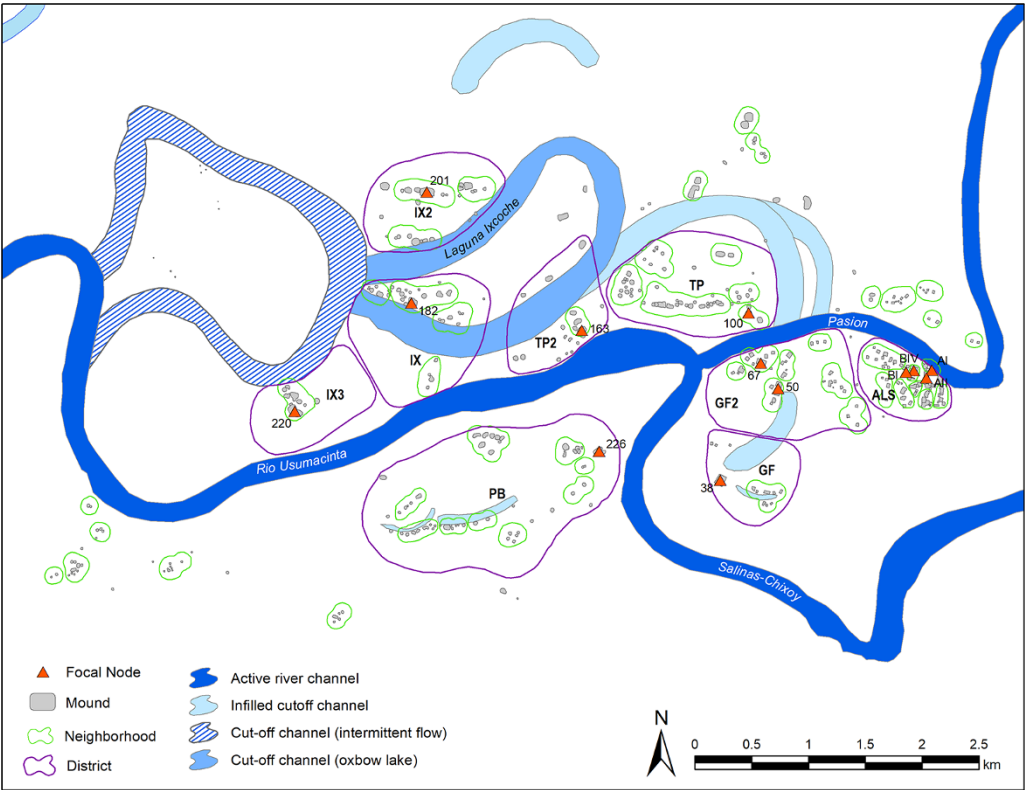


Figure 8. Regional settlement map showing districts and focal nodes. (Color online)

Table 5. Population Estimates and Settlement Pattern Summary for Defined Districts within the UUCZ.

District Name	District ID	District Area (hectare)	Structure Count	Focal Node Count	Pop. Est. Low	Pop. Est. Med.	Pop. Est. High
Altar de Sacrificios	ALS	41.8	64	4	163	202	254
El Pabellon	PB	227.7	53	1	135	167	210
El Trapiche	TP	110.5	55	1	140	174	218
El Trapiche 2	TP2	69.8	18	1	46	57	71
Grupo Frontera	GF	53.3	12	1	31	38	48
Grupo Frontera 2	GF2	102.2	32	2	82	101	127
Ixcoche	IX	109.8	30	1	77	195	1119
Ixcoche 2	IX2	81.1	26	1	66	82	103
Ixcoche 3	IX3	62.3	9	1	23	28	36
Unassigned			131		334	414	520
UUCZ (excluding post-AD 950 landforms)			430		1,097	1,359	1,707
Estimated # mounds destroyed			153		390	483	607
Total Estimated UUCZ			583		1,487	1,842	2,315

lowlands. The PAALS survey identified only one possible drainage canal and no ditched fields or terraces like those documented in more densely settled regions downstream (Golden et al. 2021; Schroder et al. 2020). Given the settlement’s close proximity to water, riparian resources procured from fishing and collecting may have made significant contributions to the local diet (Sharpe et al. 2024) in addition to cultigens other than maize (Morell-Hart et al. 2023).

Another possibility we entertain is that these unmodified, “vacant” areas could have also supported silviculture of cacao and other fruit-bearing trees. Agroforestry was a productive and sustainable strategy of resource management for the ancient Maya (Ford and Nigh 2009, 2016). However, cacao is a finicky plant requiring particular conditions for cultivation: consistently moist deep alluvial soils, high temperatures, heavy rainfall, and a shady canopy offering protection from sun and wind (Bletter and Douglas 2006)—settings not unlike those found in the greater UUCZ. Indeed, there is historical evidence of cacao production along the Pasión and Machaquila rivers during the sixteenth and seventeenth centuries (Caso Barrera and Aliphat 2006). Agricultural censuses of Mexico from 1950 and 1960 respectively estimate 1,400 and 5,000 fruit-bearing cacao trees in the UUCZ’s southern sectors (Dirección General de Estadística 1957, 1965), which could have produced 1,300 to 2,000 kg of dried beans annually. A few local residents still have cacao and other fruit-bearing trees growing in their home orchards today, attesting to the continued presence of silviculture in the region.

During the Classic period most cacao-growing regions were located along the coast, but the UUCZ is one of the few lowland interior zones where cacao could have been cultivated and easily transported due to its environmental setting and navigable waterways (Baron 2018:Figure 1). Other lowland Maya riverine settlements, like those in the Sibun Valley and along the Macal River in Belize, were also locations of cacao production during Classic and Postclassic times (McAnany et al. 2002; Muhs et al. 1985). Tentatively, we hypothesize that the “vacant” areas in this sparsely occupied fluvial landscape may have contained cacao groves and other valuable tree crops that could have been cultivated for local consumption and export, especially as demand for cacao increased during the Late Classic period (Baron 2018; McAnany 2010). Focal nodes in the rural districts may have helped coordinate and manage these activities by storing surplus or arranging shipment of these goods. This interpretation might help explain the paradoxical pattern of such low-density settlement alongside the concentration of such elaborate urban forms in the Altar epicenter, but additional lines of evidence are needed to further test these hypotheses.

Conclusion

Altar de Sacrificios has escaped proper description ever since it was first visited by archaeologists. Paradoxically, it was home to both one of the earliest intensive large-scale excavations in Maya archaeology and was later abandoned in the practical (and arguably academic) sense. Much of this was not only due to logistical difficulties working in a heavily forested tropical environment along a major political border but also significant was the existence of a rural-urban dichotomy belying Maya research. Thanks to technological and theoretical advancements—and the unfortunate destruction of tropical forests—we are now in a position to reposition Altar on the ancient Maya landscape.

The settlement contained hundreds of artificial mounds primarily aligned according to the fluvial landscape. Like other Classic Maya capital cities, it contained numerous pyramids, enclosed plazas, palaces, and carved monuments that bore the emblem and image of its dynastic rulers. But it also—like rural settlements—contained swaths of seemingly empty land and population densities that would otherwise barely register in a demographic reconstruction. While Altar did not seem to engage in political jockeying at the same level as other independent polities, it was able to provision its modest population with imported goods and perhaps a font of wealth from cacao cultivation. Such paradoxical patterns raise questions about the extent of Altar’s political and economic influence, both locally within the UUCZ but also more broadly across the Maya lowlands. One avenue for future research is to investigate the discordant sociopolitical models posed by Altar’s geographic and potentially silvicultural benefits versus its historical-demographic record of marginality.

The Proyecto Arqueológico Altar de Sacrificios has made great strides in documenting the rural landscape around this ancient provincial capital over the last nine years and progress in analyzing and interpreting the material remains from household excavations. This was possible because we prioritized methods that efficiently and inexpensively produced large-scale coverage of a region that has been largely neglected over the last half century in Maya archaeology. Our drone-based system was more than sufficient to document settlement in now-deforested environments clustered primarily along fluvial waterways. Likewise, our geomorphological reconnaissance allowed us to constrain the ages of major landforms (and associated cultural features) in the landscape while cataloging areas that most likely

contained long-destroyed settlement. Contextualizing these settlement patterns with those from other regions underscores the diverse arrangements that characterize this unique ancient urban tradition, although more research is needed to understand the specific connections and population movements between ancient cities and rural zones. Moving forward, Maya archaeology must continue to grapple with the terms, concepts, and methods we employ to better synthesize these vast datasets and produce more comprehensive models of past rural lifeways.

Acknowledgments. We thank the Instituto de Antropología e Historia (IDAEH) in Guatemala and the Instituto Nacional de Antropología e Historia (INAH) in Mexico for the permission to conduct archaeological investigations in this region. We are very grateful to all the members of the PAALS team, especially our local collaborators, whose work, dedication, and commitment enrich the research of this region. We also thank the three reviewers for their insightful feedback and suggestions, which greatly helped us improve the quality of this manuscript.

Funding Statement. The Proyecto Arqueológico Altar de Sacrificios is supported by grants from the Wenner-Gren Foundation, Archaeological Institute of America, National Science Foundation (BCS-1952503), the Rust Family Foundation, Society for American Archaeology, and Lycoming College. Mejía Ramon recognizes funding from a Pennsylvania Space Grant and the National Aeronautics and Space Administration. This work contributes to the ICTA-UAB “María de Maeztu” Program for Units of Excellence of the Spanish Ministry of Science and Innovation (CEX2024-001506-M funded by MICIU/AEI /10.13039/501100011033), and to EarlyFoods SGR, which has received funding from the Agencia de Gestió d’Ajuts Universitaris i de Recerca de Catalunya (SGR-Cat 2021, 00527).

Data Availability Statement. Topographic and color orthoimage datasets of the Altar de Sacrificios and Grupo Frontera peninsula are available on Penn State’s Scholar Sphere. Datasets collected in Mexico can be requested from the authors with permission from the Consejo de Arqueología.

Competing Interests. The authors declare none.

Note

1. A petrographic description of the so-called red sandstone published in the original Harvard monograph (Smith 1972:3) notes the very high porosity, low density, extremely soft, and highly weathered nature of this material, which is composed principally of clay. Although the original analysis notes the absence of volcanic grains, subsequent observations by Jill Onken indicate that the original material may have been composed largely of volcanic ash that had weathered to halloysite clay (Claridge and Campbell 1974), which is consistent with abundant volcanic ash observed in modern river sand deposits. An outcrop of the red “sandstone” material is located about 9 km upstream from Altar. Given its proximity and lightweight, it would not have been difficult to transport this material or carve blocks for construction. We retain the “sandstone” in quotations consistent with Harvard’s earlier usage.

References Cited

- Adams, Richard E. W. 1971. *Ceramics of Altar de Sacrificios, Guatemala*. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 63, No. 1. Harvard University, Cambridge, Massachusetts.
- Aliphat, Mario M. 1994. *Classic Maya Landscape in the Upper Usumacinta River Valley*. PhD dissertation, Department of Archaeology, University of Calgary, Calgary, Canada.
- Arnould, M. Charlotte, Dominique Michelet, and Philippe Nondédéo. 2013. Living Together in Río Bec Houses: Coresidence, Rank, and Alliance. *Ancient Mesoamerica* 24(2):469–493. <https://doi.org/10.1017/S0956536114000029>.
- Ashmore, Wendy. 1981. Some Issues of Method and Theory in Lowland Maya Settlement Archaeology. In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, pp. 37–69. School of American Research, Santa Fe, New Mexico.
- Baron, Joanne P. 2018. Making Money in Mesoamerica: Currency Production and Procurement in the Classic Maya Financial System. *Economic Anthropology* 5(2):210–223. <https://doi.org/10.1002/sea2.12118>.
- Bettencourt, Luís M. A. 2013. The Origins of Scaling in Cities. *Science* 340(6139):1438–1441. <https://doi.org/10.1126/science.1235823>.
- Bletter, Nathaniel, and C. Douglas. 2006. Cacao and Its Relatives in South America: An Overview of Taxonomy, Ecology, Biogeography, and Ethnobotany. In *Chocolate in Mesoamerica: A Cultural History of Cacao*, edited by Cameron L. McNeil, pp. 31–68. University Press of Florida, Gainesville.
- Bullard, William R. 1960. Maya Settlement Pattern in Northeastern Petén, Guatemala. *American Antiquity* 25(3):355–372. <https://doi.org/10.2307/277519>.
- Burham, Melissa, Takeshi Inomata, Daniela Triadan, and Jessica MacLellan. 2020. Ritual Practice, Urbanization, and Sociopolitical Organization at Preclassic Ceibal, Guatemala. In *Approaches to Monumental Landscapes of the Ancient Maya*, edited by Brett A. Houk, Barbara Arroyo, and Terry G. Powis, pp. 61–84. University Press of Florida, Gainesville.
- Canuto, Marcello A., and Luke Auld-Thomas. 2021. Taking the High Ground: A Model for Lowland Maya Settlement Patterns. *Journal of Anthropological Archaeology* 64:101349. <https://doi.org/10.1016/j.jaa.2021.101349>.

- 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>.
- Caso Barrera, Laura, and Mario Aliphath. 2006. Cacao, Vanilla and Annatto: Three Production and Exchange Systems in the Southern Maya Lowlands, XVI–XVII Centuries. *Journal of Latin American Geography* 5(2):29–52. <https://doi.org/10.1353/lag.2006.0015>.
- 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 & Agriculture* 20(2/3):60–77.
- Chase, Arlen F., and Diane Z. Chase. 2016. Urbanism and Anthropogenic Landscapes. *Annual Review of Anthropology* 45:361–376. <https://doi.org/10.1146/annurev-anthro-102215-095852>.
- Chase, Arlen, Diane Chase, Jaime Awe, John Weishampel, Gyles Iannone, Holley Moyes, Jason Yaeger, et al. 2014. Ancient Maya Regional Settlement and Inter-Site Analysis: The 2013 West-Central Belize LiDAR Survey. *Remote Sensing* 6(9):8671–8695. <https://doi.org/10.3390/rs6098671>.
- Chase, Arlen F., Diane Z. Chase, and Adrian S. Z. Chase. 2024. Archaeological Population Studies in Mesoamerica. In *Ancient Mesoamerican Population History: Urbanism, Social Complexity, and Change*, edited by Adrian S. Z. Chase, Arlen F. Chase, and Diane Z. Chase, pp. 5–44. University of Arizona Press, Tucson.
- Chase, Diane Z., José Lobo, Gary M. Feinman, David M. Carballo, Arlen F. Chase, Adrian S. Z. Chase, Scott R. Hutson, et al. 2023. Mesoamerican Urbanism Revisited: Environmental Change, Adaptation, Resilience, Persistence, and Collapse. *PNAS* 120(31):e2211558120. <https://doi.org/10.1073/pnas.2211558120>.
- Childe, V. Gordon. 1950. The Urban Revolution. *Town Planning Review* 21(1):3–17.
- Claridge, G. G. C., and I. B. Campbell. 1974. Presence of Halloysite as an Indication of Volcanic Ash in the McMurdo Sound Region, Antarctica. *New Zealand Journal of Geology and Geophysics* 17(3):579–585. <https://doi.org/10.1080/00288306.1973.10421582>.
- Culbert, T. Patrick, Laura Kosakowsky, Robert E. Fry, and William A. Haviland. 1990. The Population of Tikal, Guatemala. In *Pre-Columbian Population History in the Maya Lowlands*, edited by T. Patrick Culbert and Don S. Rice, pp. 103–121. University of New Mexico Press, Albuquerque.
- Cyriac, Susan, Mohammed Firoz C, and Lakshmi Priya Rajendran. 2022. Neither Rural Nor Urban: A Critical Review of the Fringe Dynamics of Settlements. In *The Palgrave Encyclopedia of Urban and Regional Futures*, edited by Robert C. Brears, pp. 1121–1134. Springer International, Cham, Switzerland.
- Dahlin, Bruce H., Timothy Beach, Sheryl Luzzadder-Beach, Hixson, David, Scott Hutson, Aline Magnoni, Eugenia Mansell, and Daniel E. Mazeau. 2005. Reconstructing Agricultural Self-Sufficiency at Chunchucmil, Yucatan, Mexico. *Ancient Mesoamerica* 16(2):229–247. <https://doi.org/10.1017/S0956536105050212>.
- Dirección General de Estadística. 1957. *Tercer Censo Agrícola, Ganadero y Ejidal, 1950: Chiapas*. Secretaría de Economía, Mexico City.
- Dirección General de Estadística. 1965. *IV Censos Agrícola, Ganadero y Ejidal, 1960: Chiapas*. Secretaría de Industria y Comercio, Mexico City.
- Drennan, Robert D. 1988. Household Location and Compact Versus Dispersed Settlement in Prehispanic Mesoamerica. In *Household and Community in the Mesoamerican Past*, edited by Richard R. Wilk and Wendy Ashmore, pp. 273–293. University of New Mexico Press, Albuquerque.
- 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(2):241–287. <https://doi.org/10.1007/s10814-019-09135-8>.
- Eppich, Keith, and Joseph W. Ball. 2024. Rehabilitating El Pozito, Northern Belize: A Classic Maya Town and Its Socioeconomic History as Reflected in Ceramics and Architecture. *Ancient Mesoamerica* 35(2):343–367. <https://doi.org/10.1017/S0956536123000172>.
- Estrada-Belli, Francisco, Marcello A. Canuto, Ivan Šprajc, and Juan Carlos Fernandez-Díaz. 2025. New Regional-Scale Classic Maya Population Estimates and Settlement Organization Models through Airborne Lidar Scanning. *Journal of Archaeological Science: Reports* 66:105288. <https://doi.org/10.1016/j.jasrep.2025.105288>.
- Fash, William L. 2001. *Scribes, Warriors and Kings: The City of Copan and the Ancient Maya*. Thames and Hudson, London.
- Fedick, Scott Lee. 1988. Prehistoric Maya Settlement and Land Use Patterns in the Upper Belize River Area, Belize, Central America. PhD dissertation, Department of Anthropology, Arizona State University, Tempe.
- Fletcher, Roland. 2009. Low-Density, Agrarian-Based Urbanism: A Comparative View. *Durham University Institute of Advanced Study Insights* 2(4):2–19.
- Fletcher, Roland. 2012. Low-Density, Agrarian-Based Urbanism: Scale, Power, and Ecology. In *The Comparative Archaeology of Complex Societies*, edited by Michael E. Smith, pp. 285–320. Cambridge University Press, New York.
- Ford, Anabel. 1981. Conditions for the Evolution of the Complex Societies: The Development of the Central Lowland Maya. PhD dissertation, Department of Anthropology, University of California, Santa Barbara.
- Ford, Anabel, Keith C. Clarke, and Gary Raines. 2009. Modeling Settlement Patterns of the Late Classic Maya Civilization with Bayesian Methods and Geographic Information Systems. *Annals of the Association of American Geographers* 99(3):496–520.
- Ford, Anabel, and Ronald Nigh. 2009. Origins of the Maya Forest Garden: Maya Resource Management. *Journal of Ethnobiology* 29(2):213–236. <https://doi.org/10.2993/0278-0771-29.2.213>.

- Ford, Anabel, and Ronald Nigh. 2016. *The Maya Forest Garden: Eight Millennia of Sustainable Cultivation of the Tropical Woodlands*. Routledge, London.
- Garrison, Thomas G. 2023. Kaj and Kingdom: Conurbation, Memory, and Landscapes of Mobile Maya Authority. In *Building an Archaeology of Maya Urbanism: Planning and Flexibility in the American Tropics*, edited by Damien B. Marken and M. Charlotte Arnauld, pp. 72–104. University Press of Colorado, Denver.
- Garrison, Thomas G., Stephen Houston, and Omar Alcover Firpi. 2019. Recentering the Rural: Lidar and Articulated Landscapes among the Maya. *Journal of Anthropological Archaeology* 53:133–146. <https://doi.org/10.1016/j.jaa.2018.11.005>.
- Golden, Charles, Andrew K. Scherer, Whittaker Schroder, Timothy Murtha, Shanti Morell-Hart, Juan Carlos Fernandez Diaz, Socorro del Pilar Jiménez Álvarez, et al. 2021. Airborne Lidar Survey, Density-Based Clustering, and Ancient Maya Settlement in the Upper Usumacinta River Region of Mexico and Guatemala. *Remote Sensing* 13(20):4109. <https://doi.org/10.3390/rs13204109>.
- Graham, Elizabeth. 1999. Stone Cities, Green Cities. *Archaeological Papers of the American Anthropological Association* 9(1):185–194. <https://doi.org/10.1525/ap3a.1999.9.1.185>.
- Haviland, William A. 1971. Entombment, Authority, and Descent at Altar de Sacrificios, Guatemala. *American Antiquity* 36(1):102–105.
- Hill, R. A., and R. I. M. Dunbar. 2003. Social Network Size in Humans. *Human Nature* 14(1):53–72. <https://doi.org/10.1007/s12110-003-1016-y>.
- Hirth, Kenneth G. 2003. The Altepetl and the Urban Structure in Prehispanic Mesoamerica. In *El Urbanismo En Mesoamerica*, edited by William T. Sanders, pp. 57–84. Instituto Nacional de Antropología e Historia, Mexico City; Pennsylvania State University, University Park.
- Horn, Sherman, Justin Tran, and Anabel Ford. 2023. Quantitative Analyses of Wealth Inequality at Classic Period El Pilar: The Gini Index and Labor Investment. *Ancient Mesoamerica* 34(3):e6. <https://doi.org/10.1017/S0956536123000081>.
- Horseman, Grace, Shanti Morell-Hart, Charles Golden, and Andrew Scherer. 2024. Suitability Models of Ancient Maya Agriculture in the Upper Usumacinta River Basin of Mexico and Guatemala. *Latin American Antiquity* 35(4):946–964. <https://doi.org/10.1017/laq.2024.29>.
- Houk, Brett A. 2015. *Ancient Maya Cities of the Eastern Lowlands*. University Press of Florida, Gainesville.
- Hutson, Scott R. 2016. *The Ancient Urban Maya: Neighborhoods, Inequality, and Built Form*. University of Florida Press, Gainesville.
- Hutson, Scott R., Nicholas P. Dunning, Bruce Cook, Thomas Ruhl, Nicolas C. Barth, and Daniel Conley. 2021. Ancient Maya Rural Settlement Patterns, Household Cooperation, and Regional Subsistence Interdependency in the Río Bec Area: Contributions from G-LiHT. *Journal of Anthropological Research* 77(4):550–579. <https://doi.org/10.1086/716750>.
- Hutson, Scott R., David R. Hixson, Aline Magnoni, Daniel Mazeau, and Bruce H. Dahlin. 2008. Site and Community at Chunchucmil and Ancient Maya Urban Centers. *Journal of Field Archaeology* 33(1):19–40.
- Iannone, Gyles, and Samuel V. Connell (editors). 2003. *Perspectives on Ancient Maya Rural Complexity*. Monograph No. 49. Cotsen Institute of Archaeology, University of California, Los Angeles.
- Ingalls, Victoria, and Jason Yaeger. 2022. Focal Nodes and Ritual Economy in Ancient Maya Hinterland Communities: A Case Study from San Lorenzo, Belize. *Ancient Mesoamerica* 33(1):116–131. <https://doi.org/10.1017/S0956536121000080>.
- 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. <https://doi.org/10.1371/journal.pone.0191619>.
- Isendahl, Christian. 2012. Agro-Urban Landscapes: The Example of Maya Lowland Cities. *Antiquity* 86(334):1112–1125. <https://doi.org/10.1017/S0003598X00048286>.
- Isendahl, Christian, Nicholas P. Dunning, Liwy Grazioso, Scott Hawken, David L. Lentz, and Vernon L. Scarborough. 2025. Growth and Decline of a Sustainable City: A Multitemporal Perspective on Blue-Black-Green Infrastructures at the Pre-Columbian Lowland Maya City of Tikal. *Urban Studies* 62(3):487–506. <https://doi.org/10.1177/00420980231224648>.
- Isendahl, Christian, and Michael E. Smith. 2013. Sustainable Agrarian Urbanism: The Low-Density Cities of the Mayas and Aztecs. *Cities* 31:132–143. <https://doi.org/10.1016/j.cities.2012.07.012>.
- Johnston, Kevin J. 2004. The “Invisible” Maya: Minimally Mounded Residential Settlement at Itzán, Petén, Guatemala. *Latin American Archaeology* 15(2):145–175. <https://doi.org/10.2307/4141552>.
- Lamb, Céline C. 2020. Ancient Maya Rurality. In *The Maya World*, edited by Scott R. Hutson and Traci Ardren, pp. 307–327. Routledge, London.
- Lamb, Céline. 2022. Rethinking the Rural in Ancient Maya Studies. *Ancient Mesoamerica* 33(1):51–61. <https://doi.org/10.1017/S095653612100033X>.
- Lemonnier, Éva. 2012. Neighborhoods in Classic Lowland Maya Societies: Identification and Definition from the La Joyanca Case Study (Northwestern Peten, Guatemala). In *The Neighborhood as a Social and Spatial Unit in Mesoamerican Cities*, edited by M. Charlotte Arnauld, Linda R. Manzanilla, and Michael E. Smith, pp. 181–201. University of Arizona Press, Tucson.
- Lemonnier, Eva, and M. Charlotte Arnauld. 2022. Defining Rurality at La Joyanca (Peten, Guatemala): Architecture, Land Use, and Social Dynamics. *Ancient Mesoamerica* 33(1):83–100. <https://doi.org/10.1017/S0956536120000413>.
- Lemonnier, Eva, and Boris Vannière. 2013. Agrarian Features, Farmsteads, and Homesteads in the Río Bec Nuclear Zone, Mexico. *Ancient Mesoamerica* 24(2):397–413. <https://doi.org/10.1017/S0956536113000242>.
- Lobo, Jose, Luis 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):731–747. <https://doi.org/10.1177/0042098019873796>.

- Lohse, Jon C., and Fred Valdez Jr. 2004. *Ancient Maya Commoners*. University of Texas Press, Austin.
- Lucero, Lisa. 2006. Local Rulers and the Maya: The Ritual History of Altar de Sacrificios. In *Water and Ritual: The Rise and Fall of Classic Maya Rulers*, edited by Lisa Lucero, pp. 114–144. University of Texas Press, Austin.
- Lucero, Lisa J., Roland Fletcher, and Robin Coningham. 2015. From “Collapse” to Urban Diaspora: The Transformation of Low-Density, Dispersed Agrarian Urbanism. *Antiquity* 89(347):1139–1154. <https://doi.org/10.15184/aqy.2015.51>.
- Marcus, Joyce. 1983. On the Nature of the Mesoamerican City. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*, edited by Evon Z. Vogt and Richard M. Leventhal, pp. 195–242. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, Massachusetts.
- Marken, Damien B. 2015. Conceptualizing the Spatial Dimensions of Classic Maya States: Polity and Urbanism at El Perú-Waka', Petén. In *Classic Maya Politics of the Southern Lowlands: Integration, Interaction, Dissolution*, edited by Damien B. Marken and James L. Fitzsimmons, pp. 123–166. University Press of Colorado, Denver.
- Marken, Damien B., and M. Charlotte Arnauld. 2023. Building an Archaeology of Maya Urbanism. In *Building an Archaeology of Maya Urbanism: Planning and Flexibility in the American Tropics*, edited by Damien B. Marken and M. Charlotte Arnauld, pp. 5–49. University Press of Colorado, Denver.
- Martin, Simon. 2001. Court and Realm: Architectural Signatures in the Classic Maya Southern Lowlands. In *Royal Courts of the Ancient Maya: Volume 1: Theory, Comparison, and Synthesis*, edited by Takeshi Inomata and Stephen D. Houston, pp. 168–194. Westview Press, Boulder, Colorado.
- Martin, Simon, and Nikolai Grube. 2008. *Chronicle of the Maya Kings and Queens: Deciphering the Dynasties of the Ancient Maya*. 2nd ed. Thames and Hudson, London.
- Mathews, Peter, and Gordon R. Willey. 1991. Prehistoric Politics of the Pasión Region: Hieroglyphic Texts and Their Archaeological Settings. In *Classic Maya Political History*, edited by T. Patrick Culbert, pp. 30–71. Cambridge University Press, Cambridge.
- McAnany, Patricia A. 2010. *Ancestral Maya Economies in Archaeological Perspective*. Cambridge University Press, Cambridge.
- McAnany, Patricia A., Ben A. Thomas, Stephen Morandi, Polly Peterson, and Eleanor Harrison. 2002. Praise the Ajaw and Pass the Kakaw: Xibun Maya and the Political Economy of Cacao. In *Ancient Maya Political Economies*, edited by Marilyn A. Masson and David A. Freidel, pp. 123–139. AltaMira Press, Walnut Creek, California.
- Mejía Ramón, Andrés G. 2019. La Prospección Fotogramétrica Fluvia y Aérea. In *Proyecto Geomorfológico de Asentamientos Antiguos del Usumacinta Superior, La Temporada 2019: Investigando la Historia Fluvial y los Patrones de Asentamiento de Altar de Sacrificios y Sus Alrededores*, edited by Jessica Munson, pp. 12–35. Instituto Nacional de Antropología e Historia, Mexico City.
- Morell-Hart, Shanti, Lydie Dussol, and Scott L. Fedick. 2023. Agriculture in the Ancient Maya Lowlands (Part 1): Paleoethnobotanical Residues and New Perspectives on Plant Management. *Journal of Archaeological Research* 31:561–615. <https://doi.org/10.1007/s10814-022-09180-w>.
- Morley, Sylvanus G. 1938. *The Inscriptions of Peten*. Vol. 2. Carnegie Institution of Washington, Washington, DC.
- Muhs, Daniel R., Robert R. Kautz, and J. Jefferson MacKinnon. 1985. Soils and the Location of Cacao Orchards at a Maya Site in Western Belize. *Journal of Archaeological Science* 12(2):121–137. [https://doi.org/10.1016/0305-4403\(85\)90057-3](https://doi.org/10.1016/0305-4403(85)90057-3).
- Munson, Jessica, Andrés G. Mejía Ramón, and Lorena Paiz Aragón. 2019. Mapeo de asentamientos en alta resolución con sistemas aéreos no tripulados en Altar de Sacrificios, Guatemala. In *XXXII Simposio de Investigaciones Arqueológicas En Guatemala, Tomo II*, edited by Barbara Arroyo, Luis Méndez Salinas, and Gloria Ajú Álvarez, pp. 637–648. Museo Nacional de Arqueología e Ethnología, Guatemala City.
- Munson, Jessica, and Jonathan Scholnick. 2022. Wealth and Well-Being in an Ancient Maya Community: A Framework for Studying the Quality of Life in Past Societies. *Journal of Archaeological Method and Theory* 29(1):1–30. <https://doi.org/10.1007/s10816-021-09508-8>.
- Munson, Jessica, Jonathan Scholnick, Andrés G. Mejía Ramón, and Lorena Paiz Aragón. 2023. Beyond House Size: Alternative Estimates of Wealth Inequality in the Ancient Maya Lowlands. *Ancient Mesoamerica* 34(3):e8. <https://doi.org/10.1017/S0956536123000044>.
- Nondédéo, Philippe, M. Charlotte Arnauld, and Dominique Michelet. 2013. Río Bec Settlement Patterns and Local Sociopolitical Organization. *Ancient Mesoamerica* 24(2):373–396. <https://doi.org/10.1017/S0956536114000017>.
- Nondédéo, Philippe, Eva Lemonnier, Julien Hiquet, Louise Purdue, Cyril Castanet, Lydie Dussol, and Marc Testé. 2023. Shaping an Agrarian Maya Town: Settlement Pattern and Land-Use Dynamics at Naachtun. In *Building an Archaeology of Maya Urbanism: Planning and Flexibility in the American Tropics*, edited by Damien B. Marken and M. Charlotte Arnauld, pp. 398–436. University Press of Colorado, Denver.
- Onken, Jill. 2023. Investigaciones Geomorfológicas. In *Informe del Proyecto Arqueológico Altar de Sacrificios, La Temporada 2022*, edited by Lorena Aragón Paiz and Jessica Munson, pp. 8–17. Instituto de Arqueología e Historia de Guatemala, Guatemala City.
- Paiz, Lorena Aragón, and Jessica Munson (editors). 2023. *Informe del Proyecto Arqueológico Altar de Sacrificios, La Temporada 2022*. Instituto de Arqueología e Historia de Guatemala, Guatemala City.
- Peuramaki-Brown, Meaghan M. 2013. Identifying Integrative Built Environments in the Archaeological Record: An Application of New Urban Design Theory to Ancient Urban Spaces. *Journal of Anthropological Archaeology* 32(4):577–594. <https://doi.org/10.1016/j.jaa.2013.09.006>.
- Puleston, Dennis Edward. 1974. *Ancient Maya Settlement Patterns and Environment at Tikal: Implications for Subsistence Models*. PhD dissertation, Department of Anthropology, University of Pennsylvania, Philadelphia.

- Raja, Rubina, and Søren M. Sindbæk. 2022. Anomalocivitas—Editorial. *Journal of Urban Archaeology* 5(1):13–18. <https://doi.org/10.1484/J.JUA.5.129840>.
- Raja, Rubina, and Søren M. Sindbæk. 2023. “Large, Dense, and . . . Heterogeneous”: A Comparative Approach to Urban Heterogeneity. *Journal of Urban Archaeology* 8(1):11–20. <https://doi.org/10.1484/J.JUA.5.135656>.
- Rice, Don S. 1976. Middle Preclassic Maya Settlement in the Central Maya Lowlands. *Journal of Field Archaeology* 3(4):425–445. <https://doi.org/10.1179/009346976791490538>.
- Ringle, William M., Tomás Gallareta Negrón, Rossana May Ciau, Kenneth E. Seligson, Juan C. Fernandez-Diaz, and David Ortégón 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>.
- Robin, Cynthia. 2012. *Chan: An Ancient Maya Farming Community*. University Press of Florida, Gainesville.
- Sanders, William T., and B. J. Price. 1968. *Mesoamerica: The Evolution of a Civilization*. Random House, New York.
- Sanders, William T., and David Webster. 1988. The Mesoamerican Urban Tradition. *American Anthropologist* 90(1):521–546.
- Scarborough, Vernon L., Fred Valdez Jr., and Nicholas Dunning (editors). 2003. *Heterarchy, Political Economy, and the Ancient Maya: The Three Rivers Region of the East-Central Yucatán Peninsula*. University of Arizona Press, Tucson.
- Schroder, Whittaker, Timothy Murtha, Eben N. Broadbent, and Angélica M. Almeyda Zambrano. 2021. A Confluence of Communities: Households and Land Use at the Junction of the Upper Usumacinta and Lacantún Rivers, Chiapas, Mexico. *World Archaeology* 53(4):688–715. <https://doi.org/10.1080/00438243.2021.1930135>.
- Schroder, Whittaker, Timothy Murtha, Charles Golden, Armando Anaya Hernández, Andrew Scherer, Shanti Morell-Hart, Angélica Almeyda Zambrano, Eben Broadbent, and Madeline Brown. 2020. The Lowland Maya Settlement Landscape: Environmental LiDAR and Ecology. *Journal of Archaeological Science: Reports* 33:102543. <https://doi.org/10.1016/j.jasrep.2020.102543>.
- Sharpe, Ashley E., Juan Manuel Palomo, Takeshi Inomata, Daniela Triadan, Flory Pinzón, Jason Curtis, Kitty Emery, et al. 2024. An Isotopic Examination of Maya Preclassic and Classic Animal and Human Diets at Ceibal, Guatemala. *Journal of Archaeological Science: Reports* 55:104522. <https://doi.org/10.1016/j.jasrep.2024.104522>.
- Simon, David. 2008. Urban Environments: Issues on the Peri-Urban Fringe. *Annual Review of Environment and Resources* 33(1):167–185. <https://doi.org/10.1146/annurev.enviro.33.021407.093240>.
- Smith, A. Ledyard. 1972. *Excavations at Altar de Sacrificios: Architecture, Settlement, Burials, and Caches*. Papers of the Peabody Museum of Archaeology and Ethnology Vol. 62, No. 2. Harvard University, Cambridge, Massachusetts.
- Smith, Michael E. 2010. The Archaeological Study of Neighborhoods and Districts in Ancient Cities. *Journal of Anthropological Archaeology* 29(2):137–154. <https://doi.org/10.1016/j.jaa.2010.01.001>.
- Smith, Michael E. 2019. Energized Crowding and the Generative Role of Settlement Aggregation and Urbanization. In *Coming Together: Comparative Approaches to Population Aggregation and Early Urbanization*, edited by Attila Gyucha. pp. 37–58, State University of New York Press, Albany.
- Smith, Michael E. 2020. Definitions and Comparisons in Urban Archaeology. *Journal of Urban Archaeology* 1(1):15–30. <https://doi.org/10.1484/J.JUA.5.120907>.
- Smith, Michael E. 2023. *Urban Life in the Distant Past: The Prehistory of Energized Crowding*. Cambridge University Press, Cambridge.
- Smith, Michael E., Scott G. Ortman, José Lobo, Claire E. Ebert, Amy E. Thompson, Keith M. Prufer, Rodrigo Liendo Stuardo, and Robert M. Rosenswig. 2021. The Low-Density Urban Systems of the Classic Period Maya and Izapa: Insights from Settlement Scaling Theory. *Latin American Antiquity* 32(1):120–137. <https://doi.org/10.1017/laq.2020.80>.
- Smith, Monica L. 2006. The Archaeology of South Asian Cities. *Journal of Archaeological Research* 14(2):97–142. <https://doi.org/10.1007/s10814-006-9002-7>.
- Thompson, Amy E., Jessica Munson, Scott G. Ortman, Andrés G. Mejía Ramón, Gary M. Feinman, Gabriela Cervantes Quequezana, Pablo Cruz, Adam S. Green, Dan Lawrence, and Paul Roscoe. 2025. Assessing Neighborhoods, Wealth Differentials, and Perceived Inequality in Preindustrial Societies. *PNAS* 122(16):e2400699121. <https://doi.org/10.1073/pnas.2400699121>.
- Thompson, Amy E., John P. Walden, Adrian S. Z. Chase, Scott R. Hutson, Damien B. Marken, Bernadette Cap, Eric C. Fries, et al. 2022. Ancient Lowland Maya Neighborhoods: Average Nearest Neighbor Analysis and Kernel Density Models, Environments, and Urban Scale. Edited by. *PLoS ONE* 17(11):e0275916 <https://doi.org/10.1371/journal.pone.0275916>.
- Tourtellot, Gair, III. 1988. *Excavations at Seibal, Department of Peten, Guatemala: Peripheral Survey and Excavation, Settlement and Community Patterns*. Memoirs of the Peabody Museum of Archaeology and Ethnology Vol. 16, No. 2. Harvard University Press, Cambridge, Massachusetts.
- Tovalin, A. Alejandro, and Víctor M. Ortiz V. 2005. El Sitio Arqueológico de La Primera Sección de Benemérito de Las Américas, Chiapas. *Arqueología* 35:34–49.
- Viñals, Esteban, and Jessica Munson. 2024. *Informe del Proyecto Arqueológico Altar de Sacrificios, La Temporada 2023*. Instituto de Arqueología e Historia de Guatemala, Guatemala City.
- Walden, John P., Claire E. Ebert, Julie A. Hoggarth, Shane M. Montgomery, and Jaime J. Awe. 2019. Modeling Variability in Classic Maya Intermediate Elite Political Strategies through Multivariate Analysis of Settlement Patterns. *Journal of Anthropological Archaeology* 55:101074. <https://doi.org/10.1016/j.jaa.2019.101074>.
- Webster, David L. 2018. *The Population of Tikal: Implications for Maya Demography*. Paris Monographs in American Archaeology No. 49. Archaeopress, Oxford.

- Wilk, Richard R., and Wendy Ashmore (editors). 1988. *Household and Community in the Mesoamerican Past*. University of New Mexico Press, Albuquerque.
- Willey, Gordon R. 1962. Mesoamerica. In *Courses toward Urban Life: Archaeological Considerations of Some Cultural Alternates*, edited by Robert J. Braidwood and Gordon R. Willey, pp. 84–105. Aldine, Chicago.
- Willey, Gordon R. 1965. *Prehistoric Maya Settlements in the Belize Valley*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 54. Harvard University, Cambridge, Massachusetts.
- Willey, Gordon R. 1973. *The Altar de Sacrificios Excavations: General Summary and Conclusions*. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 64, No. 3. Harvard University, Cambridge, Massachusetts.
- Willey, Gordon R., and Richard M. Leventhal. 1979. Prehistoric Settlement at Copán. In *Maya Archaeology and Ethnohistory*, edited by Norman Hammond and Gordon R. Willey, pp. 75–102. University of Texas Press, Austin.
- Willey, Gordon R., and A. Ledyard Smith. 1969. *The Ruins of Altar de Sacrificios, Department of Peten, Guatemala: An Introduction*. Papers of the Peabody Museum of Archaeology and Ethnology Vol. 62, No. 1. Harvard University, Cambridge, Massachusetts.
- Willey, Gordon R., A. Ledyard Smith, William R. Bullard Jr., and John A. Graham. 1960. Altar de Sacrificios, a Prehistoric Maya Crossroads. *Archaeology* 13(2):110–117.
- Yaeger, Jason, and Cynthia Robin. 2004. Heterogeneous Hinterlands: The Social and Political Organization of Commoner Settlements near Xunantunich, Belize. In *Ancient Maya Commoners*, edited by Jon C. Lohse and Fred Valdez Jr., pp. 147–174. University of Texas Press, Austin.