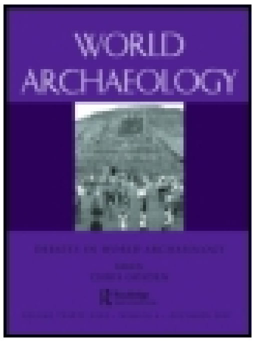

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ARTICLE

A confluence of communities: households and land use at the junction of the Upper Usumacinta and Lacantún Rivers, Chiapas, Mexico

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ABSTRACT
Constructed landscapes are composed of diverse communities, representing different social strata and perspectives of a place. In turn, the risks associated with inhabiting unpredictable environments are disproportionately felt across urban and rural landscapes. The mitigation and management of risks often fall on farming and smallholder communities, influencing decentralized strategies. These themes are explored in an archaeological context surrounding the confluence of the Upper Usumacinta and Lacantún Rivers in the neotropical Maya lowlands of Chiapas, Mexico. LiDAR data collected recently with the GatorEye unoccupied aerial vehicle (UAV) and NASA's GLiHT system have aided in the mapping of the archaeological urban centre of Benemérito de las Américas, Primera Sección and the surrounding landscape. These data have revealed coupled settlement with land management, in the form of wetland fields, reservoirs, and riverways, emphasizing the interconnectivity of household practice and land use in the region.

KEYWORDS
Maya; UAV LiDAR; remote sensing

Introduction

In November 2020, parts of Central America experienced destructive record flooding after the landfall of consecutive Hurricanes Eta and Iota. Along the border between Mexico and Guatemala, the Usumacinta River overbanked several times, causing devastating historical flood damage to communities. These disasters served as a critical reminder of the risks posed by low probability or 100-year flood events to communities along the banks of the river system. While the river is a resource and travel corridor, extreme events create uncertainty in these communities that already strike a delicate balance to minimize risk within their social and physical environments. These recent events raise questions related to how past societies who experienced similar risks in the same region interacted with the threats posed by this landscape.

We examine how Classic period (AD 250–950) Maya communities in the region of the Upper Usumacinta and Lacantún River confluence managed such risks associated with inhabiting the tropical Western Lowlands of southern Mesoamerica. In this paper, we interpret the design of a Maya urban centre and nearby settlements through a dwelling perspective (Ingold 1993),

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recognizing that management of the landscape required a balance of centralized and decentralized approaches, and negotiations among royalty, non-royal elite, and non-elite actors to sustain communities through farming and commerce. We present a new map of the archaeological site of Benemérito de las Américas, Primera Sección, Chiapas, Mexico, derived from data collected with an unoccupied aerial vehicle (UAV) LiDAR system and associated spatial analyses. We contextualize this map with other LiDAR data from NASA and field-based research, including ground verification and excavation to interpret household activities, urban scale, social differentiation, land use, and commerce at the height of the site's population during the Terminal Classic period (AD 830–950).

Beyond interpreting houses as points on the landscape, a dwelling perspective seeks to understand the choices of individuals, families, and communities and the histories that influence their attachment to places (Bachelard 1994; O'Malley 2014). While the house is an obvious centre to inform such a perspective, dwelling refers more broadly to the 'taskscape' of practices that people follow across a landscape, even outside of the home in agricultural fields, commercial areas, and mundane activities (Benjamin 1999, 17). The experience of constructed and conceptualized landscapes thus takes place at different scales and social strata, from the home to the inner and outer landscapes of the city and the countryside (Knapp and Ashmore 2000, 11; Mack 2004; Tuan 1975). Furthermore, the risks unique to a particular environment can have profoundly different effects on the experiences of economically and socially diverse communities (Scott 1976).

A key component of a dwelling perspective is the recognition that humans are inseparable from their environments and that people do not merely succumb to environmental change; instead, individuals engage with their surroundings through the production and reproduction of their built environment, resulting in changes to the landscape (Heidegger 1993; Obrador-Pons 2007; Thrift 1999). Thus, environmental risks do not merely determine how people interact with their landscapes; however, risks and resources are central factors in the settlement choices of households and the actions they take to reduce hazards (Chisholm 1962). In contrast to early interpretations of tropical environments (Meggers 1954), landscape archaeologists and historical ecologists recognize that landscapes, even those often perceived as 'natural,' are the product of often intentional human action (Erickson 2008). The range of forms of habitation in the tropics and the diversity of urbanism among the Maya affirms that such environments do not limit human activity; rather, the tropics offer a spectrum of opportunities and challenges to the individuals, households, and societies who inhabit and modify such landscapes (Chase and Chase 2016; Lucero and Gonzalez Cruz 2020). Although grounded in earlier approaches to settlement archaeology, this perspective has also benefited from studies of collective action and agency in archaeology to understand the decisions of smallholder societies on their environments (Blanton and Fargher 2008; Carballo 2013; Creekmore and Fisher 2014; Dobres and Robb 2000; Dornan 2002; Janusek and Kolata 2004; Murtha 2009; Smith 2003, 2014b, 310).

Discussions of land use among the Maya have focused on the spatial organization of urban centres and settlements (LeCount et al. 2019; Magnoni, Hutson, and Dahlin 2012), low-density urbanism (Isendahl and Smith 2013; Lucero, Fletcher, and Coningham 2015; Murtha 2015, 2017; Scarborough, Chase, and Chase 2012) and garden cities (Becker 2001; Chase and Chase 1998; Ford and Nigh 2009; Graham 2008). We build on these approaches and the increasing use of LiDAR technology alongside traditional archaeological survey and settlement studies, including both airborne and UAV or drone-mounted systems, to aid in the mapping of terrain and archaeological features (Canuto et al. 2018; Chase et al. 2011, 2012; Chase, Chase, and Chase 2017; Horn and Ford 2019; Hutson 2015; Murtha et al. 2019; Risbøl and Gustavsen 2018; Rosenswig et al. 2013; Stanton, Ardren, and Barth et al. 2020; VanValkenburgh et al. 2020). Combining remote sensing and phenomenological interpretation, we investigate the experience of living in a Classic period minor kingdom and the ways that households and communities mitigated the risks associated with living in a riverine neotropical environment (Brown 2002; Hassan 1997; Jing, Rapp, and Gao 1997; Joyce and Mueller 1997). In contrast to the emphasis on droughts across the Maya area (Gill 2000; Iannone 2014), we assess the risks associated with flooding and its effects on the experience of the constructed, conceptualized, and agrarian landscapes at a physical and cultural confluence that created a gathering of waters and communities.

Setting

The archaeological site of Benemérito de las Américas, Primera Sección shares its name with a modern community near the confluence of two of Mexico's largest river systems, the Upper Usumacinta River and one of its tributaries, the Lacantún River (Figure 1). First documented by Alejandro Tovalín and Víctor Ortiz (Tovalín and Ortiz 2005) and later by Karl Herbert Mayer (2006), we have since conducted several seasons of research at the site as part of the Busiljá-Chocoljá Archaeological Project and the Lower Lacantún Archaeological Project (Schroder 2017, 2019a; Schroder, Golden, and Scherer et al. 2019). We have also conducted preliminary reconnaissance of several other sites in the region, previously documented by other archaeologists, summarized in Table 1 (Bullard 1995; Maler 1903; Schroder, Golden, and Scherer et al. 2019; Velázquez Valadez

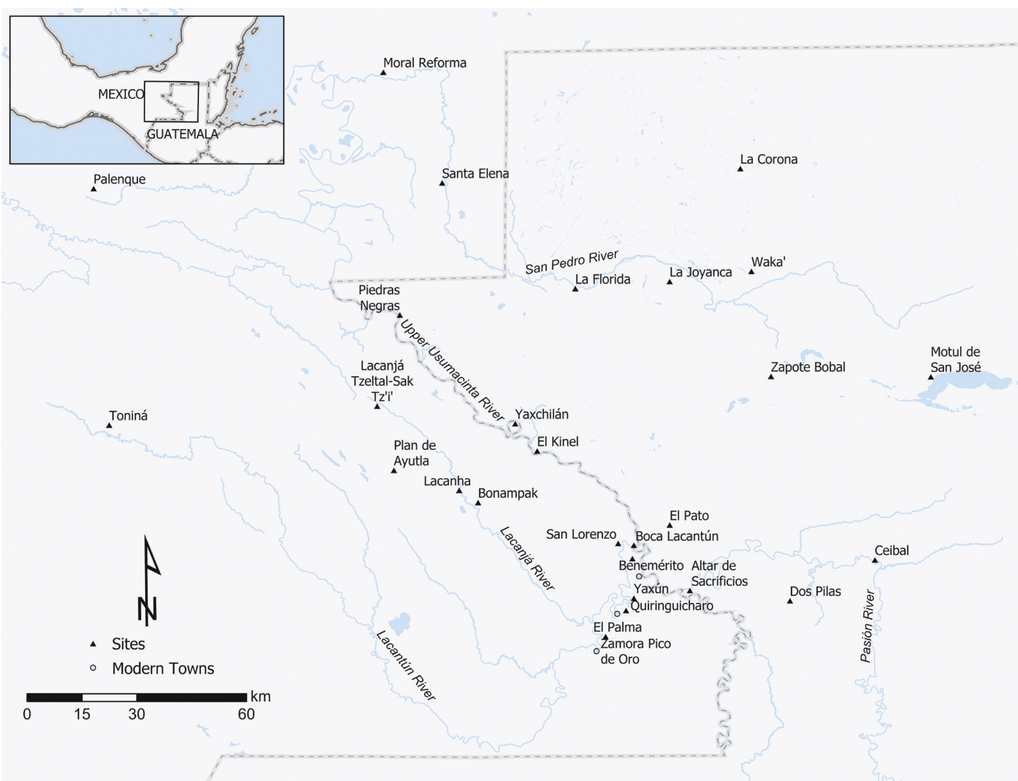

Figure 1. Map of the Western Maya Lowlands showing the location of Benemérito Primera Sección (labeled Benemérito), other archaeological sites, and modern towns along the Lower Lacantún River.

Table 1. Comparison of archaeological sites in the region. Data from sites with asterisks are based on incomplete maps, while sites in bold appear entirely or partially in G-LiHT tiles. Site extents for Benemérito Primera Sección and El Palma have two values: 1) area covered by G-LiHT for comparison with other sites in bold, and 2) total mapped area with GatorEye and drone photogrammetry, respectively. Approximate values (~) are based on published sketch maps that likely exaggerate the actual values.

Site	Main Plaza Size	Tallest Structure (relative to plaza)	Site Extent	Orien-tation	Monuments	Ball-courts	Map Source
Benemérito 1ª Sección *	1 ha	16 m	>76 ha, >255 ha	350°	13	4	G-LiHT, GatorEye
El Palma*	1 ha	13 m	>50 ha, >64 ha	10°	12	1	G-LiHT, photogrammetry (Schroder, Golden, and Scherer et al. 2019)
Yaxún*	0.75 ha	~20 m	Unknown	85°	1	1	Sketch (Bullard 1995)
San Lorenzo*	~0.75 ha	~10–15 m	Unknown	~10°	3	Unknown	Sketch (Bullard 1995)
Boca Lacantún	0.2 ha	2 m	0.5 ha	85°	Unknown	0	G-LiHT (Schroder, Golden, and Scherer et al. 2019)
Quiringuicharo*	Unknown	2 m	>4 ha	10º	Unknown	Unknown	G-LiHT

1986). Representing a relatively large urban centre for the region with carved historical monuments, Benemérito Primera Sección was likely a seat of a minor kingdom during the Classic to Terminal Classic periods, perhaps associated with the known emblem glyph, dynastic title, or toponym, Lakamtuun, linked to the nearby site of El Palma (Stuart 2007a, 2007b).

Benemérito Primera Sección marks a boundary along several watersheds, at the periphery of two archaeological culture subareas along the Pasión River or Petexbatún region and the Upper Usumacinta region. The physical geography shifts from a karstic ridge and basin landscape to an alluvial plain to the south (De La Maza 2015, 79). Downstream from Benemérito Primera Sección, the Upper Usumacinta River flows through this floodplain until reaching the Classic period dynastic centre of Yaxchilán. The discharge of the Upper Usumacinta River varies significantly on a seasonal and yearly basis, draining the waters of the Chiapas and Guatemala highlands and several lowland tributaries along its course to the Gulf of Mexico. Above Yaxchilán, this variation in volume can lead to extreme flooding events producing an expansive, arable alluvial plain of river meanders and oxbow lakes. At Yaxchilán, the river enters a fault in the limestone anticline, producing steep canyons and a series of rapids until reaching the Tabasco Plain downstream from the dynastic centre of Piedras Negras (Aliphat Fernández 1994). In this section of the Upper Usumacinta River, the restricted course of the river causes water levels to rise over 12 m above the mean during the wet season, occasionally flooding the main plaza of Yaxchilán (Aliphat Fernández 1994; Canter 2007, 4). Within the vicinity of Benemérito Primera Sección, communities along rivers would have been at even higher risks of flooding due to the limited topographic variance.

This riverine setting contrasts with the overall impression of drought-prone Maya environments in densely settled parts of the Central and Northern Lowlands. The rarity and importance of water sources in such regions have led to several Mayanists suggesting that the control of water sources in otherwise drought-prone areas was linked to elite power (Lucero 2006; Lucero and Fash 2006; Scarborough 1998, 2003), while other archaeologists have argued for more decentralized, household management of reservoirs or *aguadas* (Chase 2016; Webster 2018, 95; Weiss-Krejci and Sabbas 2002; Wyatt 2014). However, across the Western Maya Lowlands and the Usumacinta region, access to water was a different concern. These areas have abundant surface water and some of the highest annual precipitation in the lowlands (Scherer and Golden 2014b, 216). In fact, water management in the region often focused on conveyance, or controlling and draining water, rather than retention (French 2007). More important than the quantity of water, however, is seasonal and annual fluctuation. Living in the tropical riverine environment of the Lacantún-Usumacinta River confluence would have required management to drain water, while avoiding flood-prone areas. Simultaneously, prolonged droughts and deforestation followed by elevated seasonal rainfall intensity initiates significant challenges of soil erosion (Webster, Freter, and Gonlin 2000). Mapping of the landscape surrounding Benemérito Primera Sección points to several local strategies adopted by the region's Classic period inhabitants to minimize or balance such risks, documented in their choices of where to settle, as well as evidence for household and community management of water management features, including terraces, reservoirs, and channelized fields.

Methods: data collection and processing

The current map consists of the site's monumental core and associated settlement compiled from a combination of two sources of LiDAR, refined in some areas with ongoing ground verification: 1) collected by NASA Goddard's LiDAR, Hyperspectral, and Thermal Imager (G-LiHT) airborne system and 2) collected and processed by the authors using a UAV mapping system, the University of Florida GatorEye Unmanned Flying Laboratory (http://www.speclab.org/gatoreye.html) (Figures 2, 3).

Conducted in 2013, the GLiHT mission over southern Mexico was part of a REDD+ study to measure aboveground forest carbon stocks (Cook et al. 2013; Hernández-Stefanoni et al. 2015). Several archaeological studies have revisited these data (Hutson, Cook, and Conley forthcoming; Ruhl, Dunning, and Carr 2018), including our ongoing project to interpret the relationship between archaeological settlement, agricultural intensification, and environmental variation across the Yucatán peninsula (Golden et al. 2016; Schroder et al. 2020). The GLiHT data are publicly available and divided into tiles averaging 0.3 km wide by 7 km long, and the Chiapas GLAS s457 flight tile contains much of the Benemérito Primera Sección site core, which we previously used to present a more accurate map of Benemérito Primera Sección, as well as other sites in the region, including El Palma and Boca Lacantún (Schroder, Golden, and Scherer et al. 2019). The airborne laser scanning (ALS) instrument was a VQ-480 (Riegl USA, Orlando, FL, USA). More detailed discussions of the GLiHT systems have been previously published (Cook et al. 2013; Golden et al. 2016).

Due to the limited coverage of Benemérito Primera Sección along the east-west axis, we selected the site as a focus of our drone mapping pilot study in the region (Murtha et al. 2019). This system has also been used successfully in archaeological applications along the Florida Gulf Coast (Barbour et al. 2019). The GatorEye system does not offer the same expansive mapping capabilities as airborne LiDAR systems, but with proper mission planning, several 16 to 22-minute flights can be used to map localized areas of 4–12 square kilometres in a single day, depending on the number of batteries available, the ability to recharge them in the field, and the desired ground point density (Murtha et al. 2019, 3). Mapping coverage must also be determined by local permissions; in this study, we only mapped approximately half of our maximum goal (2.1 square kilometres) with the authorization of the local government and landholders. The 2019 missions utilized a VLP-32 ultra puck laser scanner (GatorEye Gen 2), an upgrade from the previous year's VLP-16 puck lite (GatorEye Gen 1), leading to higher point returns and improved processing in areas of high topographic relief and/or dense vegetation. Missions were flown at approximately 80 m above ground level, at a speed of 10 m/s, and equally spaced about 80 m apart, using a cross-hatch flight pattern to achieve the highest point density and coverage across inclined surfaces.

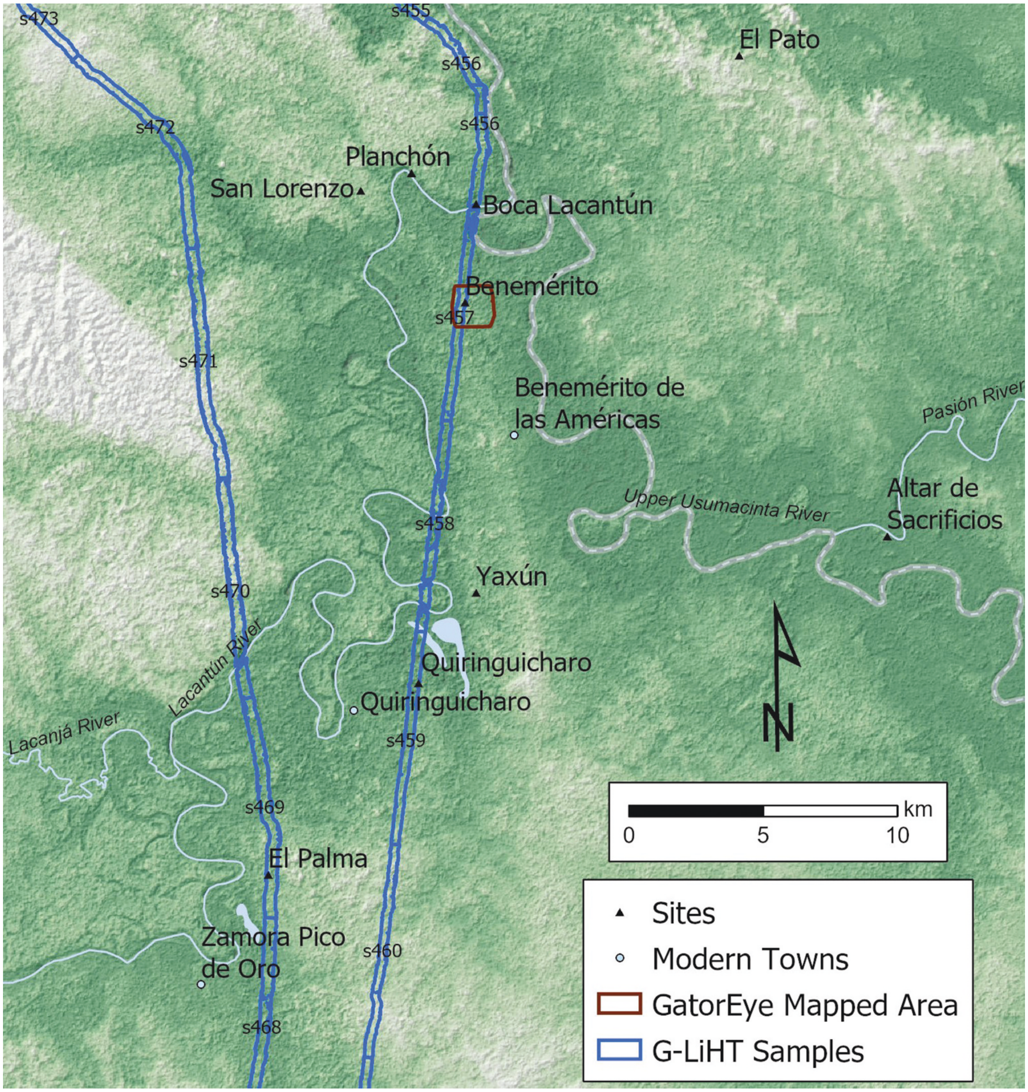

Figure 2. Map of the study area, LiDAR samples, and archaeological sites over ASTER DEM and hillshade.

The G-LiHT flight tiles were processed in LiDAR Analyst to derive sub-metre pixel resolution bare-earth digital terrain/elevation models (DTM/DEM) (Golden et al. 2016, 303). The GatorEye data were processed with the built-in classification tools in ArcGIS Pro and with LAStools (https://rapidlasso.com/). Although we continue to experiment with several processing algorithms, the results produced with ArcGIS Pro, using the Standard Classification in the Classify LAS Ground tool are satisfactory. DTMs were then created with the LAS Dataset to Raster tool using the default parameters. While the density of point returns theoretically justify sub-metre cell size sampling, higher resolution DTMs introduced a high degree of noise due to the variability in the height of pasture and low vegetation. Therefore, we opted for a 1 m pixel size to avoid the overidentification of false-positive features. Ground verification is an ongoing process and has covered approximately 13% of the known mapped area of Benemérito Primera Sección since 2017.

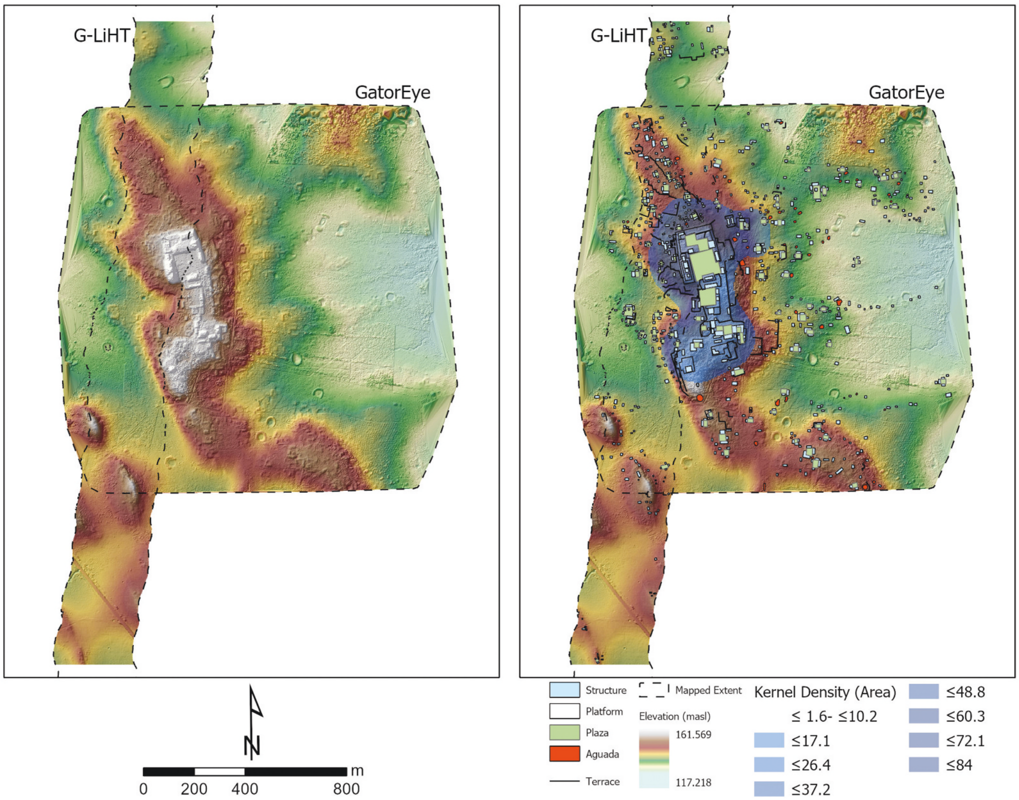

Figure 3. Combined 1 m digital terrain model (DTM) of NASA G-LiHT and GatorEye LiDAR data (left) with annotated archaeological features and kernel density of building footprint area showing the monumental core and acropolis of Benemérito Primera Sección (right).

Results

The G-LiHT survey documented 0.76 km^2 of the Benemérito Primera Sección site core, while the GatorEye survey mapped 2.1 km^2, or a total combined area of 2.55 km^2 (Figure 4). The northern and southern extents of the Benemérito Primera Sección site core are clearly delineated, with all settlement contained within a 2.6 km long north-south transect (Schroder, Golden, and Scherer et al. 2019, 164). The western and eastern limits of the Benemérito Primera Sección site core are less clear because the GatorEye survey did not fully document the site (the current east-west dimensions of the study area are approximately 1.5 km). The monumental core of the site, based on a kernel density analysis (Silverman 1986) of building footprint area shown in Figure 3, measures about 750 m from north to south and amounts to an area of approximately 24 ha, on par with other minor kingdoms in the Usumacinta region, including Lacanjá-Tzeltal-Sak Tz'i' and Bonampak (Golden et al. 2020, 72). The full scale of Benemérito Primera Sección, including the core settlement, however, is much larger than these two sites.

A summary of LAS point statistics is shown in Table 2. Ground point density is high in most areas due to the modern land use of the region, consisting of agriculture and grazing; however, much of the monumental core is obscured by secondary forest. The ground point density of the G-LiHT is especially high because the transect only included the northwestern corner of the monumental

Figure 4. Current mapped area of the Benemérito Primera Sección site core with structures mentioned in the text.

Table 2. LiDAR point summary statistics for the mapped extent of Benemérito Primera Sección.

LiDAR Source	Area km^2	All Points				Ground Points				
		Total	Density per m^2	Edge corrected density	Single flight line density	Total	Density	Edge corrected density	Single flight line density	%
GatorEye	2.1	618,298,772	297	401	42	102,192,590	49	67	7	16.5
G-LiHT	0.8	6,531,163	9	9	8	4,854,362	6	6	6	74.0

core. The ground point density of single flight lines in both the airborne and UAV systems are similar, while the high ground point density with GatorEye was a product of several overlapping flights. A lower degree of overlap at the edges of the GatorEye study area led to significant point thinning at the boundaries; therefore, edge corrected values were also calculated by reducing the study area size with a negative 150 m buffer. Edge correction was not necessary with the G-LiHT data. While standard single direction hillshade was generally sufficient to identify features, other visualizations were helpful, especially slope and positive openness/sky-view factor (Kokalj, Zakšek, and Oštir 2011, 2013; Štular et al. 2012; Zakšek, Oštir, and Kokalj 2011).

Features were manually identified and classified following the methodology discussed by Schroder et al. (2020) (Table 3). We documented a total of 776 buildings, divided into 758 structures and 18 platforms (larger basal buildings that support 1 or more structures). Structures are the best proxy for settlement and built environment density, although not all structures were domestic. Benemérito Primera Sección's density of approximately 297 structures or 304 buildings per square kilometre is within the typical range of Maya lowland urban sites, perhaps slightly below average (Barnhart 2003, 11; Chase and Chase 1998, 61; Rice and Culbert 1990; Sharer and Traxler 2006, 686; Webster 2018, 11). For comparison, densities at Palenque and Piedras Negras are 517 and 673 buildings per square kilometre, respectively (Barnhart 2003, 12; Nelson 2005, 142). In contrast to the extensive low-density urban peripheries of Central Maya Lowlands sites, Western Maya Lowland urban areas like Piedras Negras, Palenque, and Benemérito Primera Sección cluster into denser pockets of settlement, defined partly by their natural topographic setting, as well as for cultural and defensive reasons. Although these sites have some of the highest structure densities in the Maya area, their broader site footprints are relatively small, within a range of 1 to 3 square kilometres. Sites like Caracol, Belize and Tikal, Guatemala extend into settlement regions with households rather evenly dispersed across the landscape (Murtha 2015).

Table 3. Summary of all feature data across the 2.55 km^2 mapped extent of Benemérito Primera Sección; buildings refer to two types of architecture: platforms (basal supports for other architecture) and other structures that require further classification on the ground (see Schroder et al. 2020 for further definitions).

Type		Count		Total Area (ha)		Length (km)	Density (count/km^2)	Ha/ count	Density (length/km^2)	Ha/ length
Aguada		43		0.6			17	5.9		
Building		776		12.3			304	0.3		
	Structure		758		7.6		297	0.3		
	Platform		18		4.7		7	14.2		
Plaza		107		5.3			42	2.4		
Terrace		63				4.822	25	4.0	1.891	52.9
Total		**989**		**18.2**		**4.822**	**388**	**0.3**	**1.891**	**52.9**

Flood risk

The monumental core of Benemérito Primera Sección was constructed on a north-south trending ridge and consists of the site's monumental acropolis and main plaza at the north end, connected to an area with other public architecture to the south via a narrower 'neck.' The extent of anthropogenic modification to this natural landform is uncertain without further targeted excavation, but the tallest structure at the site rises 16 m above the main plaza, which was elevated above the ridge at least several metres above the natural surface based on stratigraphy revealed in looter's pits (Tovalín and Ortiz 2005, 35–37). Accounting for overlying construction fill, the natural prominence of the landform was likely no more than 30 m above the surrounding floodplain. The community of Benemérito Primera Sección collectively designed, built, modified, and adapted a constructed landscape over several centuries (Mejía-Ramón 2019, 23), augmenting the area's most prominent landform, to increase the visibility of the nearby confluence and the reverse viewshed of the acropolis from outlying parts of the urban area.

The Benemérito Primera Sección settlement location is consistent with regional observations from prior research. Communities and households throughout the Usumacinta region concentrated in elevated areas likely due to a combination of factors, including defence, viewshed, signalling, and drainage (Anaya Hernández 2001; Scherer and Golden 2009, 2014a; Schroder 2019b). At these sites, high-density settlement was partly influenced by natural topography, with structures concentrated on hilltops, plateaus, and river terraces. Despite the generally flat local landscape compared to the sites downstream, structure density at Benemérito Primera Sección still clusters in relatively upland areas. The acropolis is not in a highly defendable location; however, the prominence of the natural landform provides benefits related to viewshed and drainage.

Due to flood risk, this prominent, natural landform would have attracted settlement as a central place above the surrounding alluvial plain. A simple flood risk model based on the ASTER DEM (not accounting for stream discharge or historical data) highlights the appeal of Benemérito Primera Sección's location (Figure 5). Across the Maya lowlands, urban centres favoured upland areas, in large part for drainage purposes (Houston and Garrison 2015, 56). Still, the entirety of the mapped area of Benemérito Primera Sección is well outside the most extreme predicted flood levels. Settlement surrounding the acropolis also favoured relatively higher areas. At greater distances from the acropolis, this topography is subtle and almost undetectable from the ground, but the GatorEye DTM shows several natural spur ridges extending from the main landform, especially to the east. Based on a topographic position index analysis using the Focal Statistics and Raster Calculator tools in ArcGIS Pro 2.4.2, the majority of settlement is located in upland areas, with fewer structures than expected in low-lying areas (Figures 6, 7).

Extreme flooding events did not merely affect where people chose to settle but also influenced movement across the landscape. Measuring water levels would have been invaluable to the inhabitants of Piedras Negras, Yaxchilán, and Benemérito Primera Sección. Not only would these measurements inform local flood risk, but the rise and fall of the Usumacinta and Lacantún Rivers would also have reflected regional conditions upstream, predicting the safety of river navigation and forecasting the arrival of rains or droughts. Each of these dynastic centres, in fact, had means of interpreting fluctuations in water levels: the so-called 'sacrificial stone' at Piedras Negras, a carved outcrop along the riverbank, and the artificial stone pile, 'El Pilar,' in the middle of the river near Yaxchilán are both flooded during the wet season (Canter 2007, 4–5, 13). Near Benemérito Primera Sección, Planchón de las Figuras, an extensive natural bed of limestone along the Lacantún River and above the confluence with the Usumacinta River, could have served a similar function (Juárez

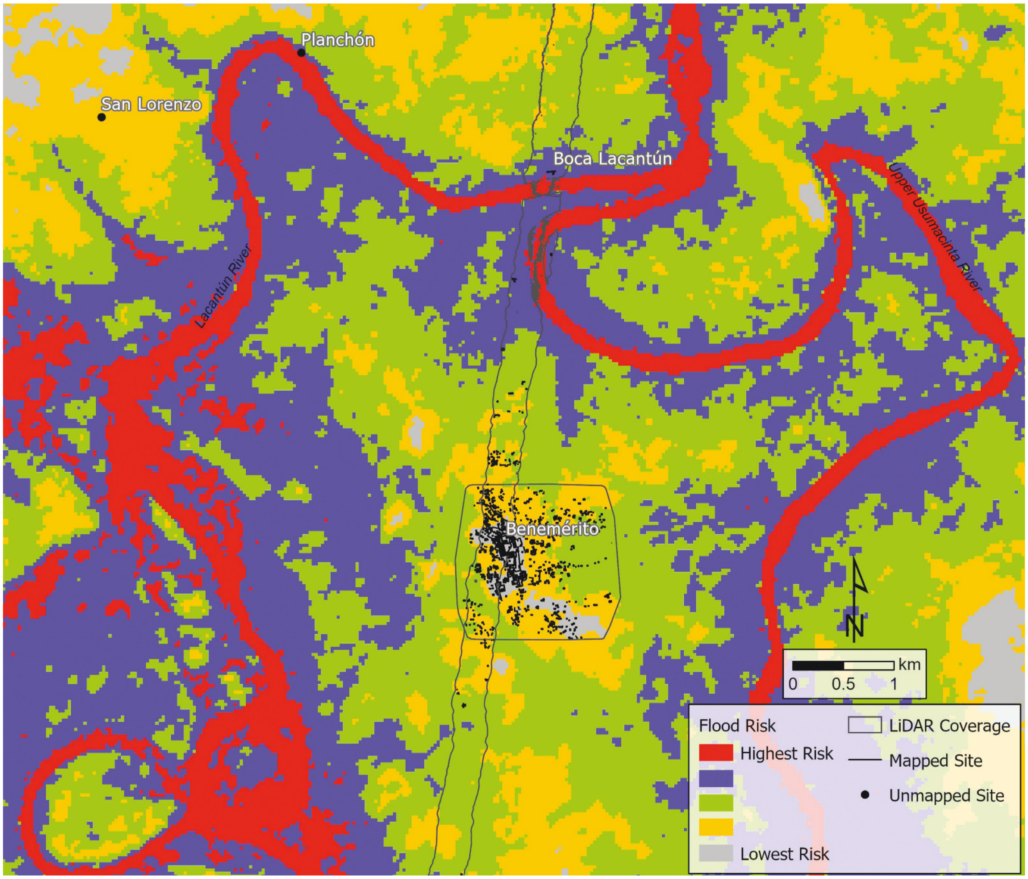

Figure 5. Simple flood risk model of the area surrounding Benemérito Primera Sección and the Upper Usumacinta/Lacantún River confluence, based on a 30 m ASTER DEM; red represents typical wet season levels, blue represents rare extreme flooding.

Cossío 1994; Maler 1903; Mülleried 1995; Stuart and Wilkerson 1995). Covered in petroglyphs and graffiti, this example of landscape art (Potter 2004; Whitley 1998) would have greeted canoe travellers entering a new environmental and political domain, or alternatively, when invisible during the wet season would have cautioned navigators against the potential for treacherous currents and rapids downstream.

Not all settlements, however, were safe from extreme flooding events. A small hamlet consisting of 7 structures oriented around 2 plazas near the Lacantún-Usumacinta River confluence, Boca Lacantún, lies on a river terrace, 15 m above the Lacantún River (see Figure 2). This relative elevation is above the bankfill level, but extreme flooding would submerge this small community. In contrast, larger urban centres like Benemérito Primera Sección and San Lorenzo were positioned in more prominent areas away from flood risk. The importance of monitoring a significant travel route, as well as the ritual significance of proximity to Planchón de las Figuras, likely outweighed the risk posed by rare flooding events, but at the same time, the lack of dense settlement in the area surrounding Boca Lacantún was a response to such threats. Although a complete analysis of settlement patterns along the Lower Lacantún River is necessary, these preliminary data suggest

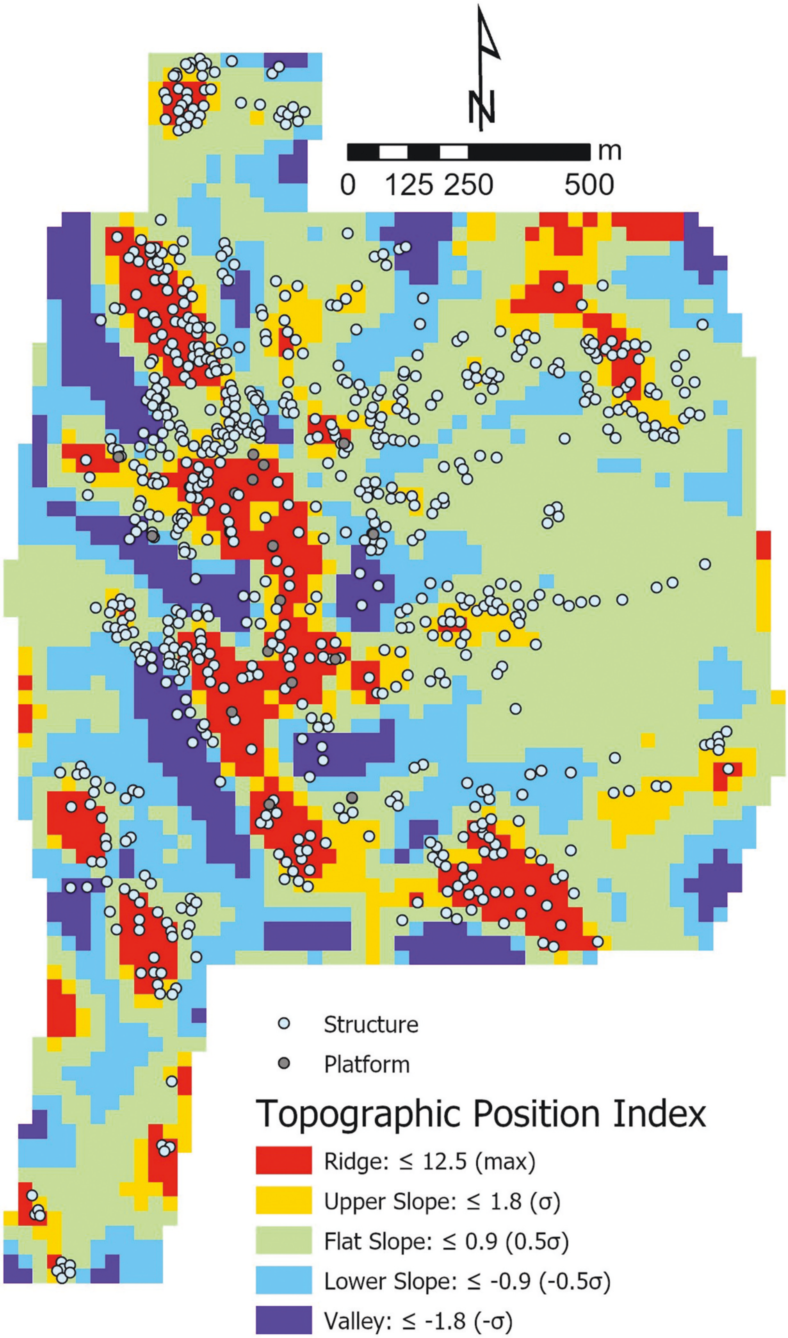

Figure 6. Map of the point pattern of structures and platforms over a Topographic Position Index (Focal Statistics) based on a 30 m DEM aggregated from the GLiHT and GatorEye LiDAR data. In this context upper and lower slope do not refer to the relative steepness but rather the relative location of the sloping area between flat slope and ridge (upper slope) or between flat slope and valley (lower slope).

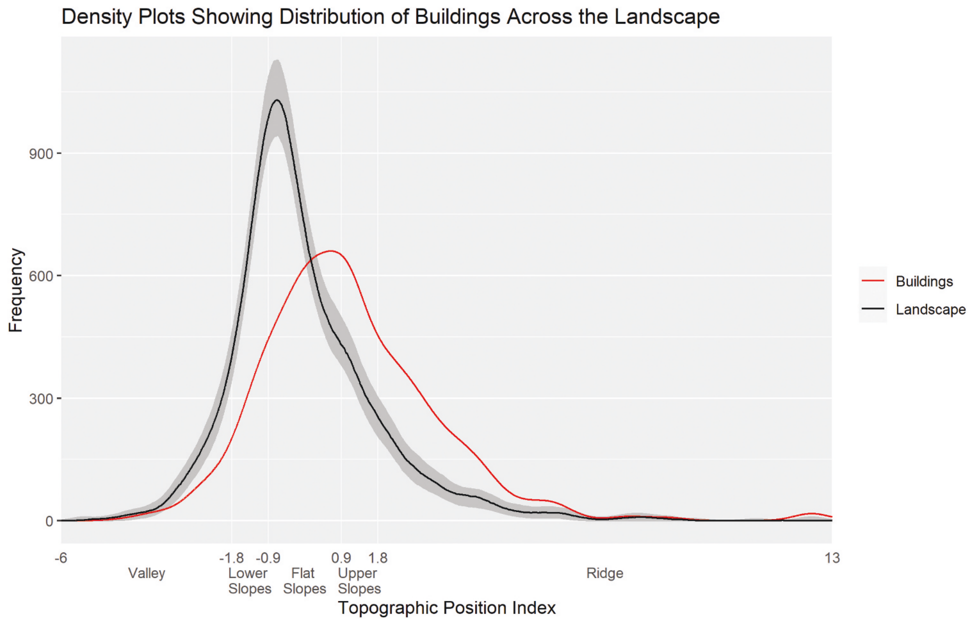

Figure 7. Kernel density plots of the topographic position index (classified by standard deviation) of the entire DEM landscape (black) with 95% confidence envelope (nsim = 1000) and building locations (red) showing highest frequencies of building locations in flat slope, upper slope, and ridge areas (see Bocinsky,2017).

that households and communities may have assumed a reasonable level of risk to ensure access to important resources and travel routes away from dynastic centres, as has been suggested near Piedras Negras (Kingsley, Golden, and Scherer et al. 2012; Schroder, Golden, and Scherer et al. 2017).

Plazas and public architecture

As with most Maya centres, the Benemérito Primera Sección acropolis consists of royal and non-royal elite residences, a main or central plaza, along with several areas of restricted and public ritual space. Large plazas were important stages for public performance, marketing, and exchange (Chase and Chase 2014; Dahlin et al. 2007; Hutson 2017; Inomata 2006; King 2015; Tsukamoto and Inomata 2014). Charles Golden and Andrew Scherer (Golden and Scherer 2013, 408) have suggested that large plazas at secondary sites within the Piedras Negras and Yaxchilán kingdoms accommodated large gatherings of people, many of whom were visitors from outlying regions, to engage in trust-building activities (Miller and Brittenham 2013). Approximately 11% of the Benemérito Primera Sección monumental core consists of plaza space (2.6 ha), including the 1 ha main plaza. This plaza area matches that of nearby El Palma, suggesting a potential degree of standardization in urban planning across the region. Another pattern in the region is an elevated, enclosed main plaza. Despite the large size of the space, these areas are generally restricted from broad view. Further study of access to this space is needed because it could have provided for controlled public performances and rituals, with limited participation of outlying households. The elevated position of the acropolis ensured that buildings surrounding the main plaza were always in view within the urban centre. Moreover, the resulting soundscapes produced by plaza activities would have been audible beyond the site core and into the urban periphery.

Other performances and rituals would have taken place in Benemérito Primera Sección's numerous ballcourts. The ballcourt, an important form of public architecture in Mesoamerica, is highly represented at Benemérito Primera Sección, amounting to at least 4 ballcourts within the site's monumental core (see Figure 4). The largest I-shaped ballcourt (Structure E6-6) is located directly to the south of the main plaza (Schroder, Golden, and Scherer et al. 2019, 164). Including the playing alley, and 'end zones,' this ballcourt measures approximately 80 m long, only slightly smaller than the largest ballcourt known from the Upper Usumacinta region at Plan de Ayutla (Martos López 2009, 65). The presence of a large ballcourt within the territory of a seemingly minor kingdom follows a pattern also observed at secondary centres within the Palenque hinterland, where several outlying sites exhibit larger ballcourts than documented at Palenque (Flores Esquivel 2011, 42). Smaller ballcourts at Benemérito Primera Sección are also located within the main acropolis; Structure E6-17 lies a mere 30 m to the southwest of the largest ballcourt, while two others (Structures F5-6 and E7-8) are approximately 190 m to the northeast and south, respectively.

Benemérito Primera Sección's largest ballcourt would have been visible only to invited spectators within the main plaza; however, other ballcourts at the site, especially Structure F5-6, are further removed from the acropolis (see Figure 4). This ballcourt may have hosted smaller events visible to members of the community rather than foreign dignitaries. Indeed, the concentration of ballcourts at Benemérito Primera Sección, higher than any primary or secondary site in the Usumacinta region, suggests the existence of several districts at the site, perhaps an eastern sector associated with the Structure F5-6 ballcourt and a western sector associated with Structure E6-17. The approximate north-south axes of these ballcourts differentiate them from the east-west axes of the other 2 more private ballcourts, including Structure E7-8, which marks the southern sector of the site. Simply, ballcourts seem to be markers of urban districts, demarcating spaces for defined social activities.

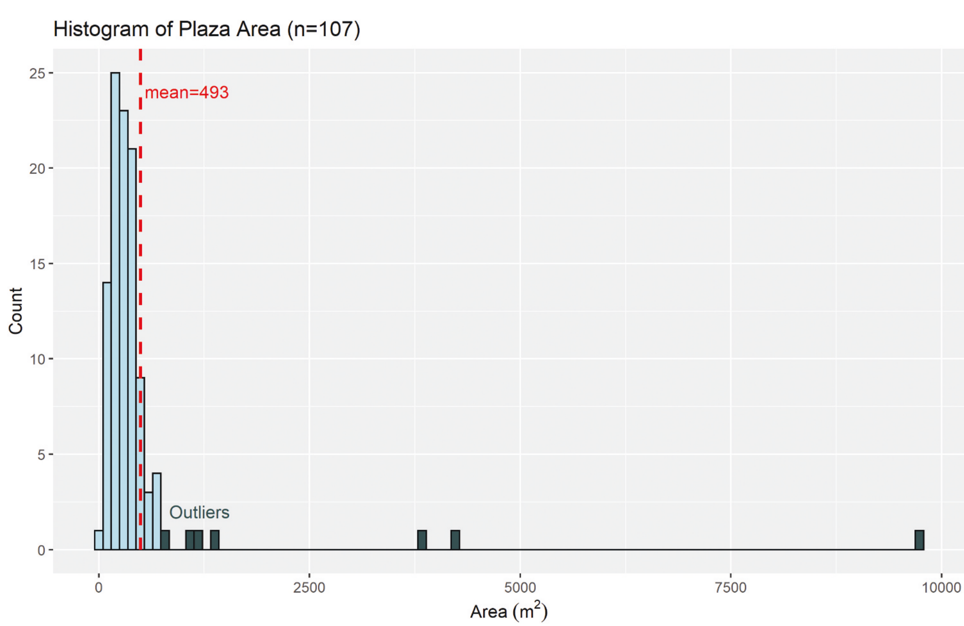

Figure 8. Distribution of plaza area at Benemérito Primera Sección, showing the mean in red and outliers in dark gray.

This pattern of districts is also reflected in the distribution of plazas across the site (Figure 8). Similar to other sites across the Maya Lowlands, plaza sizes are a skewed distribution with roughly 80% less than 500 m^2. Substantial variation is present in plaza areas larger than 500 m^2. Because the plaza or patio group is a fundamental spatial proxy for household organization among the Classic period Maya (Nelson 2005, 160; Willey 1980), smaller plazas or patios within households would have provided a setting for private and community rituals in non-royal contexts (Blackmore 2011; McAnany 2013). The largest plazas outside of the monumental core are located near Structures G4-17, D6-23, and F8-2, respectively, each possibly marking eastern, western, and southern sectors in relation to the acropolis. Further evidence for the reproduction of public rituals in private contexts or the appropriation of household rituals by royalty is the appearance of central, square platform altars or shrines within plazas of nearly all sizes, marking important locations for communal activity. These features are otherwise rare in the region and mark a significant shift in ritual practice during the Terminal Classic period (Halperin and Garrido 2020, 10; Hutson, Magnoni, and Dahlin 2017, 60).

Agrarian landscapes and water management

The alluvial plain along the Upper Usumacinta and Lower Lacantún Rivers posed a flood risk to communities but at the same time offered agricultural opportunities rare in other parts of the Maya area. The compact, clustered point pattern of settlement at Benemérito Primera Sección, as quantified in a nearest neighbour analysis (0.7 nearest neighbour ratio, $p < 0.001$), was not necessarily conducive to urban agriculture; however, dispersion at higher distances from the acropolis points to the potential for cultivation of gardens in the outer landscapes of the city. With houses and architecture constructed in upland areas above bedrock, low-lying areas with deep soil profiles were available for a variety of agricultural techniques, including swidden agriculture, household gardens, and groves (Barnhart 2003, 14; Becker 2001, 443; Chase and Chase 1998; Fisher 2014; Ford and Nigh 2009; Garrison, Houston, and Alcover Firpi 2019, 141–143; Isendahl 2012; Isendahl and Smith 2013; Marken and Murtha 2017; Murtha 2017). The extensive arable land in this area contrasts with downstream dynastic centres like Yaxchilán and Piedras Negras that had limited access to deep soils, where city dwellers must have relied on food distribution from peripheral areas (Fernández et al. 2005; Johnson et al. 2007; Nelson 2005).

The abundant cultivable land surrounding Benemérito Primera Sección explains the lack of agricultural terracing within the vicinity; despite the presence of ideal slopes with gradients below 15% (Wyatt 2008, 113), clear evidence of agricultural terracing is not present within the vicinity of Benemérito Primera Sección. Terracing is present at Benemérito Primera Sección, but its purpose is similar to examples at Palenque, which served functions related to architectural stabilization and water management (Barnhart 2003, 14, 2007, 118; Dunning, Beach, and Rue 1994; French 2007). Although such terraces could have served secondary agricultural functions as gardens, excavations are necessary to interpret their construction. Seasonal variation in rainfall would have necessitated the stabilization of slopes surrounding deforested areas of settlement to reduce the risks of erosion. The earliest examples of terracing may have been secondary effects of quarrying to construct and modify the acropolis, but the benefits of terracing to slow erosion would have been recognized over time. While present throughout the region in household contexts where elite oversight was not necessary for their construction (Golden et al. 2020; Schroder, Golden, and Scherer et al. 2017; Schroder 2019b), terracing at Benemérito Primera Sección centres primarily on the main acropolis, the area most susceptible to erosion.

Deep soil profiles also provided earthen building materials for domestic structures, especially to the east of the main acropolis in the vicinity of Structures G4-3 and G4-13 and also documented at the nearby site of El Kinel (Golden and Scherer 2006; Houston, Escobedo, and Golden et al. 2006; Scherer, Golden, and Arroyave 2014). These structures are spatially correlated with several excavated borrow pits, many of which served a secondary function as household reservoirs or *aguadas* (Figures 9, 10). While the 2 largest borrow pits at the site are located near the acropolis, suggesting a possible degree of centralized oversight, these features require ground verification to determine if they held water, and the majority of reservoirs at the site cluster away from the monumental core and were managed by households (Figure 11). Flooding and rising water tables would have increased the number of functioning reservoirs.

Although physical evidence of agricultural intensification or landesque capital has not been identified near the Benemérito Primera Sección site core, we have documented in the G-LiHT survey evidence for channelized or drained fields approximately 14 km to the southwest of Benemérito Primera Sección and 2 km to the northeast of the modern town of Quiringuicharo (Figure 12). This evidence adds to the recent LiDAR identification of a larger scale of wetland agriculture in the Maya area than previously recognized (Beach, Luzzadder-Beach, and Krause et al. 2019; Canuto et al. 2018). The Quiringuicharo system of channelized fields consists of several linear features creating in some places chequerboard patterns and in other areas forming orthogonal features perpendicular to natural arroyos. The longest such features extend at least 375 m from the nearest arroyo, and spacing between channels ranges from approximately 10 to 15 m, covering a total area of 76 ha. Due to the limited coverage of the corresponding G-LiHT tile, the full surface area of these fields is likely more extensive. These channelized fields are associated with a small, undocumented archaeological site, and a larger, secondary site, Yaxún, is located more than 4 km to the northeast (Bullard

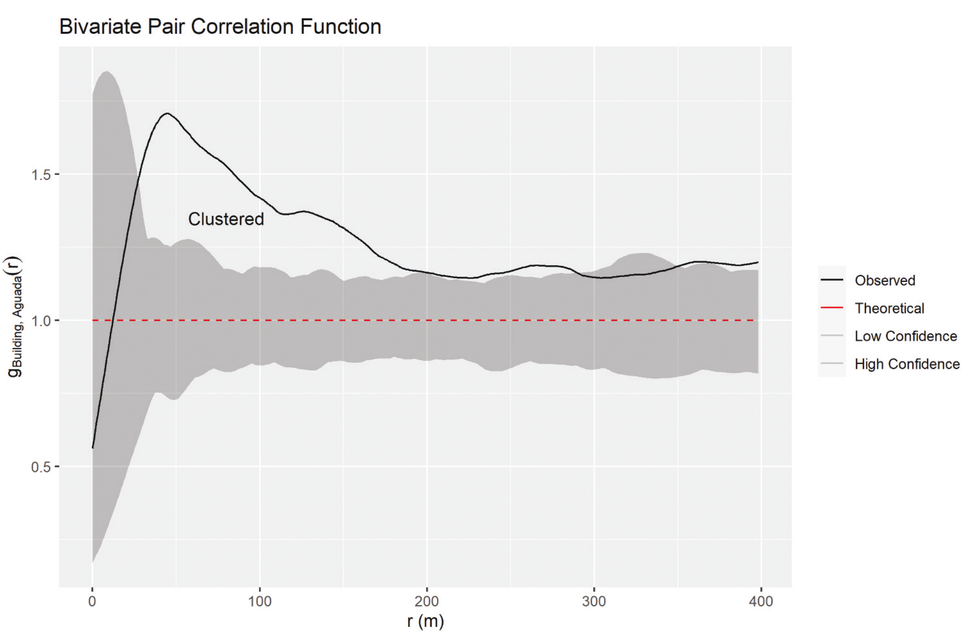

Figure 9. Bivariate Pair Correlation Function (PCF) with simulation envelope (nsim = 1000) showing highest clustering of aguadas relative to buildings between approximately 25 and 200 m above the envelope (see Riris, 2017). 75% of structures are located within 200 m of an aguada.

Figure 10. Household aguada with Structure G5-1 in the background (photo by Saúl Ascensio Bocanegra).

1995; Schroder, Golden, and Scherer et al. 2019). The primary function of such drained fields would have been to control the water table to increase agricultural yield. The construction of such channels would have required lower initial investment, but their maintenance would have been costly

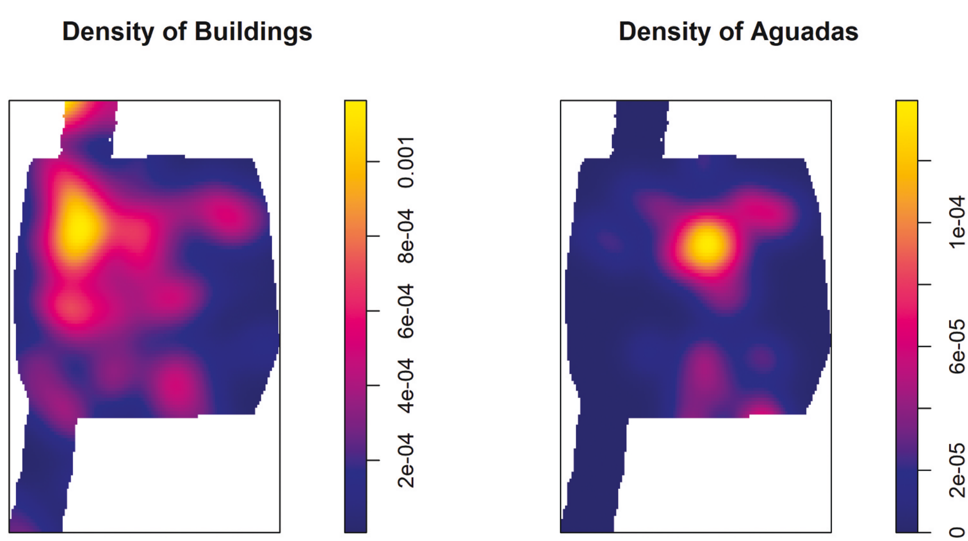

Figure 11. Kernel densities (sigma = 100) of buildings and aguadas showing highest densities of aguadas clustering away from highest densities of buildings (see Riris, 2017).

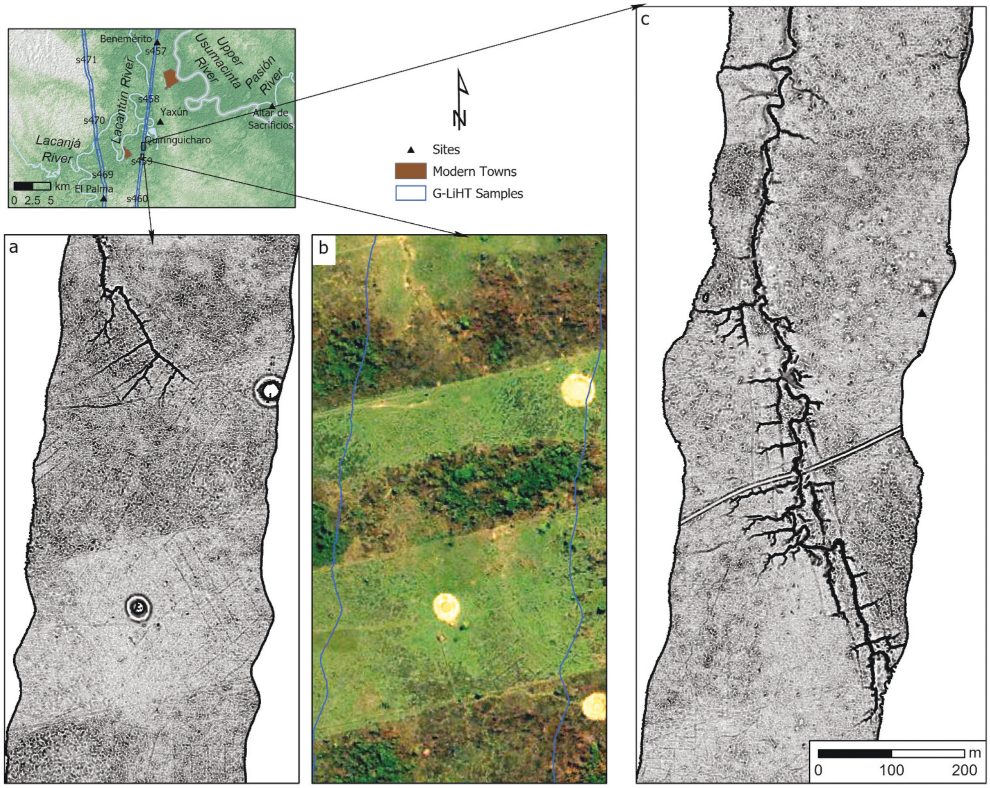

Figure 12. Remote sensing imagery of drained wetland fields near Quiringuicharo: a) a positive openness visualization of G-LiHT data (Chiapas s459 GLAS) showing several radial canals emanating from a natural arroyo, b) the same extent with some fields visible in historical Google Earth imagery (5/2005, © Maxar Technologies), and c) a positive openness visualization of an extension of the same field system along another arroyo 500 m to the north adjacent to a previously undocumented site within the same G-LiHT tile.

(Baugher 2001, 27). The current evidence suggests that such intensive agriculture was not under direct elite control; however, the Lacantún and Usumacinta Rivers would have aided the movement of goods across the watershed. Any surplus produced intensively could have supported parts of the kingdom that experienced a season of harvest failure due to local variations in rainfall.

Conclusion

The 2020 flooding of modern communities and the distribution of archaeological hamlets and urban centres in relation to flood risk along the Usumacinta River underscores the instability of tropical riverine environments. As the environment itself fluctuates, the human perception of that landscape is also inconstant. The experience of a place, therefore, develops over time and depends on the viewer's own physical and social position within that landscape (Mack 2004; Tuan 1975). Seasonal and yearly variations endemic to the tropics influence a cyclical view of land-use change, while abrupt, rare catastrophes can produce unpredictable and varied responses across and within communities. Low probability, 100-year flood cycles that span generations and that are affected by distant weather patterns can be unforeseeable; however, memory, oral histories, and indigenous knowledge can serve as a record to mitigate risks, a form of 'learning as dwelling' (Nakashima, Galloway Mclean, and Thulstrup et al. 2012; Plumb 2008; Wilcox 2009). The record of prehispanic anthropogenic modification to the landscape so far documented by this study suggests extensive approaches to exploit and manipulate the fluvial geomorphology of the region at least during the Classic period.

This research raises questions of scale and integration, especially apparent when comparing how populations lived in and managed the tropical riverine environment of the Upper Usumacinta-Lacantún River watershed with other archaeological cultures in similar regions across the globe. Comparative approaches adopted by Mayanists have concentrated on Angkor for its environmental context and agricultural infrastructure (Coe 1957; Webster 2013). The scale and interconnectivity of water management and population densities at Angkor, however, were higher than at even the largest and most powerful Maya centres (Evans et al. 2007, 14, 279). Dubbed the 'hydraulic city,' Angkor's extensive water management systems of canals, embankments, and reservoirs/barays connected periphery to urban centre (Buckley et al. 2010; Day et al. 2012; Evans et al. 2013; Groslier 1979; Ichita et al. 2016), a form of integration that has been observed in some parts of the Maya Lowlands on a smaller scale but much less apparent near Benemérito Primera Sección (Canuto et al. 2018; Chase and Chase 1998; Garrison, Houston, and Alcover Firpi 2019; Murtha 2015). However, some researchers have argued that much of the landscape system of Angkor was decentralized, and the importance of centralized planning has been exaggerated (Hawken 2013; Iannone 2016, 198). Thus, despite a mix of central and local planning among Angkor and the Maya, decentralized systems were more widespread, for example, at Benemérito Primera Sección.

Still, overreliance on rigid infrastructure may have been more detrimental to the long-term resilience of such systems (Buckley et al. 2010, 6749–6750). The effects of environmental change on the differing scales of infrastructure among Angkor and the Maya produced some similar results, with a shift away from inland agriculture to maritime and interregional trade (Chandler 2003; Sabloff and Rathje 1975; Vickery 1977). The increasing vulnerability of landscape systems over time in the context of seasonal variations in rainfall present important areas for comparison, but localized responses to coupled socio-environmental processes must be emphasized. Chronological data are currently lacking in the region surrounding Benemérito Primera Sección to assess the centre's role during the political transformations of the ninth century CE, as well as the resilience of water management and agricultural systems, but these questions will inform future research.

We have focused primarily on the mapping of an archaeological urban centre, the site of Benemérito de las Américas, Primera Sección contextualized within the broader landscape of the region surrounding the Usumacinta-Lacantún River confluence. This junction remains a significant environmental feature, draining the waters of the highlands and linking several modern, growing population centres in both Mexico and Guatemala. This confluence is also a focal point of travel, mirroring its importance in the past for river navigation in a theoretical circuit around the Western Maya Lowlands (Canter 2007). Constructed landscapes such as the archaeological community at Benemérito Primera Sección contributed to the existing power imbued into the conceptualized landscape and manifested in landscape art at Planchón de las Figuras. The common spatial process of urban nucleation (Gyucha 2019; Smith 2014a) took place at Benemérito Primera Sección where households favoured upland areas around the acropolis that was constructed on an already important natural vantage point in the region. Public performance areas, including plazas and ballcourts, added to the sanctity and significance of this location, encouraging the gathering of members of the community and visitors from afar.

Peripheral households of the outer urban and rural landscapes viewed these rituals from a different perspective. The visibility of the Benemérito Primera Sección acropolis ensured that members of outlying patio groups within the urban area could experience aspects of the site's 'moral community' and even the most restricted elite activities from a distance (Fitzsimmons 2015; Golden and Scherer 2013; Houston, Escobedo, and Child 2003). Although peripheral households could not necessarily participate directly, their private rituals paralleled those conducted in the acropolis, within the spaces of smaller plazas around platform altars in the city's surrounding districts, mapped on to the cardinal directions and site axis. Similarly, water management, though present to a degree in the form of terracing around the acropolis, was largely practiced and managed by outlying households and communities. Reservoirs clustered near households and drained fields in rural areas were largely decentralized but ensured that resources could be distributed along waterways to areas that experienced prolonged periods of higher risk. The same rivers that posed threats of flooding and hazardous navigation promoted the integration of diverse households and communities across this neotropical landscape.

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References

Aliphat Fernández, M. M. 1994. "Classic Maya Landscape in the Upper Usumacinta River Valley." Unpublished PhD diss., University of Calgary.

Anaya Hernández, A. 2001. *Site Interaction and Political Geography in the Upper Usumacinta Region during the Late Classic: A GIS Approach*. BAR International Series 994. Oxford: J. and E. Hedges.

Bachelard, G. 1994. *The Poetics of Space*. Boston: Beacon Press.

Barbour, T. E., K. E. Sassaman, A. Almeyda Zambrano, E. N. Broadbent, B. Wilkinson, R. Kanaski. 2019. "Rare pre-Columbian Settlement on the Florida Gulf Coast Revealed through High-resolution Drone LiDAR." *Proceedings of the National Academy of Sciences* 116 (47): 23493–23498. doi:10.1073/pnas.1911285116.

Barnhart, E. L. 2003. "Urbanism at Palenque." *PARI Journal* 4 (1): 10–16.

Barnhart, E. L. 2007. "Indicators of Urbanism at Palenque." In *Palenque: Recent Investigations at the Classic Maya Center*, edited by D. B. Marken, 107–122. Lanham: AltaMira Press.

Baugher, S. 2001. "What Is It? Archaeological Evidence of 19th-century Agricultural Drainage Systems." *Northeast Historical Archaeology* 31 (1): 23–40. doi:10.22191/neha/vol31/iss1/4.

Beach, T., S. Luzzadder-Beach, S. Krause, T. Guderjan, F. Valdez Jr., J. Carlos Fernandez-Diaz, S. Eshleman, and C. Doyle. 2019. "Ancient Maya Wetland Fields Revealed under Tropical Forest Canopy from Laser Scanning and Multiproxy Evidence." *Proceedings of the National Academy of Sciences* 201910553. doi:10.1073/pnas.1910553116.

Becker, M. J. 2001. "Houselots at Tikal Guatemala: It's What's Out Back that Counts." In *Reconstruyendo La Ciudad Maya: El Urbanismo En Las Sociedades Antiguas*, edited by A. Ciudad Ruiz, M. J. Iglesias Ponce De León, and M. D. C. Martínez Martínez, 427–460. Madrid: Sociedad Española de Estudios Mayas.

Benjamin, W. 1999. *The Arcades Project*. (trans. H Eiland and K McLaughlin). Cambridge: Belknap Press of Harvard University Press.

Blackmore, C. 2011. "Ritual among the Masses: Deconstructing Identity and Class in an Ancient Maya Neighborhood." *Latin American Antiquity* 22 (2): 159–177. doi:10.7183/1045-6635.22.2.159.

Blanton, R., and L. Fargher. 2008. *Collective Action in the Formation of Pre-Modern States*. New York: Springer.

Bocinsky, K. 2017. "Landscape-based hypothesis testing in R." How to do archaeological science in R, edited by B. Marwick. https://benmarwick.github.io/How-To-Do-Archaeological-Science-Using-R/landscape-based-hypothesis-testing-in-r.html. Accessed May 26 2021.

Brown, T. 2002. "Floodplain Landscapes and Archaeology: Fluvial Events and Human Agency." *Journal of Wetland Archaeology* 2 (1): 89–104. doi:10.1179/jwa.2002.2.1.89.

Buckley, B. M., K. J. Anchukaitis, D. Penny, R. Fletcher, E. R. Cook, M. Sano, L. C. Nam, et al. 2010. "Climate as a Contributing Factor in the Demise of Angkor, Cambodia." *Proceedings of the National Academy of Sciences* 107 (15): 6748–6752. doi:10.1073/pnas.0910827107.

Bullard, W. R., Jr. 1995. "Ruinas ceremoniales Mayas en el curso inferior del río Lacantún, México." In *Cuatro Estudios Sobre El Planchón de Las Figuras*, edited by R. García Moll, 47–66. Mexico City: Instituto Nacional de Antropología e Historia.

Canter, R. L. 2007. "Rivers among the Ruins: The Usumacinta." *The PARI Journal* 7 (3): 1–24.

Canuto, M., F. Estrada-Belli, T. G. Garrison, S. D. Houston, M. J. Acuña, M. Kováč, D. Marken, et al. 2018. "Ancient Lowland Maya Complexity as Revealed by Airborne Laser Scanning of Northern Guatemala." *Science* 361 (6409): eaau0137. doi:10.1126/science.aau0137.

Carballo, D. M., ed. 2013. *Cooperation and Collective Action: Archaeological Perspectives*. Boulder: University Press of Colorado.

Chandler, D. 2003. *A History of Cambodia*. Chiang Mai: Silkworm Books.

Chase, A. S. Z. 2016. "Beyond Elite Control: Residential Reservoirs at Caracol, Belize." *Wiley Interdisciplinary Reviews*: *Water* 3 (6): 885–897. doi:10.1002/wat2.1171.

Chase, A. F., and D. 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. doi:10.1525/cag.1998.20.2-3.60.

Chase, A. F., and D. Z. Chase. 2016. "Urbanism and Anthropogenic Landscapes." *Annual Review of Anthropology* 45 (1): 361–376. doi:10.1146/annurev-anthro-102215-095852.

Chase, A. F., D. Z. Chase, C. T. Fisher, S. J. Leisz, J. F. Weishampel. 2012. "Geospatial Revolution and Remote Sensing LiDAR in Mesoamerican Archaeology." *Proceedings of the National Academy of Sciences* 109 (32): 12916–12921. doi:10.1073/pnas.1205198109.

Chase, A. F., D. Z. Chase, J. F. Weishampel, J. B. Drake, R. L. Shrestha, K. C. Slatton, J. J. Awe, et al. 2011. "Airborne LiDAR, Archaeology, and the Ancient Maya Landscape at Caracol, Belize." *Journal of Archaeological Science* 38 (2): 387–398. doi:10.1016/j.jas.2010.09.018.

Chase, A. S. Z., D. Z. Chase, and A. F. Chase. 2017. "LiDAR for Archaeological Research and the Study of Historical Landscapes." In *Sensing the Past*, edited by N. Masini and F. Soldovieri, 89–100. Cham: Springer International Publishing. doi:10.1007/978-3-319-50518-3_4.

Chase, D. Z., and A. F. Chase. 2014. "Ancient Maya Markets and the Economic Integration of Caracol, Belize." *Ancient Mesoamerica* 25 (1): 239–250. doi:10.1017/S0956536114000145.

Chisholm, M. 1962. *Rural Settlement and Land Use*. 1st ed. New York: Routledge. doi:10.4324/9781315128832.

Coe, M. D. 1957. "The Khmer Settlement Pattern: A Possible Analogy with that of the Maya." *American Antiquity* 22 (4): 409–410. doi:10.2307/276143.

Cook, B., L. Corp, R. Nelson, E. Middleton, D. Morton, J. McCorkel, J. Masek, et al. 2013. "NASA Goddard's LiDAR, Hyperspectral and Thermal (G-liht) Airborne Imager." *Remote Sensing* 5 (8): 4045–4066. doi:10.3390/rs5084045.

Creekmore, A. T., and K. D. Fisher, eds. 2014. *Making Ancient Cities: Space and Place in Early Urban Societies*. Cambridge: Cambridge University Press.

Dahlin, B. H., C. T. Jensen, R. E. Terry, D. R. Wright, T. Beach. 2007. "In Search of an Ancient Maya Market." *Latin American Antiquity* 18 (4): 363–384. doi:10.2307/25478193.

Day, M. B., D. A. Hodell, M. Brenner, H. J. Chapman, J. H. Curtis, W. F. Kenney, A. L. Kolata, et al. 2012. "Paleoenvironmental History of the West Baray, Angkor (Cambodia)." *Proceedings of the National Academy of Sciences* 109 (4): 1046–1051. doi:10.1073/pnas.1111282109.

De La Maza, J. 2015. "Caracterización De La Subcuenca Del Lacantún." In *Conservación y Desarrollo Sustentable En La Selva Lacandona*, edited by J. Carabias, J. De La Maza, and R. Cadena, 79–86. Mexico City: Natura y Ecosistemas Mexicanos.

Dobres, M.-A., and J. Robb, eds. 2000. *Agency in Archaeology*. Abingdon: Routledge.

Dornan, J. L. 2002. "Agency and Archaeology: Past, Present, and Future Directions." *Journal of Archaeological Method and Theory* 9 (4): 303–329. doi:10.1023/A:1021318432161.

Dunning, N. P., T. Beach, and D. J. Rue. 1994. "Soil Erosion, Slope Management, and Ancient Terracing in the Maya Lowlands." *Latin American Antiquity* 5: 51–69. doi:10.2307/971902.

Erickson, C. L. 2008. "Amazonia: The Historical Ecology of a Domesticated Landscape." In *The Handbook of South American Archaeology*, edited by H. Silverman and W. H. Isbell, 157–183. New York: Springer.

Evans, D., R. J. Fletcher, C. Pottier, J.-B. Chevance, D. Soutif, B. S. Tan, S. Im, et al. 2013. "Uncovering Archaeological Landscapes at Angkor Using Lidar." *Proceedings of the National Academy of Sciences* 110 (31): 12595–12600. doi:10.1073/pnas.1306539110.

Evans, D., C. Pottier, R. Fletcher, S. Hensley, I. Tapley, A. Milne, M. Barbetti, et al. 2007. "A Comprehensive Archaeological Map of the world's Largest Preindustrial Settlement Complex at Angkor, Cambodia." *Proceedings of the National Academy of Sciences* 104 (36): 14277–14282. doi:10.1073/pnas.0702525104.

Fernández, F., K. Johnson, R. Terry, S. Nelson, D. Webster. 2005. "Soil Resources of the Ancient Maya at Piedras Negras, Guatemala." *Soil Science Society of America Journal* 69 (6): 2020–2032. doi:10.2136/sssaj2004.0306.

Fisher, C. 2014. "The Role of Infield Agriculture in Maya Cities." *Journal of Anthropological Archaeology* 36: 196–210. doi:10.1016/j.jaa.2014.10.001.

Fitzsimmons, J. L. 2015. "The Charismatic Polity: Zapote Bobal and the Birth of Authority at Jaguar Hill." In *Classic Maya Polities of the Southern Lowlands: Integration, Interaction, and Dissolution*, edited by D. B. Marken and J. L. Fitzsimmons, 225–242. Boulder: University Press of Colorado.

Flores Esquivel, A. 2011. "Centros cívico-ceremoniales menores o 'sitios de orden secundario' en la región de Palenque: Características y compontentes." In *B'aakal: Arqueología de La Región de Palenque, Chiapas, México. Temporadas 1996–2006*, edited by R. Liendo Stuardo, 35–50. BAR International Series. Oxford: Archaeopress.

Ford, A., and R. Nigh. 2009. "Origins of the Maya Forest Garden: Maya Resource Management." *Journal of Ethnobiology* 29 (2): 213–236. doi:10.2993/0278-0771-29.2.213.

French, K. D. 2007. "Creating Space through Water Management at the Classic Maya Site of Palenque, Chiapas." In *Palenque: Recent Investigations at the Classic Maya Center*, edited by D. B. Marken, 123–134. Lanham: AltaMira Press.

Garrison, T. G., S. D. Houston, and O. Alcover Firpi. 2019. "Recentering the Rural: Lidar and Articulated Landscapes among the Maya." *Journal of Anthropological Archaeology* 53: 133–146. doi:10.1016/j.jaa.2018.11.005.

Gill, R. B. 2000. *The Great Maya Droughts: Water, Life, and Death*. Albuquerque: University of New Mexico Press.

Golden, C., T. Murtha, B. Cook, D. S. Shaffer, W. Schroder, E. J. Hermitt, O. Alcover Firpi, et al. 2016. "Reanalyzing Environmental Lidar Data for Archaeology: Mesoamerican Applications and Implications." *Journal of Archaeological Science: Reports* 9: 293–308. doi:10.1016/j.jasrep.2016.07.029.

Golden, C., A. Scherer, and W. Schroder, C. Vella, and A. Roche Recinos. 2020. "Decentralizing the Economies of the Maya West." In *The Real Business of Ancient Maya Economies: From Farmers' Fields to Rulers' Realms*, edited by M. A. Masson, D. A. Freidel, A. A. Demarest, 403–417. Gainesville: University Press of Florida. doi:10.5744/florida/9780813066295.003.0023.

Golden, C., and A. K. Scherer. 2006. "Border Problems: Recent Archaeological Research along the Usumacinta River." *PARI Journal* 7 (2): 1–16.

Golden, C., and A. K. Scherer. 2013. "Territory, Trust, Growth, and Collapse in Classic Period Maya Kingdoms." *Current Anthropology* 54 (4): 397–417. doi:10.1086/671054.

Golden, C., A. K. Scherer, S. Houston, W. Schroder, S. Morell-Hart, S. D. P. Jiménez Álvarez, G. V. Kollias, et al. 2020. "Centering the Classic Maya Kingdom of Sak Tz'i'." *Journal of Field Archaeology* 45 (2): 67–85. doi:10.1080/00934690.2019.1684748.

Graham, E. 2008. "Stone Cities, Green Cities." *Archeological Papers of the American Anthropological Association* 9 (1): 185–194. doi:10.1525/ap3a.1999.9.1.185.

Groslier, B. P. 1979. "Le cité hydraulique angkorienne: Exploitation ou surexploitation du sol?" *Bulletin De L'école Française d'Extrême Orient* 66: 161–202. doi:10.3406/befeo.1979.4014.

Gyucha, A., ed. 2019. *Coming Together: Comparative Approaches to Population Aggregation and Early Urbanization*. Albany: SUNY Press.

Halperin, C. T., and J. L. Garrido. 2020. "Architectural Aesthetics, Orientations, and Reuse at the Terminal Classic Maya Site of Ucanal, Petén, Guatemala." *Journal of Field Archaeology* 45 (1): 46–66. doi:10.1080/00934690.2019.1676033.

Hassan, F. A. 1997. "The Dynamics of a Riverine Civilization: A Geoarchaeological Perspective on the Nile Valley, Egypt." *World Archaeology* 29 (1): 51–74. doi:10.1080/00438243.1997.9980363.

Hawken, S. 2013. "Designs of Kings and Farmers: Landscape Systems of the Greater Angkor Urban Complex." *Asian Perspectives* 52 (2): 347–367. doi:10.1353/asi.2013.0010.

Heidegger, M. 1993. "Building, Dwelling, Thinking." In *Basic Writings*, edited by D. F. Krell, 343–364. New York: Harper Collins.

Hernández-Stefanoni, J. L., K. D. Johnson, B. D. Cook, J. M. Dupuy, R. Birdsey, A. Peduzzi, F. Tun-Dzul, et al. 2015. "Estimating Species Richness and Biomass of Tropical Dry Forests Using LIDAR during Leaf-on and Leaf-off Canopy Conditions." *Applied Vegetation Science* 18 (4): 724–732. doi:10.1111/avsc.12190.

Horn, S. W., and A. Ford. 2019. "Beyond the Magic Wand: Methodological Developments and Results from Integrated Lidar Survey at the Ancient Maya Center El Pilar." *STAR: Science & Technology of Archaeological Research* 1–15. doi:10.1080/20548923.2019.1700452.

Houston, S., and T. G. Garrison. 2015. "The Dedicated City: Meaning and Morphology in Classic Maya Urbanism." In *The Cambridge World History, Volume III: Early Cities in Comparative Perspective, 4000 BCE–1200 CE*, edited by N. Yoffee, 48–73. Cambridge: Cambridge University Press.

Houston, S.D., H.L. Escobedo, M.B. Child, C. Golden, and R. Muñoz. 2003. "The Moral Community: Maya Settlement Transformation at Piedras Negras, Guatemala." In *The Social Construction of Ancient Cities*, edited by M. L. Smith, 212–253. Washington, DC: Smithsonian Books.

Houston, S.D., H.L. Escobedo, C. Golden, A. Scherer, R. Vásquez, A.L. Arroyave, F. Quiroa, and J.C. Meléndez. 2006. "La Técnica and El Kinel: Mounds and Monuments Upriver from Yaxchilán." *Mexicon* 28 (5): 87–93.

Hutson, S. R. 2015. "Adapting LiDAR Data for Regional Variation in the Tropics: A Case Study from the Northern Maya Lowlands." *Journal of Archaeological Science: Reports* 4: 252–263. doi:10.1016/j.jasrep.2015.09.012.

Hutson, S. R. 2017. *Ancient Maya Commerce*. Boulder: University Press of Colorado.

Hutson, S.R., N.P. Dunning, B. Cook, T. Ruhl, N.C. Barth, and D. Conley. Ancient Maya Rural Settlement Patterns, Household Cooperation, and Regional Subsistence Interdependency in the Río Bec Area: Contributions from G-LiHT. *Journal of Anthropological Research*.

Hutson, S. R., A. Magnoni, and B. H. Dahlin. 2017. "Architectural Group Typology and Excavation Sampling within Chunchucmil." In *Ancient Maya Commerce: Multidisciplinary Research at Chunchucmil*, edited by S. R. Hutson, 51–72. Boulder: University Press of Colorado.

Iannone, G., ed. 2014. *The Great Maya Droughts in Cultural Context: Case Studies in Resilience and Vulnerability*. Boulder: University Press of Colorado.

Iannone, G. 2016. "Release and Reorganization in the Tropics: A Comparative Perspective." In *Beyond Collapse: Archaeological Perspectives in Resilience, Revitalization, and Transformation in Complex Societies*, edited by R. K. Faulseit, 179–212. Carbondale: Center for Archaeological Investigations, Occasional Paper No. 42, Southern Illinois University.

Ichita, S., H. Tsuyoshi, C. Tatsuro, S. Mariko. 2016. "The Advanced Hydraulic City Structure of the Royal City of Angkor Thom and Vicinity Revealed through a High-Resolution Red Relief Image Map." *Archaeological Discovery* 4 (1): 22–36. doi:10.4236/ad.2016.41003.

Ingold, T. 1993. "The Temporality of the Landscape." *World Archaeology* 25 (2): 152–174. doi:10.1080/00438243.1993.9980235.

Inomata, T. 2006. "Plazas, Performers, and Spectators." *Current Anthropology* 47 (5): 805–842. doi:10.1086/506279.

Isendahl, C. 2012. "Agro-urban Landscapes: The Example of Maya Lowland Cities." *Antiquity* 86 (334): 1112–1125. doi:10.1017/S0003598X00048286.

Isendahl, C., and M. E. Smith. 2013. "Sustainable Agrarian Urbanism: The Low-density Cities of the Mayas and Aztecs." *Cities* 31: 132–143. doi:10.1016/j.cities.2012.07.012.

Janusek, J. W., and A. L. Kolata. 2004. "Top-down or Bottom-up: Rural Settlement and Raised Field Agriculture in the Lake Titicaca Basin, Bolivia." *Journal of Anthropological Archaeology* 23 (4): 404–430. doi:10.1016/j.jaa.2004.08.001.

Jing, Z., G. Rapp Jr. (Rip), and T. Gao. 1997. "Geoarchaeological Aids in the Investigation of Early Shang Civilization on the Floodplain of the Lower Yellow River, China." *World Archaeology* 29 (1): 36–50. doi:10.1080/00438243.1997.9980362.

Johnson, K. D., R. E. Terry, M. W. Jackson, C. Golden. 2007. "Ancient Soil Resources of the Usumacinta River Region, Guatemala." *Journal of Archaeological Science* 34 (7): 1117–1129. doi:10.1016/j.jas.2006.10.004.

Joyce, A. A., and R. G. Mueller. 1997. "Prehispanic Human Ecology of the Río Verde Drainage Basin, Mexico." *World Archaeology* 29 (1): 75–94. doi:10.1080/00438243.1997.9980364

Juárez Cossío, D. 1994. "Boca Lacantún: El Planchón de las Figuras." *Arqueología Mexicana* 8: 36–38.

King, E. M., ed. 2015. *The Ancient Maya Marketplace: The Archaeology of Transient Space*. Tucson: University of Arizona Press.

Kingsley, M.J., C.W. Golden, A.K. Scherer, and L.M. Marroquin de Franco. 2012. "Parallelism in Occupation: Tracking the Pre- and Post-dynastic Evolution of Piedras Negras, Guatemala through Its Secondary Site, El Porvenir." *Mexicon* 34 (5): 109–117.

Knapp, A. B., and W. Ashmore. 2000. "Archaeological Landscapes: Constructed, Conceptualized, Ideational." In *Archaeologies of Landscape: Contemporary Perspectives*, edited by W. Ashmore and A. B. Knapp, 1–32. Malden, MA: Blackwell.

Kokalj, Ž., K. Zakšek, and K. Oštir. 2011. "Application of Sky-view Factor for the Visualisation of Historic Landscape Features in Lidar-derived Relief Models." *Antiquity* 85 (327): 263–273. doi:10.1017/S0003598X00067594.

Kokalj, Ž., K. Zakšek, and K. Oštir. 2013. "Visualizations of Lidar Derived Relief Models." In *Interpreting Archaeological Topography: Airborne Laser Scanning, 3D Data and Ground Observation*, edited by R. S. Opitz and D. C. Cowley, 100–114. Oxford: Oxbow Books (Occasional Publication of the Aerial Archaeology Research Group 5).

LeCount, L. J., C. P. Walker, J. H. Blitz, T. C. Nelson 2019. "Land Tenure Systems at the Ancient Maya Site of Actuncan, Belize." *Latin American Antiquity* 30 (2): 245–265. doi:10.1017/laq.2019.16.

Lucero, L. J. 2006. *Water and Ritual: The Rise and Fall of Classic Maya Rulers*. Austin: University of Texas Press.

Lucero, L. J., and B. W. Fash, eds. 2006. *Precolumbian Water Management: Ideology, Ritual, and Power*. Tucson: University of Arizona Press.

Lucero, L. J., R. J. Fletcher, and R. Coningham. 2015. "From 'Collapse' to Urban Diaspora: The Transformation of Low-density, Dispersed Agrarian Urbanism." *Antiquity* 89 (347): 1139–1154. doi:10.15184/aqy.2015.51.

Lucero, L. J., and J. Gonzalez Cruz. 2020. "Reconceptualizing Urbanism: Insights from Maya Cosmology." *Frontiers in Sustainable Cities* 2: 1–15. doi:10.3389/frsc.2020.00001.

Mack, A. 2004. "One Landscape, Many Experiences: Differing Perspectives of the Temple Districts of Vijayanagara." *Journal of Archaeological Method and Theory* 11 (1): 59–81. doi:10.1023/B:JARM.0000014617.58744.1d.

Magnoni, A., S. R. Hutson, and B. Dahlin. 2012. "Living in the City: Settlement Patterns and the Urban Experience at Classic Period Chunchucmil, Yucatan, Mexico." *Ancient Mesoamerica* 23 (2): 313–343. doi:10.1017/S0956536112000223.

Maler, T. 1903. Researches in the Central Portion of the Usumatsintla Valley: Reports of Explorations for the Museum.—Part Second. Memoirs 2(2). Peabody Museum of American Archaeology and Ethnology, Harvard University, Cambridge, MA.

Marken, D., and T. Murtha. 2017. "Maya Cities, People and Place: Comparative Perspectives from El Peru and Tikal." *Research Reports in Belizean Archaeology* 14: 177–187.

Martos López, L. A. 2009. "The Discovery of Plan De Ayutla, Mexico." In *Maya Archaeology 1*, edited by C. Golden, S. Houston, and J. Skidmore, 60–75. San Francisco: Precolumbia Meso Press.

Mayer, K. H. 2006. "The Maya Ruins of Primera Sección, Chiapas, Mexico." *Mexicon* 28: 63–66.

McAnany, P. A. 2013. *Living with the Ancestors: Kinship and Kingship in Ancient Maya Society*. Revised ed. New York: Cambridge University Press.

Meggers, B. 1954. "Environmental Limitation on the Development of Culture." *American Anthropologist* 56 (5): 801–824. doi:10.1525/aa.1954.56.5.02a00060.

Mejía-Ramón, A. 2019. "La Prospección Fotogramétrica Fluvial Y Aérea." In *Informe Del Proyecto Geomorfológico de Asentamientos Antiguos Del Usumacinta Superior, La Temporada de 2019: Investigando La Historia Fluvial y Los Patrones de Asentamiento de Altar de Sacrificios y Sus Alrededores*, edited by J. Munson and A. L. Paiz, 12–35. Mexico City: Instituto Nacional de Antropología e Historia.

Miller, M., and C. Brittenham. 2013. *The Spectacle of the Late Maya Court: Reflections on the Murals of Bonampak*. Austin: University of Texas Press.

Mülleried, F. K. G. 1995. "El llamado el Planchón de las Figuras en el estado de Chiapas." In *Cuatro Estudios Sobre El Planchón de Las Figuras*, edited by R. García Moll, 67–75. Mexico City: Instituto Nacional de Antropología e Historia.

Murtha, T. 2017. "Rethinking Urban Density: Archaeology, Low Density Urbanism and Sustainability." In *Architecture, Archaeology and Contemporary City Planning: Issues of Scale*, edited by J. Dixon, G. Verdiani, and P. Cornell, 92–100. London: Museum of London Archaeology.

Murtha, T. M. 2009. *Land and Labor: Classic Maya Agriculture at Caracol, Belize*. Berlin: VDM Verlag Dr. Müller.

Murtha, T. M. 2015. "Negotiated Landscapes: Comparative Settlement Ecology of Tikal and Caracol." In *Classic Maya Polities of the Southern Lowlands: Integration, Interaction, Dissolution*, edited by D. B. Marken and J. L. Fitzpatrick, 75–98. Boulder: University Press of Colorado.

Murtha, T. M., E. N. Broadbent, C. Golden, A. Scherer, W. Schroder, B. Wilkinson, A. A. Zambrano, et al. 2019. "Drone-mounted Lidar Survey of Maya Settlement and Landscape." *Latin American Antiquity* 30 (3): 630–636. doi:10.1017/laq.2019.51.

Nakashima, D.J., K. Galloway McLean, H.D. Thulstrup, A. Ramos Castillo, and J.T. Rubis. 2012. *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*. Paris and Darwin: UNESCO and UNU.

Nelson, Z. 2005. “Settlement and Population at Piedras Negras.” Unpublished PhD diss., Pennsylvania State University.

O’Malley, M. 2014. “Such Building Only Takes Care: A Study of Dwelling in the Work of Heidegger, Ingold, Malinowski, and Thoreau.” Unpublished Master’s (MA) thesis, Ohio State University, Columbus.

Obrador-Pons, P. 2007. “Dwelling.” In *Companion Encyclopaedia of Geography: From Local to Global*, edited by I. Douglas, R. Huggett, and C. Perkins, 957–968. London: Routledge.

Plumb, D. 2008. “Learning as Dwelling.” *Studies in the Education of Adults* 40 (1): 62–79. doi:10.1080/02660830.2008.11661556.

Potter, J. M. 2004. “The Creation of Person, the Creation of Place: Hunting Landscapes in the American Southwest.” *American Antiquity* 69 (2): 322–338. doi:10.2307/4128423.

Rice, D. S., and T. P. Culbert. 1990. “Historical Contexts for Population Reconstruction in the Maya Lowlands.” In *Precolumbian Population History in the Maya Lowlands*, edited by T. P. Culbert and D. S. Rice, 1-36. Albuquerque: University of New Mexico Press.

Riris, P. 2017. “Basic spatial analysis in R: point pattern analysis.” How to do archaeological science in R, edited by B. Marwick. https://benmarwick.github.io/How-To-Do-Archaeological-Science-Using-R/basic-spatial-analysis-in-r-point-pattern-analysis.html. Accessed May 26 2021.

Risbøl, O., and L. Gustavsen. 2018. “LiDAR from Drones Employed for Mapping Archaeology - Potential, Benefits and Challenges.” *Archaeological Prospection* 25 (4): 329–338. doi:10.1002/arp.1712.

Rosenswig, R. M., R. López-Torrijos, C. E. Antonelli, R. R. Mendelsohn. 2013. “Lidar Mapping and Surface Survey of the Izapa State on the Tropical Piedmont of Chiapas, Mexico.” *Journal of Archaeological Science* 40 (3): 1493–1507. doi:10.1016/j.jas.2012.10.034.

Ruhl, T., N. P. Dunning, and C. Carr. 2018. “Lidar Reveals Possible Network of Ancient Maya Marketplaces in Southwestern Campeche, Mexico.” *Mexicon* 40 (3): 83–91.

Sabloff, J. A., and W. L. Rathje. 1975. “The Rise of a Maya Merchant Class.” *Scientific American* 233 (4): 72–82. doi:10.1038/scientificamerican1075-72.

Scarborough, V. L. 1998. “Ecology and Ritual: Water Management and the Maya.” *Latin American Antiquity* 9 (2): 135–159. doi:10.2307/971991.

Scarborough, V. L. 2003. *The Flow of Power: Ancient Water Systems and Landscapes*. Santa Fe: School of American Research.

Scarborough, V. L., A. F. Chase, and D. Z. Chase. 2012. “Low-Density Urbanism, Sustainability, and IHOPE-Maya: Can the past Provide More than History?” *UGEC Viewpoints* 8: 20–24.

Scherer, A. K., and C. Golden. 2014a. “War in the West: History, Landscape, and Classic Maya Conflict.” In *Embattled Bodies, Embattled Places: War in Pre-Columbian Mesoamerica and the Andes*, edited by A. K. Scherer and J. W. Verano, 57–92. Washington, DC: Dumbarton Oaks.

Scherer, A. K., and C. Golden. 2014b. “Water in the West: Chronology and Collapse of the Western Maya River Kingdoms.” In *The Great Maya Droughts in Cultural Context*, edited by G. Iannone, 207–229. Boulder: University Press of Colorado.

Scherer, A.K., C. Golden, A.L. Arroyave, and G. Pérez Robles. 2014. “Danse Macabre: Death, Community, and Kingdom at El Kinel, Guatemala.” In *The Bioarchaeology of Space and Place*, edited by G. Wrobel, 193–224. New York: Springer.

Scherer, A. K., and C. W. Golden. 2009. “Tecolote, Guatemala: Archaeological Evidence for a Fortified Late Classic Maya Political Border.” *Journal of Field Archaeology* 34 (3): 285–305. doi:10.1179/009346909791070907.

Schroder, W. 2017. “Reconocimiento en Benemérito de las Américas, Primera Sección.” In *Proyecto Arqueológico Busiljá-Chocoljá: Informe de La Octava Temporada Presentado Ante El Consejo de Arqueología*, edited by W. Schroder, C. Golden, and A. K. Scherer, 171–180. Mexico City: Instituto Nacional de Antropología e Historia.

Schroder, W. 2019a. “Benemérito de las Américas, Primera Sección: Investigaciones preliminares.” In *Proyecto Arqueológico Busiljá-Chocoljá: Informe de La Décima Temporada Presentado Ante El Consejo de Arqueología*, edited by A. K. Scherer and C. Golden, 375–400. Mexico City: Instituto Nacional de Antropología e Historia.

Schroder, W. 2019b. “Community Resilience through Crisis at El Infiernito, Chiapas, a Fortified Refuge in the Upper Usumacinta Valley.” Unpublished PhD dissertation, University of Pennsylvania.

Schroder, W., C. Golden, A. Scherer, T.M. Murtha, and O. Alcover Firpi. 2019. “Remote Sensing and Reconnaissance along the Lacantún River: The Lakamtuun Dynasty and the Sites of El Palma and Benemérito De Las Américas, Primera Sección.” *Mexicon* 41 (6): 157–167.

Schroder, W., C.W. Golden, A.K. Scherer, S. Jiménez Álvarez, J. Dobereiner, and A. Mendez Cab. 2017. "At the Crossroads of Kingdoms: Recent Investigations on the Periphery of Piedras Negras and Its Neighbors." *The PARI Journal* 17 (4): 1–15.

Schroder, W., T. Murtha, C. Golden, A. Anaya Hernández, A. Scherer, S. Morell-Hart, A. Almeyda Zambrano, et al. 2020. "The Lowland Maya Settlement Landscape: Environmental LiDAR and Ecology." *Journal of Archaeological Science: Reports* 33: 102543. doi:10.1016/j.jasrep.2020.102543.

Scott, J. C. 1976. *The Moral Economy of the Peasant: Rebellion and Subsistence in Southeast Asia*. New Haven: Yale University Press.

Sharer, R. J., and L. P. Traxler. 2006. *The Ancient Maya*. Sixth ed. Stanford: Stanford University Press.

Silverman, B. W. 1986. *Density Estimation for Statistics and Data Analysis*. New York: Chapman and Hall.

Smith, M. E. 2014a. "Peasant Mobility, Local Migration and Premodern Urbanization." *World Archaeology* 46 (4): 516–533. doi:10.1080/00438243.2014.931818.

Smith, M. L., ed. 2003. *The Social Construction of Ancient Cities*. Washington, D.C.: Smithsonian Institution Press.

Smith, M. L. 2014b. "The Archaeology of Urban Landscapes." *Annual Review of Anthropology* 43 (1): 307–323. doi:10.1146/annurev-anthro-102313-025839.

Stanton, T.W., T. Ardren, N.C. Barth, J.C. Fernandez-Diaz, P. Rohrer, D. Meyer, S.J. Miller, A. Magnoni, M. 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. doi:10.1016/j.jasrep.2019.102178.

Stuart, D. 2007a. "Place Names and Polities in the Usumacinta Region." In: *XXXI Annual Maya Meetings at the University of Texas, Austin. March 2007*, Austin, TX, 2007.

Stuart, D. 2007b. "The Captives on Piedras Negras, Panel 12." In *Maya Decipherment*, edited by D. Stuart, accessed May 26 2021. https://decipherment.wordpress.com/2007/08/18/the-captives-on-piedras-negras-panel-12/ .

Stuart, G., and J. Wilkerson. 1995. "Las figuras de el Planchón de las Figuras, Chiapas." In *Cuatro Estudios Sobre El Planchón de Las Figuras*, edited by R. García Moll, 77–161. Mexico City: Instituto Nacional de Antropología e Historia.

Štular, B., Ž. Kokalj, K. Oštir, L. Nuninger. 2012. "Visualization of Lidar-derived Relief Models for Detection of Archaeological Features." *Journal of Archaeological Science* 39 (11): 3354–3360. doi:10.1016/j.jas.2012.05.029.

Thrift, N. 1999. "Steps to an Ecology of Place." In *Human Geography Today*, edited by D. Massey, J. Allen, and P. Sarre, 295–322. Cambridge: Polity Press.

Tovalín, A., and V. Ortiz. 2005. "El sitio arqueológico de la Primera Sección de Benemérito de las Américas, Chiapas." *Arqueología* 35: 33–49.

Tsukamoto, K., and T. Inomata, eds. 2014. *Mesoamerican Plazas: Arenas of Community and Power*. Tucson: University of Arizona Press.

Tuan, Y. 1975. "Place: An Experiential Perspective." *Geographical Review* 65 (2): 151–165. doi:10.2307/213970.

VanValkenburgh, P., K. C. Cushman, L. J. C. Castillo Butters, C. R. Vega, C. B. Roberts, C. Kepler, J. Kellner, et al. 2020. "Lasers without Lost Cities: Using Drone Lidar to Capture Architectural Complexity at Kuelap, Amazonas, Peru." *Journal of Field Archaeology* 45 (sup1): S75–S88. doi:10.1080/00934690.2020.1713287.

Velázquez Valadez, R. 1986. "Localización Y Reconocimiento De Un Sitio Arqueológico En La Región Del Marqués De Comillas: El Palma, Chiapas." In *Tres Sitios Arqueológicos En Chiapas: El Palma, Agua Escondida y El Cafetal*, edited by J. García-Bárcena, R. García Moll, D. Juárez Cossío, D. Santamaría, and R. Velázquez Valadez, 7–20. Mexico City: Instituto Nacional de Antropología e Historia and University of Pittsburgh.

Vickery, M. T. 1977. "Cambodia after Angkor: The Chronicular Evidence for the Fourteenth to Sixteenth Centuries." Unpublished PhD dissertation, Yale University, New Haven.

Webster, D. 2013. "A Chinese Traveler Visits the Maya." *Mexicon* 35 (6): 140–147.

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

Webster, D., A. Freter, and N. Gonlin. 2000. *Copán: The Rise and Fall of an Ancient Maya Kingdom*. Fort Worth: Harcourt College Publishers.

Weiss-Krejci, E., and T. Sabbas. 2002. "The Potential Role of Small Depressions as Water Storage Features in the Central Maya Lowlands." *Latin American Antiquity* 13 (3): 343–357. doi:10.2307/972115.

Whitley, D. S. 1998. “Finding Rain in the Desert: Landscape, Gender, and Far Western North American Rock-art.” In *The Archaeology of Rock Art*, edited by C. Chippendale and P. S. C. Taçon, 11–29. Cambridge: Cambridge University Press.
Wilcox, M. 2009. “Marketing Conquest and the Vanishing Indian: An Indigenous Response to Jared Diamond’s Archaeology of the American Southwest.” In *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*, edited by P. A. McAnany and N. Yoffee, 113–141. Cambridge: Cambridge University Press.
Willey, G. R. 1980. “Toward a Holistic View of Ancient Maya Civilization.” *Man* 15: 249–266.
Wyatt, A. R. 2008. “Gardens on Hills: Ancient Maya Terracing and Agricultural Production at Chan, Belize.” Unpublished PhD diss., University of Illinois at Chicago.
Wyatt, A. R. 2014. “The Scale and Organization of Ancient Maya Water Management.” *Wiley Interdisciplinary Reviews*: *Water* 1 (5): 449–467. doi:10.1002/wat2.1042.
Zakšek, K., K. Oštir, and Ž. Kokalj. 2011. “Sky-view Factor as a Relief Visualization Technique.” *Remote Sensing* 3 (2): 398–415. doi:10.3390/rs3020398.