1 THE ANCIENT MAYA CITY: ANTHROPOGENIC LANDSCAPES, SETTLEMENT ARCHAEOLOGY, AND CARACOL, BELIZE

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Maya archaeology has seen substantial effort invested in mapping and recording site plans and boundaries. This research has been particularly advanced through the application of LiDAR technology to the ancient Maya landscape, which has more easily permitted the registration of both the topography and the modifications made to the land surface – features only rarely mapped at large-scale by archaeological projects. When combined with over 30 years of archaeological research, LiDAR permits us to determine Caracol's spatial and temporal boundaries and landscape modifications, as well as to demonstrate how the site operated as a city through the use of embedded administrative nodes connected to an extensive solar causeway system. A comparative review of settlement data in the Maya region indicates that the ancient Maya minimally had two kinds of cities. In one form of urbanism, such as at Caracol, sustainable agricultural practices could be carried out within the boundaries of the city; in the other form of Maya urbanism, the settlement was too dense and compact for the practice of sustainable agriculture, meaning that primary agricultural fields must have existed outside the city boundaries. This conclusion significantly advances our understanding of tropical urbanism in antiquity.

Introduction

"To estimate population it is necessary to define the boundaries of sites. This is not an easy matter in parts of the Maya lowlands."

(Rice and Culbert 1990:20)

Among the many issues that have bedeviled Maya archaeologists is whether or not the Maya had true cities. During the last two centuries, scholars have argued various positions, ranging from the ancient Maya being a complex society living in urban environments to them being mere peasants who occasionally used vacant ceremonial centers (Becker 1979; D. Chase et al. 1990; Sanders and Webster 1988; Smith 1989). Because of the subtropical forest that covered most Maya ruins, researchers have had trouble mapping the full extent of ancient Maya settlement, often of necessity sampling settlement distribution on the landscape. The use of LiDAR in support of Maya settlement research has now helped to resolve many of the past questions and issues, fully revealing Maya cities, smaller centers, and the scale and nature of their regional settlements (A. Chase et al. 2010, 2011, 2012, 2014a, 2014b; D. Chase et al. 2011). However, even without LiDAR, the long and extensive history of research in the Maya area is itself sufficient to identify the nature of and variation among ancient Maya cities.

While ancient Maya settlement differs from that found in Europe and the Middle East, it is nevertheless consistent with a form of urban development found in other tropical environments around the world. Tropical urbanism is often characterized by a dispersed settlement pattern that is fully integrated with agriculture – forming a truly "green" city in the sense of modern aspirations. Many of the ancient tropical cities covered large areas of anthropogenically-modified landscape and were also home to large populations. The city of Angkor in Cambodia is believed to have had a population of 750,000 people that covered 1000 sq km at C.E. 900 (Evans et al. 2013); Anuradhapura, Sri Lanka had a population of at least 250,000 people that covered 500 sq km in C.E. 1100 (Lucero et al. 2015). Caracol, Belize was occupied by at least 100,000 people and covered more than 200 sq km of area by C.E. 700 (A. Chase et al. 2011, 2014). However, this form of tropical urbanism – termed "low density agrarian-based urbanism" (Fletcher 2009, 2012) – encompasses a wide range of variability in form, even in the Maya area.

Archaeological settlement work undertaken in the past century demonstrates the range in Maya site plans and residential units across time and geographic location. No single site plan or scale of settlement monolithically defines the ancient Maya. Some sites have defined centers and other do not. The scale and density of settlement at a given site also varies. Not only are cultural, sociopolitical, and environmental factors at work, but as will be noted below, measures of residential settlement

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density may also be used to indicate the existence of varied agricultural strategies among these cities.

Yet, there are some similarities among all Maya sites. One commonality among Maya sites, regardless of scale, is the anthropogenic modification of their landscapes. The public architecture at most Maya centers includes large plazas, elevated temples, stone vaulted buildings (sometimes labeled as palaces), and ballcourts. Many Maya sites also contain formally constructed roads or causeways, but there are at minimum two different kinds of causeway systems: (1) inter-site causeways, and (2) intra-site causeways (A. Chase and D. Chase 2001; Shaw 2008). Inter-site causeways are usually fairly long-distance and serve to join one site to another site (examples include Mirador to Nakbe; Coba to Yaxuna at 101 km; and, Ake to Uki). Intra-site causeways come in several different forms and plans. They can be dendritic, as at Caracol, or quadripartite as at Coba (with two overlaying sytems), Dzibilichaltun, and Ek Balam. They can also serve to link public space to public space internally, as at Tikal, or to link high status residences to public space, as at Labna and Sayil; in other cases, intra-site causeways can link high status residences not only to public space but also to each other, as at Chichen Itza and Chunchucmil.

The long and broad history of excavation of Maya sites also permits us to see the evolution of Maya settlement on the landscape, particularly within the Southern Maya lowlands. Here, the earliest expression of formal monumental architecture is usually represented by the construction of an E Group (A. Chase et al. 2014b:8685), commonly referred to as an "astronomical observatory." To some degree, at least in the Southern lowlands, E Groups and their variants are also correlated with interactions grounded in an early trade route between the Maya interior core and the Caribbean coast (A. Chase and D. Chase 2016). Not all centers with E Groups grew to become cities. But, those centers that did construct E Groups generally retained them as core features of their landscape during later time periods because of the cosmological connotations of this distinct architectural form.

Thus, in the aggregate, certain architectural markers dominate Maya centers and cities over time. For the Middle and Late Preclassic Periods (BC 800 – AD 250) a similar core plan established central monumental architecture, the E Group. For the Late Preclassic and Early Classic Periods (B.C.E. 300 – AD 550) we can infer the ascent of dynastic rule in many Maya centers through the appearance of formal palaces (A. Chase and D. Chase 2006). In the Late Classic (AD 550 – 900) there is a transformation of some sites into major centers accompanied with the ascription of physical space for markets and administration (D. Chase and A. Chase 2014a; A. Chase et al. 2015) as population inter-dependency increases. Finally, Postclassic Period cities are more compact, potentially deriving from an earlier city patterning found in the Northern lowlands (as discussed below).

The Maya City of Caracol, Belize

The combined settlement and excavation work undertaken at Caracol, Belize provides an example of the development of one ancient Maya city. For Caracol, 23 sq km of the site was mapped by traditional means, indicating a vast settlement area that was integrated by a dendritic causeway system (A. Chase and D. Chase 1987, 2001a). In 2009, LiDAR confirmed a much larger settlement area for the site, on the order of 160 sq km of continuous residential units, as well as the northern and southern boundaries for the site (A. Chase et al. 2011). Even more LiDAR obtained in 2013 delimited the eastern boundary of Caracol, increasing the urban size to 200 sq km (A. Chase et al. 2014b). The western boundary of the site has still not been fully defined (Figure 1). What all these data show are a highly integrated city with multiple administrative and market plazas (D. Chase and A. Chase 2014a). The ancient Maya settlement found in the rest of the 2013 landscape surveyed in western Belize by LiDAR (total 2013 survey = 1057 sq km) differs in significant ways; not found elsewhere in this landscape is the broad-scale spatial integration of settlement, agricultural fields, public plazas, and causeways that occurs at Caracol (A. Chase et al. 2014b:8688). Thus, the LiDAR data not only begin to indicate the

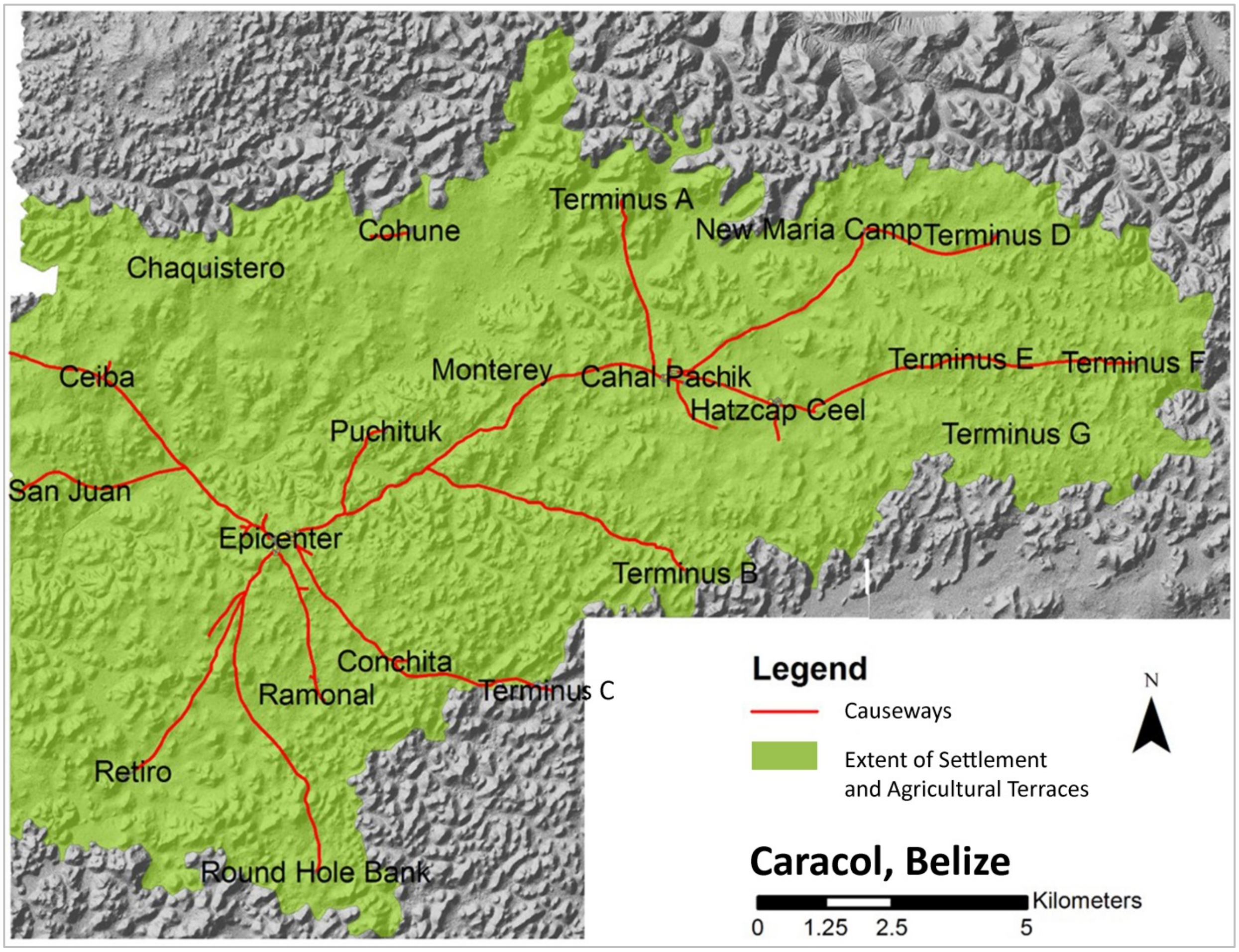

Figure 1. The ancient city of Caracol, Belize showing its causeway system and maximum extent of the urban spread as defined by its termini groups, settlement, and agricultural terraces (courtesy of ASZ Chase).

multiple ways in which the ancient Maya organized space but also suggest that there is still significant regional variability to be encountered and defined.

Long-term archaeological research at Caracol, Belize contextualizes the LiDAR data and demonstrates that the ancient Maya that resided in this part of central Belize were urban and that the arrangement of their settlement on the landscape of the Vaca Plateau does indeed constitute a city. Perhaps the earliest expression of this urban environment were the 12 m wide causeways that connected together three previously distinct centers with E Groups. Even after their incorporation into metropolitan Caracol, the E Groups at Cahal Pichik and Hatzcap Ceel remained unchanged and still comprise the most massive architecture at those locales. However, the E Group in the Caracol epicenter was not only rebuilt but another epicentral plaza (Caana) was constructed to house the royal palace (A. Chase and D. Chase 2001b, 2006). The city was subsequently more fully integrated by a dendritic series of roads that connected the center of the city to a series of formal plazas that functioned as administrative and market locations during the Late Classic Period (C.E. 550-900). These same roadways permitted access to these administrative and market locations by the city's inhabitants and provided a ready form of communication.

Caracol's residential groups were generally composed of a series of structures arranged on the cardinal directions around rectangular plazas with an eastern structure in each plaza reserved for mortuary ritual (A. Chase and D. Chase 1994). However, Caracol's many residential groups were not homogeneous. Rather, there was variation in status, as indicated by both plazuela size and dietary differences. Households produced different items for distribution in markets. Also, in contrast to many contemporary neighborhoods in which status levels are approximately the same (Blanton 2015:4), ancient Caracol neighborhoods housed a population of mixed statuses (A. Chase and D. Chase 2014).

Most households had access to constructed reservoirs within a short distance of their residential group that would have supplied their water. The Caracol Maya also had the ability to gather water off the roofs of their buildings when it rained, probably in large ceramic basins. While it is clear from reservoir distribution that these constructed features were controlled by households (A.S.Z. Chase 2012), in periods of low rainfall, they would have been able to get water from larger reservoirs associated with the dispersed public architectural nodes at Caracol or from the occasional spring or even the rivers, using Caracol's causeway system.

Caracol's urban environment was truly "green." Settlement and agriculture were fully intermixed, something that was probably found at most other Maya cities as well (Isendahl and Smith 2013) – at least within the Southern Maya lowlands (see discussion below). The extensive stone-lined and soil-filled terrace systems at Caracol attest to the investments placed on agricultural production. Households generally had proximate access to some 2.2 hectares of land that could be used for gardens and crops, meaning that these residential groups were likely self-sustaining (for similar comparative figures see Lemonnier and Vanniere 2013). At least for Caracol, subsistence activities on the agricultural terracing adjacent to households also dictated the spacing of residential settlement, effectively implementing a "building code" where households were generally 100-150 m apart (D. Chase and A. Chase 2014b). Besides ensuring the agricultural sustainability of the site's residential groups (e.g. Drennan 1988), this less concentrated spacing would have also helped ensure healthier urban residents (e.g., Netting 1977; Storey 1992). However, while able to produce needed agricultural products, these same households did not create all the goods and services that were needed to survive; rather, there was interdependency among households at the site (A Chase and D. Chase 2015).

Beyond basic subsistence and water, most of Caracol's residents were dependent on the goods and services that were produced by other households and that were available at the public market areas located within the cityscape (A. Chase et al. 2015). As the managed landscape both expanded in size and was infilled with residential groups and agricultural fields (D. Chase and A. Chase 2014b), this public infrastructure was crucial to supplying pottery, lithics, ritual materials, foreign food items, and presumably a series of crafts to the bulk of Caracol's population. Each household appears to have specialized in the manufacture of specific craft items that served as that household's form of currency for participation within the market system (A. Chase and D. Chase 2015). By the Late Classic Period, markets were clearly key to the functioning of many Maya cities and polities – and the infrastructure dependency that markets fostered is one of the hallmarks of urbanization.

At Caracol, the natural landscape was completely refashioned by the ancient Maya. Where agricultural terraces occur, the land was often cleared to bedrock and then rebuilt (A. Chase and D. Chase 1998). Rock and soil was removed for construction activity; quarries were covered with agricultural terraces. A byproduct of this activity was that the ancient Maya were able to moderate and manage water-flow over the landscape (A.S.Z. Chase and Weishampel 2016). They recycled some of their garbage into these terraces and refuse was also recycled into building efforts as structures and plazas were increasingly expanded and elevated. Excavation has shown that the Caracol Maya also practiced urban renewal in which an existing residential group was entirely removed and building started anew, sometimes on a flattened fill platform and sometimes from bedrock.

Broader Settlement Issues

Any understanding of ancient Maya settlement is ultimately tied to determining how past populations were distributed over their landscape. Ancient demographic reconstructions are in turn tied to interpretations of social organization and the relationships of families and family size as reflected on the ground in residential units, cities, and polities. While such considerations are fundamental to building models of past Maya societies, they are fraught with pitfalls to be negotiated. For instance, how many individuals lived in a house? How many houses are there in Maya residential groups? How many houses and residential groups are there in any one site? How big is a given site? How do sites relate to each other in a given region? Were all the remains that are viewable today on the landscape occupied contemporaneously?

As archaeologists, we often extrapolate our interpretations from a limited sample of recorded and excavated data using simple conventional methods to establish plausible population numbers. A long contentious debate has resulted in the general association of 5 people as being resident in each Maya house (see Culbert and Rice 1990). But, this number does not help establish the contemporaneity of houses, nor the number of houses within a given Maya residential unit, nor how many houses or residential units are found at any one site. There remains supposition involved not only in associations of numbers of people per household, but also in what actually defines a household – a structure or a residential group. Because past Maya settlement work of necessity covered only limited samples of any site, it has been extremely difficult to define the size, edges, or boundaries of any site. Intra-site population density has been another problematic factor. Residential density varies within different portions of the same site; and, transect surveys between sites have shown that Maya residential groups are unevenly distributed in areas between centers, but that population is still present (and can be relatively dense). One transect survey done between Tikal and Uaxactun (Puleston 1983) revealed an average "rural" settlement density of 32 structures per sq km; another done between Yaxha and Tikal (Ford 1990) had an average density of 65 structures per sq km (corrected to 110 structures per sq km with removal of bajos). The implications of these numbers will need to be re-considered as our inter-site settlement sample grows.

In spite of past issues, settlement work undertaken in the last 25 years (since the publication of Culbert and Rice in 1990) and LiDAR have begun to provide us with a better understanding of the structure of ancient Maya settlement. First, it is not uniform. Just as there are architectural differences between the Puuc area, the Rio Bec Region, and the Peten of Guatemala, so too are there differences in city structure and household composition across the Maya area. In the past, we focused on household counts in order to make population estimates, but investigations of Maya residential groups have revealed that special purpose structures also comprise any household in numbers larger than was previously thought (e.g, A. Chase and D. Chase 2014). Thus, the residential group itself is probably a better unit for undertaking population estimates at any given site. Unfortunately, this is easier said than done because of issues of scale, mapping, and potential inconsistences in the number of household residents; however, LiDAR should make it possible to provide more systematic counts of these units.

Maya cultural and political affiliations also can be seen in the variations among residential groups that are evident in different portions of the Maya lowlands. For instance, the walled residential groups of Coba (Garduno 1979) and of Chunchucmil (Hutson 2015, Hutson et al. 2008) in the Northern lowlands are indicative of one specific residential tradition focused on dense occupation without major inter-household agriculture that permitted a successful adaptation to a difficult environment. This residential tradition is also seen in Postclassic sites in the Northern lowlands, such as at Mayapan (Hare et al. 2014) and Tulum (Sanders 1960). Other traditions see a more dispersed pattern for residential units that were less focused on plazuela residential groups, such as at Dzibilchaltun, Mexico (Stuart 1979) or on a pattern of agglutinated residential plazas, such as at Copan, Honduras (Fash 2001). Lemonnier and Vanniere (2013) have argued that the Rio Bec region is populated with intermixed residential groups of different statuses that exist outside of any formal urban centers. LiDAR data for Yaxnohcah, Mexico demonstrates a proliferation of residential units that resemble enclosed plaza courtyards with long low rectangular buildings on most sides of the plaza (Reese-Taylor, personal communication 2016). This contrasts with residential groups in the Southern lowlands where distinct mounded buildings are usually centered on the sides of plazas with varied external access points. While Caracol and Tikal share this latter arrangement for their residential plazas, there are distinct differences between the two sites; many of Caracol's residential groups are situated on elevated platforms while those of Tikal are not; only 6% of Tikal's mapped groups have a focus on an eastern shrine building while over 70% of Caracol's groups focus on an eastern shrine (A. Chase and D. Chase 2014). These residential variations are likely useful indicators of cultural and political units.

While Maya cultural and political associations may be reflected in the kinds of residential units that occur at a given site, density figures for Maya sites and settlements also are reflective of their societies. In a note for his 1990 paper, Turner (1990:314-315) suggested that density figures in "rural" areas strongly differed between Tikal and Rio Bec, but the implications of this statement could not be fully contextualized because there were few comparative samples. Since this time, significant work has been undertaken at sites like Caracol (Figure 2) and Chunchucmil (Figure 3), which further demonstrate differences in both density and scale across the Maya lowlands. For Chunchucmil, Dahlin and his colleagues (2005) showed that the population was too dense and the soil too poor for the city to have grown all its necessary food within the immediate region. Thus, while Chunchucmil may have had kitchen gardens within the urban confines, its agricultural fields would have been located outside of its urban area or food stuffs would have needed to be imported into the city (this is similar to what Sanders et al. [1979] describe for Teotihuacan in the Valley of Mexico). However, it appears that Chunchucmil is reflective of general settlement patterns found elsewhere in the Northern lowlands (Table 1). When taken in aggregate for this area, it strongly suggests that agriculture

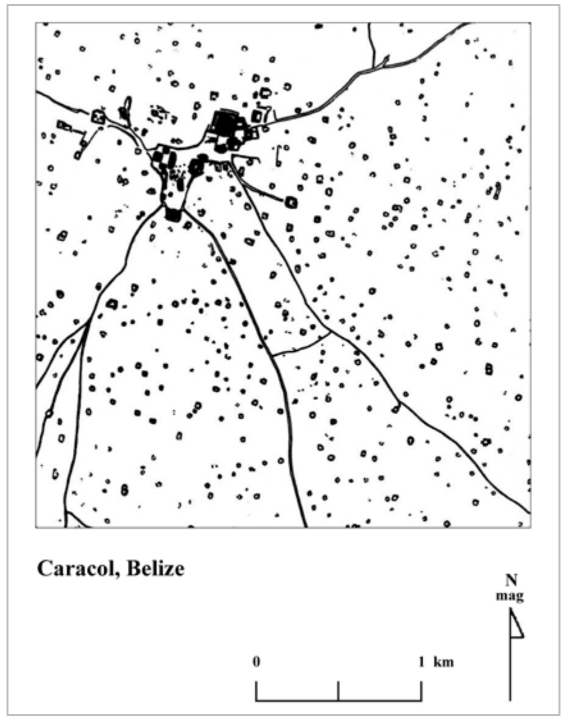

Figure 2. Central 9 sq km of settlement at Caracol, Belize showing the rather evenly spaced distribution of the site's residential groups.

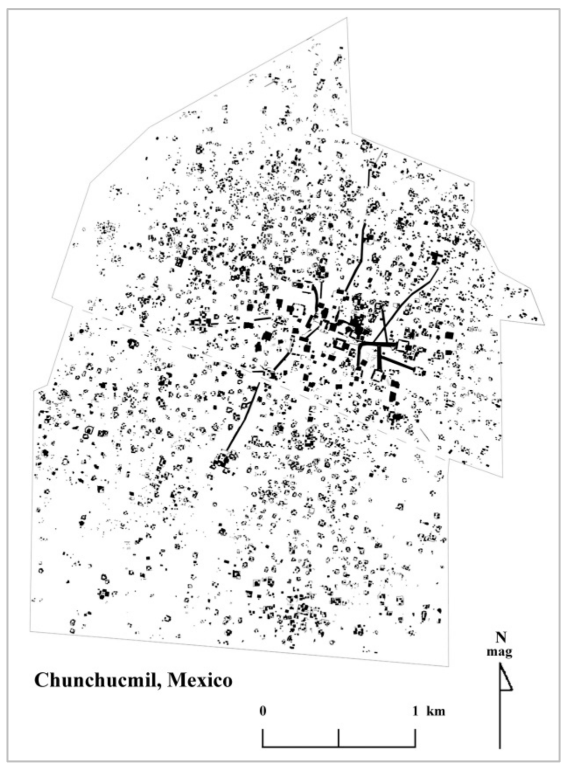

Figure 3. Central 9.4 sq km of settlement at Chunchucmil, Mexico showing a more compact and dense settlement focused on the site's central architecture (after Hutson et al. 2008).

Table 1. Population Estimates of Maya Cities.

Site	Size	Estimated Population	Density per sq km
NORTHERN AND WESTERN LOWLANDS			
Palenque, MX	2.2 sq km	4147-6200 individuals	1,885-2,818 indvs./sq km
Sayil, MX	ca. 5 sq km	10,000 individuals	2,000 indvs./sq km
Dzibilchaltun, MX	19 sq km	23,292 individuals	1,231 indvs./sq km
Chunchucmil, MX	20-25 sq km	40-42,500 individuals	1,700-2,125 indvs./sq km
Coba, MX	80 sq km	50,000 individuals	1400 indvs./sq
Mayapan, MX	4.2 sq km	12,000 individuals	2,857 indvs./sq km
SOUTHERN LOWLANDS			
Tikal, GUAT	120 sq km	62,240 individuals	517 indvs./sq km
Caracol, BZ	200 sq km	100,000 individuals	500 indvs./sq km
Tayasal, GUAT	54 sq km	27,000 individuals	500 indvs./sq km

Site sizes and estimated populations are derived from the following sources: Barnhart 2005; A. Chase 1990; A. Chase et al. 2011, 2014a; Culbert et al. 1990; Folan et al. 1983; Hare et al. 2014; Hudson 2016; Sabloff and Tourtellot 1991; Stuart 1979.

undertaken within the urban confines of most sites in the Northern lowlands was insufficient to sustain these communities. However, the residential density for the Southern lowlands is quite different (see Table 1). Comparisons to contemporary studies of land productivity suggest that the areas immediately adjacent to residential units in cities like Tikal and Caracol could have been sufficient to provide for agricultural sustainability within their urban areas (e.g., Netting 1977; see also Sanders et al. 1979).

Thus, for the broader Maya area, referring to everything as a "low density agrarian city" (Fletcher 2009; Isendahl and Smith 2013) masks significant differences in urban sustainability mechanisms. Most Maya cities can be classified as "green," to use modern terminology (e.g., Campbell 1996; see also Graham 1999), but there appears to have been at least two different kinds of Maya urban development (Figure 4). Colloquially, we can refer to these ancient Maya cities as being either (1) agriculturally non-self-sustainable or (2) agriculturally self-sustainable. Most sustainable Maya cities were located in the Southern lowlands and were more dispersed over their landscapes than their counterparts in the Northern lowlands, which had a much higher settlement density (Table 1). Sustainable cities, like Caracol, could come in different sizes, but could grow to become sprawling "suburban" metropoli with intensive, presumably maintainable, agriculture within their urban limits. Non-sustainable cities, like Chuchucmil or Palenque, were often more compact and denser than the sustainable community cities, taking up less spatial area. While they were also "green" in that they likely had kitchen gardens associated with each residential unit, the overall urban footprint was often smaller and these cities were dependent on extensive agriculture beyond their urban boundaries. One or more

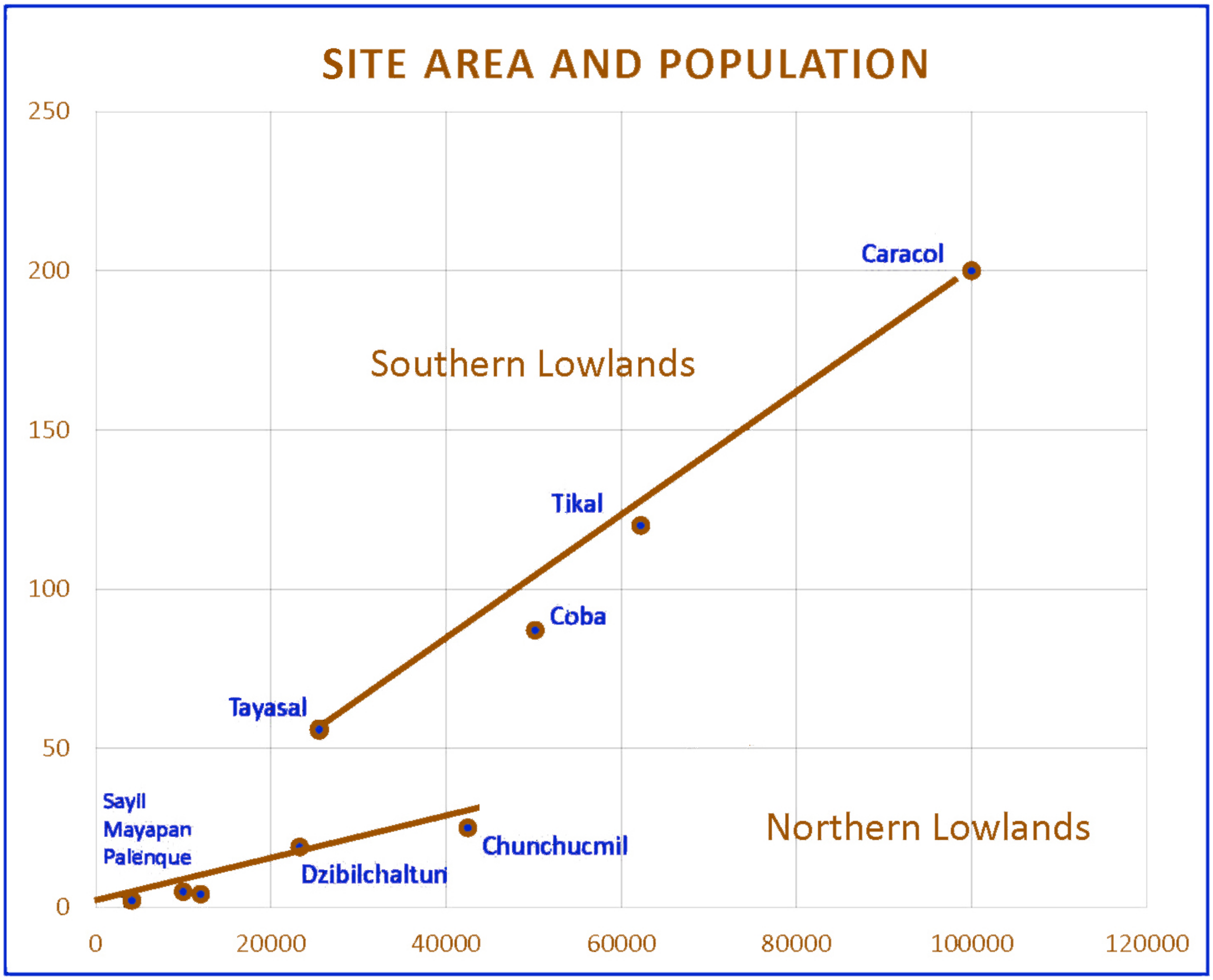

Figure 4. Graph showing a comparison of ancient Maya cities of the Southern Lowlands that could practice sustainable agriculture within their urban boundaries and ancient Maya cities of the Northern Lowlands that could not practice sustainable agriculture within their urban boundaries.

members of each household would have had to have maintained agricultural fields outside of city limits. Of the two kinds of cities, archaeology suggests that Classic Period agriculturally self-sustainable cities of the Southern lowlands have longer stratigraphic and development sequences and may have been more resilient than the agriculturally non-self-sustainable cities of the Northern lowlands, perhaps because of the proximity of food resources. Yet, in an ironic twist, only "transplanted" non-sustainable cities like Mayapan and Santa Rita Corozal (D. Chase and A. Chase 1988) survived or regenerated following the Classic Maya collapse.

Our view of Maya cities has advanced beyond our understanding of 25 years ago and even beyond the relatively recent characterization of them as "low density agrarian cities" (Fletcher 2009, 2012). While we have previously categorized Maya cities in terms of concentric and sector organization (Marcus 1983; Marcus and Sabloff 2008), changes in our understanding of the Maya economy confirm that contemporary urban models – such as Burgess's (1923) "concentric city," Garreau's (1991) "edge city," or Gottmann's (1961) "megalopolis" or "edgeless city" – have applicability to the ancient Maya (A. Chase and D. Chase 2007; A. Chase et al. 2001; D. Chase et al. 1990). Importantly, the variability found in Maya urban centers also moves us beyond comparing a uniform, generalized Maya city to other early low-density cities in Cambodia, Indonesia, and Sri Lanka (e.g., Lucero et al. 2015) that were based on different social principles, agricultural products, and agricultural practices, including an irrigated landscape.

Conclusion

Maya urbanism can generally be referred to as "green" not only because of the subtropical environment in which it existed but also because the residential units within the larger centers generally incorporated either kitchen gardens alone or kitchen gardens and inter-residential group self-sustainable agriculture within the urban confines. Maya urbanism was not monolithic; at a minimum, it came in two different forms and scales. The relationship between Maya urbanism and agriculture during the Classic Period was strongly correlated. For the two basic kinds of Maya cities defined here – agriculturally self-sustainable and agriculturally non-self-sustainable – it is suspected that different developmental paths were followed because of their different relationships between urban settlement and agriculture. Sustainable cities were focused on agricultural self-sufficiency, even to the point of path-dependence (D. Chase and A. Chase 2014b); when they reached their maximum scale, more hierarchical control was necessary to make the whole system work. In contrast, non-sustainable cities presumably required an external focus to agricultural productivity because they could not sustain themselves solely within their urban boundaries; their denser residential clustering and smaller size may have resulted, at least in certain times, in a more heterarchical society. In general, Maya urbanism took on its own distinctive form because of its technology and crops; the New World plants (maize) differed significantly from Old World plants (rice, millet, taro, and yams) and Maya agriculture did not have the same focus on irrigation that occurred in the low-density settlements of Southeast Asia. Thus, Maya cities are generally not as compact or densely occupied as the planned urban cities found in many Old World societies. Nevertheless, there are striking differences in subtropical urbanism, even within the Maya lowlands. These variant urban forms, developed over almost a millennium, constituted successful adaptations to the world's subtropical environments and should be added to the dataset for world urbanism.

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