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Tropical Landscapes and the Ancient Maya: Diversity in Time and Space

Arlen F. Chase
UCF
Lisa J. Lucero
Illinois, Urbana-Champaign
Vernon L. Scarborough
Cincinnati
Diane Z. Chase
UCF
Rafael Cobos
UADY
Nicholas P. Dunning
Cincinnati
Scott L. Fedick
California, Riverside
Vilma Fialko
IDAH
Joel D. Gunn
UNC, Greensboro
Michelle Hegmon
ASU
Gyles Iannone
Trent
David L. Lentz
Cincinnati
Rodrigo Liendo
UNAM
Keith Prufer

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New Mexico
Jeremy A. Sabloff
Santa Fe Institute
Joseph A. Tainter
Utah State
Fred Valdez Jr
Texas, Austin
and
Sander E. van der Leeuw
ASU and Santa Fe Institute

ABSTRACT

Archaeologists have begun to understand that many of the challenges facing our technologically sophisticated, resource dependent, urban systems were also destabilizing factors in ancient complex societies. The focus of IHOPE-Maya is to identify how humans living in the tropical Maya Lowlands in present-day Central America responded to and impacted their environments over the past three millennia, and to relate knowledge of those processes to modern and future coupled human–environment systems. To better frame variability in ancient lowland Maya development and decline, the area that they once occupied may be subdivided into a series of geographical regions in which the collected archaeological data can be correlated with environmental differences. Although beginning as small agricultural communities occupying a variety of ecological niches in the humid tropics of Mesoamerica, the ancient Maya became an increasingly complex set of societies involved in intensive and extensive resource exploitation. Their development process was not linear, but also involved periods of rapid growth that were punctuated by contractions. Thus, the long-term development and disintegration of Maya geopolitical institutions presents an excellent vantage from which to study resilience, vulnerability, and the consequences of decision-making in ancient complex societies. [Maya, archaeology, environment, variability, sustainability]

Various individuals and authors—from politicians to philosophers to historians to scientists—have argued that knowledge of the past is an important key to the future and that, conversely, an ignorance of earlier times and events can result in the unnecessary repetition of historically known failures and problems (Burke 1790; Lipe 1984; Oaklander and Smith 1994; Santayana 1905). Archaeologists often focus narrowly on specific sites and issues, eschewing broader applications. In an attempt to remedy this situation, archaeologists have joined with biologists, geographers, meteorologists, and others under the umbrella organization "IHOPE" (Integrated History and Future of People on Earth). This project calls together a broad range of active researchers to explore human–nature relationships. The intent of these efforts is to integrate knowledge of the past with a dynamic global perspective that can be used to meaningfully address current world problems.

One subgroup of the IHOPE team is focused on exploring the adaptations of the ancient Maya of southeastern Mexico and upper Central America. Despite temporal, technological, and environmental differences, many issues that are of interest to archaeologists reconstructing prehistoric Maya lifeways are also of contemporary concern. These issues include, but are not limited to: sustainability and resilience; the role of political and economic factors in collapse and or the disruption and transformation of social stability; maximum or optimal population levels associated with specific environmental adaptations; the impact of climate change; and the nature of past forms of urbanism and landscape modifications. Thus, IHOPE scholars propose not only to develop an integrated history of the ancient Maya, but also to provide rich data from a precocious, non-modern, non-western culture that will add to our understanding of the dynamics of human–environment inter-relationships. The expected end product is the ability to provide multiple "answers" to understanding processes underlying complex, globally relevant issues.

It is important to note at the outset that there is substantial variation in the archaeological past that most researchers currently lump together and call "Maya." The ancient Maya were not a single uniform or unified civilization; as we shall see, variation is both regional and temporal. Not only did languages differ across the Maya region (Sharer and Traxler 2006:25–28), but so too did governmental structures (Roys 1957) as well as cultural and kinship principles (Fox and Justeson 1986); the variable historical and environmental circumstances that were found throughout the Lowlands further compounded the differences (Dunning et al. 1998). This sometimes occurred even when their communities were only a few kilometers apart (Stanton and Garreta 2001). These ancient, and for that matter modern, differences within the Maya Lowlands—and the explicit recognition of the lack of uniformity in and of itself (e.g., Scarborough et al. 2003)—are important to meeting the IHOPE goals because they offer opportunities to test variable effects of the same global-scale phenomena, such as climate change and radical shifts in economic orientations, on differing local situations.

Although greatly changed by historical circumstances, the present-day Maya still comprise distinct language and ethnic groups. Yucatec Maya of the northern Lowlands speak and dress differently than the Chorti Maya in the far southeast of the southern Lowlands and the Tzotzil Maya in the Chiapas region of the southwestern Lowlands; they are still distinct groups of Maya, but more closely related linguistically than the extremely variant Quiche Maya of the Guatemalan Highlands. Some 31 modern languages are classified as "Mayan," and these 31 languages are separated into four major groups that have substantial antiquity (Campbell and Kaufman 1985). Researchers still disagree as to exactly what language was spoken by the "Classic Maya" who produced the carved stone monuments (stelae and altars) during the Classic and Terminal Classic periods (ca. C.E. 250–900; see Figure 2.1 for Maya time periods) and their accompanying hieroglyphic texts (Houston and Lacadena 2000).

Some argue that the Classic Mayan language found in the hieroglyphs was a prestige language that was distinct from the actual languages that were spoken by local populations across the Lowlands (see Houston et al. 1996); this view portrays the Maya as unified in their cultural expression. Linguists, however, posit at least three different contemporary dialects or languages in the hieroglyphic texts of the Classic period (Wichmann 2006).

By C.E. 800, the Maya region was filled with a number of different kinds of polities, some outward-looking and others inward-looking. The polities ranged in size from expansive regional states—some with desires of forming multi-ethnic, hegemonic empires—to smaller city-states and other more loosely organized "associations" (Chase et al. 2009). While we sometimes refer to this ancient area today as a monolithic "Maya," in reality the groups that comprised these polities not only spoke a variety of different Mayan languages and dialects, but also practiced varied forms of social and political organization, endorsed different religious practices, and evinced a host of other cultural differences. Depending upon proximity and opportunity, many of these diverse groups interacted within a broader Mesoamerican world system that was interconnected and reactive to far-distant shocks and stimuli. Thus, ancient Maya populations followed varied trajectories developmentally and responded differently to climatic and environmental changes, external challenges, and internal stresses.

Some 27 environmental "adaptive regions" have been defined for the Maya Lowlands (Dunning et al. 1998; see also Chapter 1) based on differences in agricultural soils, wet and dry seasons, water supply and quality, and other factors. The southeastern Maya Lowlands are so moist that they support a complex canopy tropical rain forest ranging up to 40 meters in height. Yet, the northwest corner of the peninsula is so dry it approaches desert-like extremes. Although some outliers occur, the northwestern Lowlands appear to have supported less dense human populations than the southeastern Lowlands. Thus, despite the overall diversity, the environmental settings define certain constraints to the structural responses that are possible.

IHOPE researchers have been meeting to assess the differences and similarities in the archaeological, environmental, and climatic records for different parts of the Maya Lowlands. We are attempting to develop a meta-language that permits the integration of disparate groups of data collected over more than one hundred years from dozens of intensively excavated sites. Through the use of the same analytical measurements to compare and communicate archaeological and environmental information, we hope to ferret out an understanding of diverse past processes of adaptation to a varied landscape, thereby gaining insights into how the ancient Maya successfully lived as farmers in the lowlands of present-day Mexico, Guatemala, Belize, and Honduras for millennia. The Maya adapted and survived in the Lowlands for 3000 years; nevertheless, their success was punctuated by periodic disruptions, the most dramatic being the disintegration of their Classic period civilization around C.E. 900 (Demarest et al. 2004). Their history, therefore, holds clues for the successful adaptations of modern societies to rapidly changing conditions.

Examining Maya Landscapes

To provide an integrated Maya history, scholars working in the Maya Lowlands have joined together to compare and contrast diverse data sets from key areas. Ten "zones"

Beginning	End	Period Name	MAJOR EVENTS	Symbol
CE 1958	2000	Post-IGY	International Geophysical Year Earth System observations	IGY
1920	1958	Instrumental observation	Carnegie Institution of Washington research	Inst
1550	1920	Historic	Maya integrated into modern nation states	Hist
1250	1550	Late Postclassic	northern Lowlands heavily occupied	Lpo
1000	1250	Early Postclassic	florescence of eastern Yucatec coastal sites	Epo
900	1000	Terminal Classic 2	florescence of Chichén Itzá in northern Lowlands	T2
800	900	Terminal Classic 1	political collapse in the southern Lowlands	T1
700	800	Late Classic 2	regional polities dominate the Lowlands	L2
550	700	Late Classic 1	florescence of regional centers in southern Lowlands	L1
450	550	Early Classic 3	transition to stratified regional polities	E3
350	450	Early Classic 2	vaulted buildings and Teotihuacan-like elite pottery	E2
250	350	Early Classic 1	widespread appearance of polychrome ceramics	E1
1 BCE/CE	250	Late Preclassic b	changes potentially reflective of a mini-collapse	Plb
-300	1	Late Preclassic a	large vertical monumental constructions	Pla
-800	-300	Middle Preclassic	large horizontal monumental constructions	Pm
-2000	-800	Early Preclassic	first recognizable Maya peoples	Pe
-3500 BCE	-1500	Archaic	Paleo-Indian lithic points	Ar

Figure 2.1. Maya cultural periods.

were designated as the basic building blocks for a comparative database. These archaeological regions are distributed across the Maya Lowlands and represent long-term established research areas from which extensive collected data already exist. While they are not exhaustive of the variability in environments or of the different ethnic groups that were once manifest across this region, they are representative of the diversity in the ancient Maya Lowlands (Figure 2.2).

These zones provide the basis for compiling standardized comparative data sets that address long-term change and transformation within the quarter-million square kilometers identified as the Maya Lowlands. The ancient population for this region is estimated as having been between three and thirteen million people by C.E. 700 (Turner 1990:302); the most recent estimate places at least 4,665,000 people in the Maya area (Storey 2012:910). The archaeological data provide information about how these societies coped with, cared for, and or destroyed both their environment and themselves. It is only in modern times that the Maya are within reach of their ancient population numbers (Leventhal et al. 2012:51). Thus, a comparative examination of these zones provides important clues concerning stability, resilience, and sustainability that have relevance for modern societies.

For each of these ten zones, a controlled dataset can be formulated that focuses on both the biophysical environment and the past cultural landscape. The biophysical setting is characterized in terms of the general availability of water (climate [including seasonality and precipitation patterns], water-table, surface water, natural sinkholes, and or *aguadas* [naturally occurring low areas where water pools]), the richness of resources (biomass availability), and the potential of the terrain for agriculture (soils and topography [including slope and elevation]). A characterization of the ancient environment can also be reconstructed directly from the archaeological record—ranging from ancient flora (including pollen) and faunal remains to highly visible cultural modifications of the landscape related to water retention

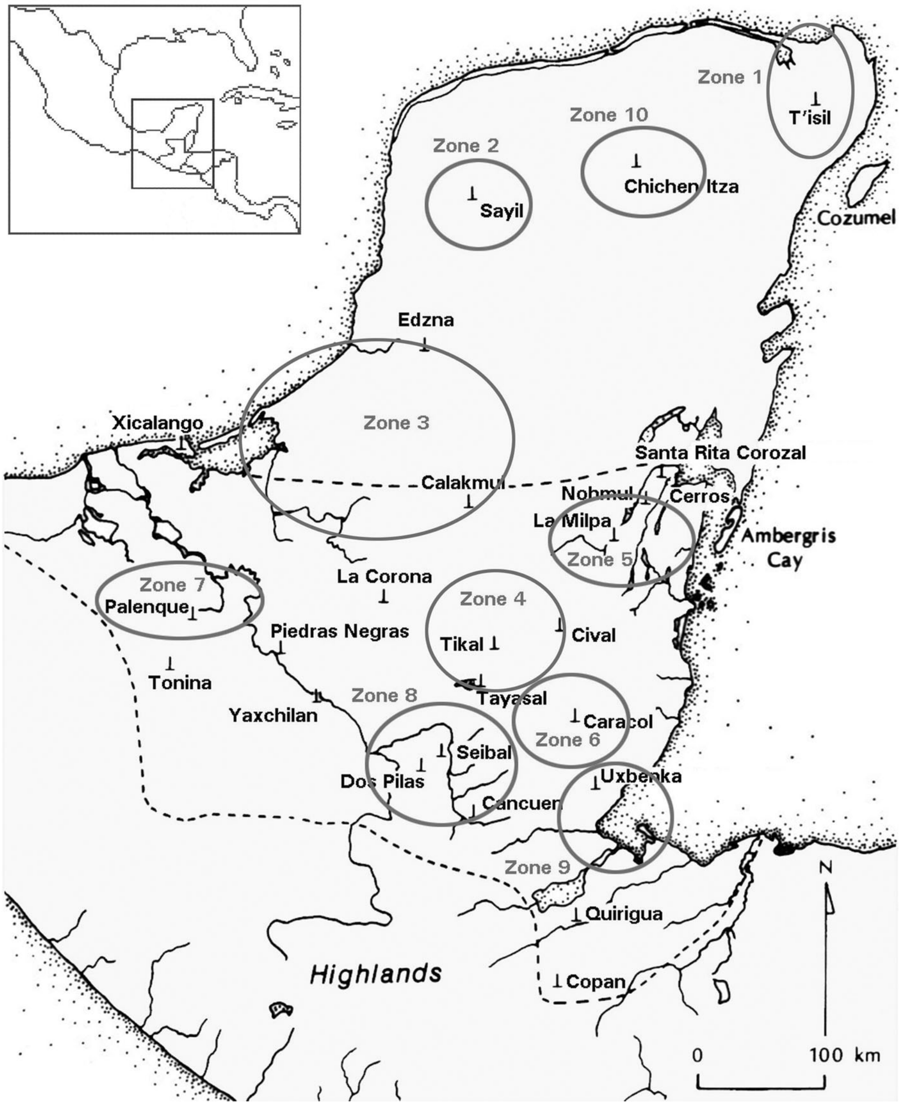

Figure 2.2. Location of lowland Maya zones: (1) T'isil and Yalahau; (2) Sayil and the Puuc; (3) Calakmul and Campeche; (4) Tikal and east-central Petén; (5) La Milpa and northern Belize; (6) Caracol and the Vaca Plateau; (7) Palenque and Sierra de Chiapas foothills; 8) Seibal and the Rio Pasion (9) Uxbenka and the Toledo foothills; (10) Chichén Itzá and Yucatan.

(constructed bedrock chambers [called "chultuns" by Maya researchers], wells, and reservoirs), hydraulic management (canals and dams), and enhanced agricultural production (terraces and raised or drained fields).

The ancient cultural landscape is sometimes more difficult to interpret than the past biophysical environment. In the Maya area, however, settlement density (structures per square kilometer) is quantifiable because of the proclivity of the ancient Maya to build their architectural constructions atop raised stone foundations, meaning that they can be mapped and recorded largely without excavation These same constructions can be subdivided into public spaces (ballcourts, palaces, range buildings, or temples) versus non-public spaces (solitary constructions, residential plaza groups). In some cases, architectural remains of infrastructure (roadways, public plazas, dry storage facilities) can also be identified. An architectural footprint for the landscape can be established for each site that distinguishes between built and non-architectural space. Such metrics permit a different comparative view of settlement density that is not solely based on structure count. Architectural mass and energetics add yet another dimension to this quantification.

Archaeological excavation permits a reconstruction of shifting site layout and development over time by providing needed temporal control for dating the architectural remains. Usually, temporal depth is added to the architectural stratigraphy through the use of contextually controlled ceramic analysis combined with radiocarbon dating and or with the ancient Maya calendar (e.g., A. Chase 1994). While Maya dates in tombs can sometimes be dated to a specific year, ceramics generally provide a chronological precision on the order of 50 to 200 years and radiocarbon dates provide a similar range of accuracy. While ceramic style and form are used in the Maya area to anchor archaeological time and track sequenced developments, pottery and other artifacts (e.g., obsidian, grinding stone, chert, jade, and marine shell) are also utilized to infer broader interactions within the Mesoamerican world system beyond the level of the polity. Skeletal remains provide information about diet, health, migration, social divisions, and adaptive success. Analyses of floral and faunal remains from archaeological sites provide not only the substance for radiocarbon dating, but also evidence for agricultural practices, forest management approaches, and other subsistence activities. Finally, besides sometimes refining the time scale, Maya hieroglyphs provide direct data about past social structures.

While the rich databases available to Maya archaeology are often taken for granted in broader regional syntheses, it is possible to examine different expressions of this civilization by looking at assorted archaeological and ecological zones. While the dry season usually occurs from May through December in most of the Maya region, topography, temperature, elevation, rainfall totals, access to water, and patterns in vegetation diverge across the geographic space occupied by the Maya; their ancient cultural patterns are similarly varied. Thus, diverse environmental zones tend to be associated with different developmental trajectories and spatial signatures.

T'isil and Yalahau (Zone 1)

The Yalahau region of northern Quintana Roo, Mexico, is a distinctive physiographic zone characterized by a system of inland freshwater wetlands. These north-south trending wetlands follow the underlying Holbox fracture zone and represent the exposure of the water table. Archaeological research has found that nearly all of the wetlands contain evidence of ancient engineering features that most likely functioned to control movement of soil and water and to facilitate the cultivation of crops or the management of wetland resources (Fedick and Mathews 2005; Fedick and Morrison 2004; Fedick et al. 2000; Glover 2012). The generally flat terrain surrounding the wetlands averages only about six meters above sea level; the water table is further exposed by numerous natural sinkholes (cenotes). Water can also be easily accessed through the excavation of wells. The freshwater aquifer of the region is perhaps the thickest in the northern Yucatan Peninsula and serves today as the sole source of water for the Cancun-Tulum development area, the fastest growing urban area in Mexico. The location of the Yalahau region in the northeast corner of the Yucatan Peninsula places it in a rainfall anomaly that receives an average of 2000 millimeters of annual rain, often in the context of hurricanes that pass through with great frequency. The region does experience a distinct dry season, usually between March and May, when rain rarely falls. Vegetation in the wetlands includes a range of aquatic plants (e.g., sedges and cattails) and swamp forest; uplands are characterized by medium-canopy deciduous tropical forest. The earliest occupation in the region is represented by a very scant occurrence of Middle Preclassic ceramics that date between 700 and 400 B.C.E. The region appears to have experienced rapid population growth during the Late Preclassic into the Early Classic, from 100 B.C.E. to about C.E. 350 or 450. The region has relatively little in the way of monumental architecture, although many larger sites (such as Kantunilkin and Naranjal) do include platforms reaching up to 50 meters on a side coupled with pyramids of 5 to 14 meters in height. The well-documented site of T'isil attained a settlement density of 731 structures per square kilometer (Fedick and Mathews 2005:39), unusually high for an ancient Maya community. After achieving a relatively high level of regional population, there seems to have been a dramatic depopulation, leaving only traces of occupation throughout the Late Classic into the Postclassic, with the exception of a Terminal Classic or Early Postclassic presence centered on the northern coastal site of Vista Alegre. Beginning in the Late Postclassic, around C.E. 1250, there was an influx of people into the region that focused on reoccupying previously abandoned sites. While not achieving the population levels of the Late Preclassic, the Postclassic occupation appears to have continued to the time of initial Spanish contact, after which the population declined rapidly. The region is still sparsely occupied today.

Sayil and the Puuc (Zone 2)

The Terminal Classic city of Sayil is located in the Puuc region of western Yucatan state (Sabloff and Tourtellot 1991, 1994). The Puuc region is the only significantly hilly area in the northern Lowlands and is the home of such major archaeological sites as Uxmal, Kabah, Labna, Kiuic, and Oxkintok (Pollock 1980). While the basal area is approximately 25 meters above sea level, the relatively low hills

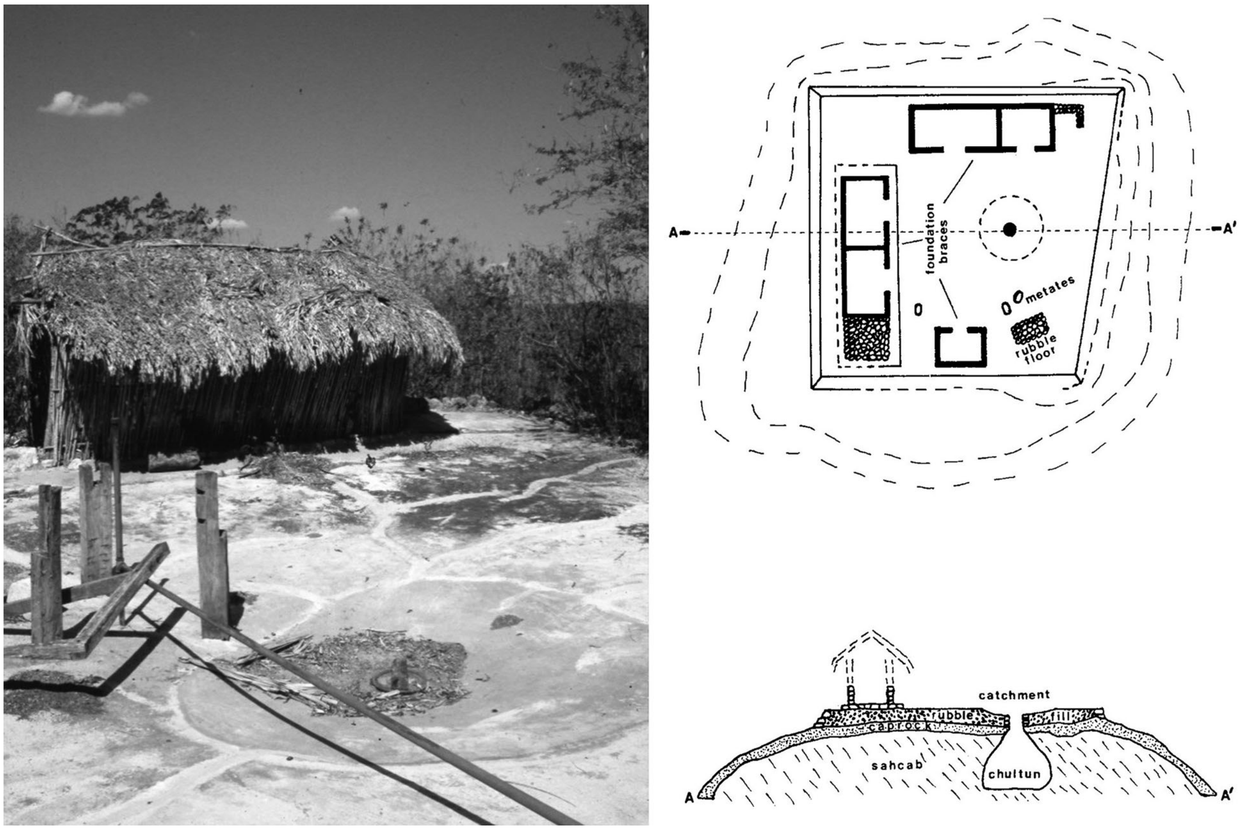

Figure 2.3. Water storage chultun from the Puuc region (Zone 2) of the northern Lowlands, showing the use of a paved plaza area for water collection.

rise an additional 40 to 100 meters in height. The region also has a deep water table and lacks readily available water with no rivers, lakes, or cenotes. Thus, the inhabitants of Sayil, in particular, and the region, in general, constructed numerous bedrock water cisterns (*chultuns*) to capture rainwater during the rainy season in order to provide potable water during the spring dry season (Figure 2.3). The extreme effort needed to secure water in the Puuc region may have fortuitously adapted its inhabitants to withstand the onset of coming drier conditions (Carmean et al. 2004). There is evidence at Sayil that open spaces around houses in the urban core were used for gardens and that zones beyond the first row of hills around the Sayil Valley were used for the cultivation of maize and other crops (Smyth and Dore 1992).

Surprisingly, there is only limited evidence for terracing and other intensive agricultural features in the Puuc region. The principal florescence of Puuc region cultural development was from the middle of the 8th century to the early 10th century C.E., although there is some variation from site to site. In recent years, new evidence has emerged for important earlier development going back as far as the Preclassic period. During the Terminal Classic florescence, the Puuc region reached its maximum Precolumbian population with both city and village size increasing and with population expansion into areas between previously occupied sites (Dunning and Kowalski 1994). Sizable cities like Kabah, Sayil, and Labna were located within 5 to 7 kilometers of each other. This also was the time that the heights in monumental architecture and art—for which the region is most notably famous—reached their apogee (Pollock 1980). Postclassic period occupation is found scattered throughout the zone and there is a sizeable modern population in this part of Mexico.

Calakmul and Campeche (Zone 3)

Located on the western slopes of the Yucatan Peninsula between 0 and 400 meters above sea level, the Campeche Zone consists of a series of north-south trending hill systems and valleys that step upward from the coast to the central spine of the peninsula. The topography is karstic and there are no standing lakes in the interior valleys. However, the coastal plain in the middle reaches of the Candelaria and Champoton Rivers are broad swamps. The

Edzna Valley is the most northerly clay basin (Matheny 1983). Running water is present toward the coast in the Candelaria and Champoton River basins. Rainfall ranges between 1300 millimeters of rain per year in the south to 700 millimeters in the north. Monthly average temperatures in the modern city of Campeche vary from 17˚C in January to 33˚C in late May or early June. Approximately 25 meters-high forest covers most of the region, excepting those areas where modern agriculture has been developed, such as the Edzna Valley. In antiquity, a major component of the population concentrated in the interior Calakmul Basin with the ancient city of Calakmul being one of the larger capitals among the many Maya polities of the Classic period (Folan 1992; Carrasco 1996). Earliest settlement in the region dates to approximately 600 B.C.E. By C.E. 700, over 50,000 Maya occupied the urban center of Calakmul (Folan et al. 1995; calculated as 55% occupation of over 6000 structures mapped). Calakmul is thought to have been composed originally of many small barrios located around natural water holes (called "aguadas" in the Maya area) in the gullies that cross the city and run into swamps (called "bajos" in the Maya area) to the north and west. A focal plaza was eventually constructed near El Laberinto Bajo at the southern edge of the city. This plaza is surrounded by many formal structures, including the imposing Structure II, which at 55 meters in elevation is one of the largest human-made structures in the Maya Lowlands (Folan 1992). The scale of the administrative structure of the city is reflected in the size of these buildings. Most agriculture is thought to have taken place on slumped sediments around the edge of the bajos and in upland *milpas*—rain-dependent tropical gardens adapted to rough, rocky terrain. Hot burns during the milpa cycle restored vital trace elements to the soils, probably explaining much of the 1500-year longevity of the city. At the very beginning of the 9th century, environmental instability appears to have precipitated abandonment of Calakmul, followed by a reoccupation of the center by a smaller population from the north. By the end of the 9th century the city was abandoned except for pilgrimage visitors who left *ocarinas* and *incensarios* on the steps of the city's architectural complexes (see Braswell et al. 2004).

Tikal and East-Central Peten (Zone 4)

This limestone region is characterized by a chain of interior land-locked lakes as well as rivers that run east-west, ultimately emptying into the Caribbean Sea to the east. Ancient settlement is located on the shores of Lakes Yaxha and Petén-Itzá (Figure 2.4a) and along the banks of the Rivers Holmul and Ixcanrio. The hydrology of the zone is also characterized by the presence of a system of stationary *bajos*, or seasonal wetlands, that fill with water in the rainy season, making seasonal canoe transport possible over great distances. The vegetation of the upland areas in this zone is largely tropical deciduous forest dominated by broadleaf trees with a canopy height as high as 40 meters. The climate in the area is generally hot with a maximum temperature of 39˚C and an average temperature of 30˚C. The humidity in the region averages 78% and often reaches 100%. The average annual precipitation is 1800 millimeters, distributed over approximately 180 days of the year. The highest point in the east-central Peten is 300 meters above sea level.

More than 300 Maya sites occur within the zone, including the major centers of Tikal, Yaxha, Nakum, Naranjo, Xultun, Holmul, Rio Azul, and Uaxactun. Tikal is probably the best documented site archaeologically, having been excavated for almost 50 years (Coe 1990; Coe and Haviland 1982; Laporte and Fialko 1995; Sabloff 2003). Like other major centers in the zone, Tikal exhibits large-scale architecture in the form of temples and palaces (Figure 2.5) and has a rich history contained within its hieroglyphic texts that document ancient political inter-relationships with other areas (Martin and Grube 2000). Intermediate-level sites within this zone also exhibit urban development and impressive architecture (see Puleston 1983). Smaller centers occur at the peripheries of the major and intermediate centers and represent aggregated residential settlement where specialized activities were practiced (Fry 2003). Many major and intermediate centers of this zone present archaeological evidence for continuous occupation from the Preclassic through Late Classic periods; however, many smaller centers only appear to have been occupied during the Late Classic period.

La Milpa and Northern Belize (Zone 5)

Extending from the Three Rivers Region of northwest Belize, down the escarpment(s) and across a broad plain to Lamanai, this zone continues east to the Belize coast. The region ranges from sea level to approximately 240 meters above sea level. The area is underlain by a limestone shelf that displays significant topographic variation along its western border, as demonstrated by a series of karst terraces. The Rio Azul becomes the Blue Creek and, when joined by the Rio Bravo, is then the Rio Hondo. The New River flows from the Hill Bank area and passes Lamanai on its course to Chetumal Bay. Numerous smaller drainages feed the larger flowing streams and water holes of the zone. Both on the western escarpments and in the lower zones close to the coast are many bajos, aguadas, and swamps that are often fed by the many smaller drainages. The forest canopy ranges

a b c d

Figure 2.4. Water was crucial for the survival of the ancient Maya in the tropics and it came in many forms: (a.) Lake Péten-Itza in northern Guatemala (Zone 4); (b.) a constructed reservoir at Caracol (Zone 6); (c.) natural waterfalls near Palenque (Zone 7); (d.) the Cenote Sagrado, a limestone sinkhole, at Chichén Itzá (Zone 10).

to a height of 25 meters in a large portion of the western part of the zone and in segmented patches across the lower plain. Rainfall is typical of the Maya Lowlands with a rainy season from June through January and a dry season from February through May. The amount of rain across the zone is approximately 1500 millimeters per year with some slightly wetter areas in the west. Human activity in the region began in Paleo-Indian times and continued through the Archaic, as evidenced by lithic artifacts in both the western and coastal areas (Lohse 2010). Archaic occupation occurs near Colha, where some evidence of deforestation and cultigens appear by 3400 B.C.E. Maya occupation is continuous from about 800 B.C.E. through the Postclassic (C.E. 900–1532) and into the Historic period (Shafer and Hester 1991). Throughout the region there is evidence of significant Maya occupation, as represented by numerous hamlets, villages, and cities, including: Lamanai, La Milpa, Dos Hombres, Chan Chich, Rio Azul, and Kinal (Scarborough et al. 2003). Agricultural methods are documented by the physical remains of channelized fields and terraces that are found across the zone (Lauzader-Beach et al. 2012). Water management features are also a significant component of Maya activity in the

Figure 2.5. View of the ruins of Tikal (Zone 4) showing remains of vaulted buildings within the covering tropical forest.

region. Most sites appear to have been rapidly abandoned between C.E. 800 and 900, as was the case in most other regions, but the circumstances of the abandonment remain obscure. One significant exception to any collapse scenario is Lamanai, which continues directly into the Postclassic and also into the Historic era without interruption (Pendergast 1986). As at Lamanai, archaeological data also show that Santa Rita Corozal extended into the Historic period (Chase and Chase 1988).

Caracol and the Vaca Plateau (Zone 6)

Located between 450 and 600 meters above sea level, the Vaca Plateau is a level plain located amidst the karst topography of west-central Belize. Even though the Macal River borders the area to the west and the Chiquibul River borders the area to the east, no running water can be found in the uplands. This part of Belize receives between 2000 and 2400 millimeters of rain per year with temperatures varying from 6˚C to 39˚C, sometimes within the same 24 hour period. Today, subtropic moist rainforest canopy averages approximately 25 meters in height and covers the entire region. In antiquity, the entire Vaca Plateau and the karst topography south of it was densely occupied by the ancient Maya. Earliest settlement in the region dates to approximately 600 B.C.E. By C.E. 650, approximately 100,000 Maya had integrated a 200 square kilometer area into the single urban center of Caracol (Chase and Chase 2007; Chase et al. 2011). Caracol is characterized by thousands of residential groups set among constructed agricultural terraces with an embedded road system that dendritically linked public architecture throughout the region. To store water in this region, the ancient inhabitants constructed hundreds of reservoirs (Figure 2.4b), most loosely attached to mundane residential groups. Extensive systems of terraces covered most of the hills and valleys within Caracol and these constructed features served to manage the landscape hydrology and retain water for crops (Figure 2.6; see also Chase and Chase 1998). These agricultural fields were developed and used over approximately 600 years. At the very beginning of the tenth century C.E., however, the entire region appears to have been abandoned. Today, the Belizean part of the zone is unoccupied while the adjacent parts of Guatemala are being rapidly settled.

Palenque and Sierra de Chiapas Foothills (Zone 7)

The upper Usumacinta River area encompasses three environmentally diverse geological systems that run from approximately 25 to 150 meters above sea level. From north to south these are the Pleistocene fluvial terraces, the Intermediate Plains, and the Tertiary formations of the Sierra de Chiapas. The Intermediate Plains are generally not suited for agriculture because of shallow soils and poor drainage.

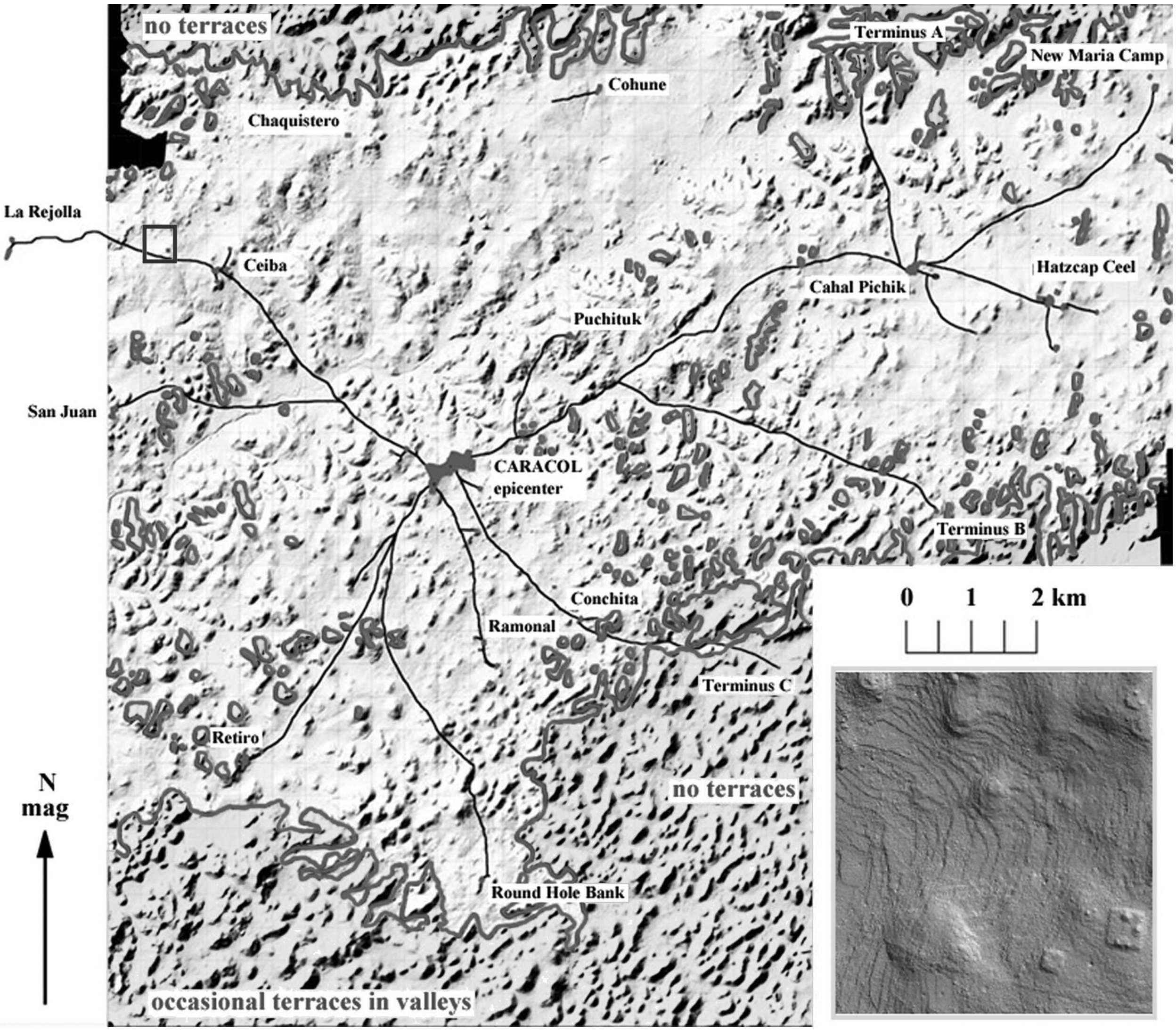

Figure 2.6. *LiDAR Digital Elevation Model of Caracol, Belize (Zone 6) showing location of causeways, major architectural groups, and agricultural terracing (after Chase et al. 2011). Most of the site is terraced (see inset LiDAR image and its location on DEM) and represents an anthropogenic landscape. Settlement is continuous throughout this area and represents a Maya low-density urban adaptation that was successful for approximately 500 years.*

In contrast, the comparatively high settlement densities for the ancient Maya found in the Tertiary foothills demonstrate the importance of this zone during Precolumbian times; the vast majority of ancient sites are located along the first escarpments of the Sierra de Chiapas. Several factors account for the presence of population concentrations: transportation along the base and through the valleys of the Chiapas foothills; rich non-agricultural resources; and a varied ecosystem. Site variability in terms of settlement characteristics or density might be due to differences in subsistence adaptations to the contrasting landscapes present within the Usumacinta drainage; however, other aspects of settlement variation (location of civic ceremonial centers, settlement layout) might be the result of historical and social circumstances tied to the development of social inequalities and hierarchical organizations associated with the rise of political complexity in the region. Some of these historical processes indicate that important changes occurred in the region with the rise of particular places—Palenque (Figure 2.7), Pomoná, Chinikihá, El Arenal, and Reforma-Moral—as centers of paramount political power.

The Middle Preclassic (800–300 B.C.E.) seems to have been a moment of noticeable population growth in the Middle Usumacinta area. The sites at Tierra Blanca, Tiradero, and Povicuc—located on rich Usumacinta River alluvial soils and adjacent bluffs—functioned as central points for

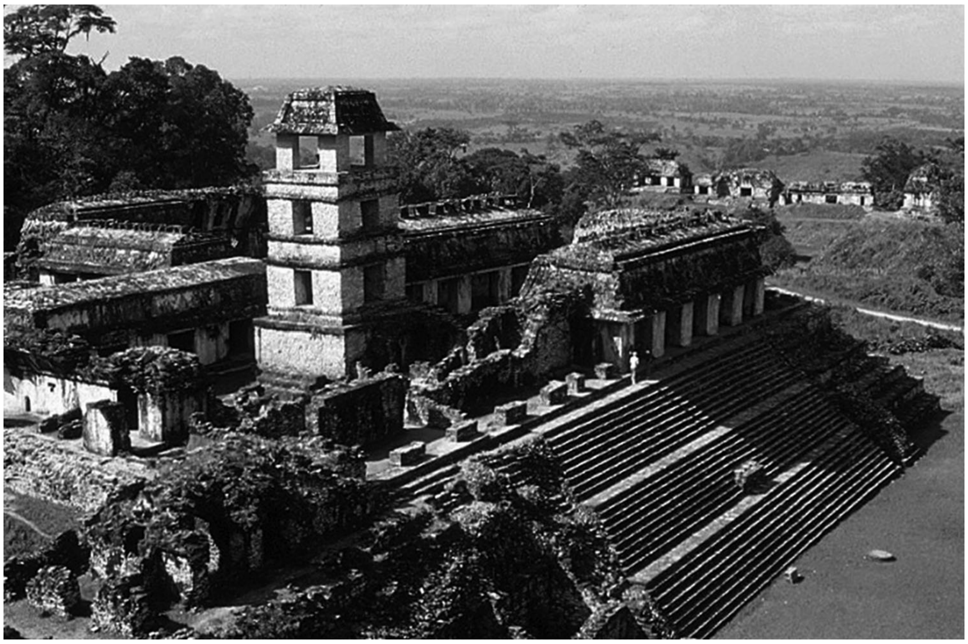

Figure 2.7. Palenque is located in the foothills of the Sierra de Chiapas overlooking the vast Tabasco Plain (Zone 7).

a series of smaller mounds located on either margin of the river. The dispersed settlement pattern along rivers during the Late Preclassic (300 B.C.E.–C.E. 250) and Early Classic periods (C.E. 250–550) has been explained as the logical result of an early agricultural population seeking the most favorable lands along river levees (Liendo 2008). Populations were low during the Early Classic, a fact that suggests little competition for resources; and, it appears that there was a population decline along the middle Usumacinta during this era. However, the end of the Early Classic marks a change in the trends described for earlier periods with population nucleation taking place along the Tertiary foothills of the Sierra de Chiapas, as represented by the development of new settlements at Chinikihá, Chancalá, Yoxihá, and Palenque. Research in Palenque and, more recently, in the Chinikiha region indicates that the Late Classic period (especially during the 8th and the first half of the 9th centuries) was a time of great development and innovation for this zone (Liendo 2005).

Seibal and the Rio Pasion (Zone 8)

Sandwiched between upland regions to the east, west, and south, the area comprising the south-central portion of the Maya Lowlands is characterized by a limestone and shale landscape that rises approximately 100 to 150 meters above sea level. The numerous streams and lagoons in this zone provided permanent water sources; these perennial water courses also facilitated transport and communication. Rainfall in this zone is slightly less than that found to the east and west in areas of higher elevation. As in other zones, the upland soils are agriculturally productive. While alluvial soils are plentiful within this zone and would have been productive had they been well drained, the many kilometers of natural river levees and floodplains are actually low-lying, marshy, and seasonally inundated. Thus, these swamplands are too waterlogged or leached to have been agriculturally productive without human management, for which there is currently no evidence. A series of Maya sites are known from the Pasion region, including Altar de Sacrificios (Willey 1973) and Seibal (Willey 1982; Tourtellot 1988). Settlement of the Rio Pasion zone occurred in the early part of the Preclassic period (ca. 900 B.C.E.) and continued through the 10th century C.E. Recent information from Dos Pilas, Aguateca, Cancuen, and smaller Guatemalan sites east of Yaxchilan, Mexico indicate a complex and contentious political history for this zone during the Late Classic period (Demarest 2013; Golden et al. 2011). Later Postclassic occupation is rare in this zone, which is only sparsely occupied today.

Uxbenka and the Toledo Foothills (Zone 9)

Ranging from sea level to almost 700 meters in elevation, the southern Belize zone stretches from the coastal plain to the eastern flank of the Maya Mountains, the largest relief feature in the Maya Lowlands. The majority of archaeological communities in the region—Uxbenka, Lubaantun, Pusilha, and Nimli Punit—are found in the Toledo Uplands and the Bladen, Columbia, and Deep River valleys in the eastern slope of the Maya Mountains. The Toledo Uplands are characterized by extremely fertile soils derived partly from weathered mud, sand, and silt-stone. The region is circumscribed geographically and difficult to access: to the north it is bounded by inhospitable pine-barrens; to the west, by the formidable Maya Mountains; to the south, by the swampy Temash and Sarstoon River basins; and to the east, by the Caribbean Sea. Annual precipitation can exceed 5000 millimeters. Today, much of the region is populated by Mopan and Q'eqchi' subsistence farmers, though the mountainous areas remain unoccupied since the 10th century C.E. The earliest human presence dates to the late Paleoindian period, with the first sedentary communities likely emerging between 1500 and 800 B.C.E. Despite highly productive soils and abundant rainfall, polities of the Classic period are diminutive compared to neighboring regions (Leventhal 1990). A range of biotic and mineral resources not found elsewhere in the Maya Lowlands may have fueled regional economic growth in the Late Classic, when no fewer than 12 monument-bearing polities dotted the landscape (Braswell and Prufer 2009). By the 10th century the region was in decline and there is little evidence of reoccupation before the 15th century.

Chichén Itzá and Yucatan (Zone 10)

The karstic plain of the northern-central portion of the Yucatán Peninsula has an average elevation of 25 meters above sea level that corresponds with the Eocene-derived Pisté Formation in which Chichén Itzá is located. Natural features of the Pisté Formation include cenotes, dry depressions, and fertile soils. At Chichén Itzá, the principal architectural groups of the settlement are located close to these natural features and next to limestone quarries. Their construction was due in large part to the easy access to potable water, areas with excellent soils for agricultural practices, and quarries to procure construction materials. Two great cenotes, Sagrado (Figure 2.4d) and Xtoloc, are located in the center of Chichén Itzá; around these water sources are many massive constructions with vaulted buildings and elaborate architecture. The Great Terrace (Figure 2.8), the Monjas Complex, the Initial Series Group, and the Groups of the Three and Four Lintels are distributed among various dry depressions of great size, which are located either to the east or west of these architectural groups.

The spatial distribution of the physiographic elements that dominate Chichén Itzá's landscape played a key role in determining the construction and internal arrangement of this ancient city (Ruppert 1952). The area in which the site developed was sparsely settled by 300 B.C.E. During subsequent phases of occupation, the settlement developed at Chichén Itzá by combining green areas with monumental architecture made of masonry and vaults, domestic and residential structures, monumental art, and internal causeways. Between C.E. 800 and 1000, Chichén Itzá was a dominant center in Mesoamerica (Cobos 2004). In the later Postclassic period the site served as a destination for religious pilgrimage. Sizeable other ancient centers, such as Yaxuna, exist a short distance from Chichén Itzá and modern communities overlay many other ancient Maya sites in the general vicinity.

Discussion and Summary

Even a cursory review of the selected zones demonstrates the diversity and variability in and among Maya Lowland environments and adaptations. There were marked differences with regard to water availability, with each area investing in slightly different approaches and innovations (Lucero 2006). For example, during an acute drought in the early 9th century, the Maya of the Puuc Hills (Zone 2) appear to have increased their population levels by constructing sizable household water collection systems using chultuns. Evidence from neighboring western Yucatan (Zone 3), however, indicates that this same drought coincided with a loss of population (Gunn and Folan 2000). In contrast, northeastern Yucatan (Zone 1) was more influenced by fluctuations in its water table due to changes in sea level (Fedick and Morrison 2004).

Similarities are evident across all zones. For the most part ancient Maya settlement is characterized by low-density urbanism. This appears to be an important organizational principle for an area with high ecological diversity and low individual species density (Scarborough and Burnside 2010). Such low-density agrarian urbanism (Fletcher 2009) provided a successful adaptation to hot and humid environments with a mosaic pattern of fertile soils, an inconsistent water supply, and the likelihood of rapid disease vector growth. At large centers like Caracol (Zone 6), the anthropogenic landscape contains dispersed residential units situated amidst terraces and reservoirs, all linked by an extensive causeway system (Chase and Chase 1996, 2007). The Maya also created garden space within and between rural communities (Fialko 2004; Scarborough et al. 2003).

Figure 2.8. The western side of the Castillo at Chichén Itzá (Zone 10), a construction dating to the Terminal Classic period, showing 2009 excavations into the Great Terrace.

During the Late Classic, the pollen record indicates that major tree species were depleted. This has been interpreted to mean that native tropical vegetation sustained growing populations and was sacrificed to construct built environments (Lentz and Hockaday 2009; Ford and Nigh 2009). That both hardwoods and softwood species were declining in unison in the Late Classic could suggest a stressed overall interior environment. Notwithstanding the decline in the interior forests, however, there is widespread evidence that the ancient Maya were skilled at the practice of arboriculture (Lentz 1999) and, at least to some degree, replaced "natural" forests with orchards of domesticated trees with high economic value. By standardizing the data sets within each of the ten zones and facilitating communication among the researchers working in these areas, a significantly improved understanding of ancient Maya societies is assured. Identification of types and degrees of resilience, stability, rigidity (integration, hierarchy, conformity), and pan-regional interaction within the ancient Maya context is overdue. Such considerations will not only elucidate temporal and spatial variation within the Maya Lowlands, but also permit the ancient Maya to be more directly compared to the developmental trajectories of other civilizations.

In spite of over a hundred years of rich and well-reported archaeological data and complementary natural scientific research in the Maya area, until recently, we have thought of the Maya as a monolithic culture and have not focused on the social and landscape differences within this region, which surely had an impact on past adaptations and management strategies. By considering the constituent units of the ancient Maya, both the cultural and environmental variability become evident; comparing and contrasting these microcosms also serves to highlight aspects that may have been responsible for different developmental trajectories.

At several points in their long history, the Maya reached a precarious imbalance with their environments that proved unsustainable; when exactly this occurred differs throughout the Maya area. For some Maya groups, this imbalance was reached in the Late Preclassic period. For others, it occurred at the end of the 9th century C.E. The causes of any "collapse" varied spatially and temporally throughout the Maya region and likely included political mismanagement, warfare, and shifting economic opportunities—as well as environmental issues (Kennett et al. 2012; Turner and Sabloff 2012). However, by the end of the Late Classic period, food production had been repeatedly intensified in many parts of the Maya region to support ever larger populations. Refuse was carefully managed and recycled into building projects. Arable lands were manufactured from residual soils. Supplies and resources were imported from distant places and administratively marketed to populations. Governance systems employed a variety of techniques to control and manage populations. The situation was not unlike that of today in which population pressure places great demands upon the underlying ecology to support the infrastructure of society. To some extent, the globalization models that are used to describe variability within today's world are just as pertinent for the past Maya world.

The environments and the social systems in the ancient Maya Lowlands constituted a highly complex and nuanced set of relationships and interdependencies that operated at many scales. The ancient Maya landscapes resulted from a series of past decisions that placed many of their societies on trajectories that eventually became unsustainable. By examining the ecological and climatic variability that exists in this region in relation to the various cultural responses that are evident in the archaeological record, it becomes possible to use these long-term temporal data to inform modern policy debates. To understand the kinds and degrees of change in this ancient society, commonly held blanket statements about the effects of climate change, human-induced degradation, human-induced ecological enhancement, causation, and fundamental dating concerns—as well as geographical and temporal scaling—must be reassessed. By employing both quantitative and qualitative measures of variable dependency and interdependency based on our working methodology, we hope to contribute to broader worldwide comparative goals. The enterprise is timely and should serve as a model for subsequent research both for the immediacy of the tropical Maya Lowlands and for other research and planning efforts elsewhere in the world.

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