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A Tale of Three Cities

Effects of the AD 536 Event in the Lowland Maya Heartland

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> It was the best of times, it was the
> worst of times . . .
>
> —Charles Dickens,
> *A Tale of Two Cities*

Directly linking climate change and cultural change is difficult. However, it is occasionally possible to link extraordinary climatic events to the archaeological record. The AD 536 event is such an instance. Given its global reach, impact from the AD 536 event had to have been felt in the Maya area. The archaeological records of three of the most important Maya cities that have been excavated—Calakmul, Caracol, Tikal—may be used to examine this impact. Although the developmental trajectories of all three significantly changed in the mid-sixth century, their paths reveal the pursuit of divergent sociopolitical and economic strategies relating to subsistence, sustainability, and trade.

THE AD 536 EVENT

Beginning in November AD 535, an atmospheric event variously described as a "dry fog" or "dust veil" descended on much of the world, all too often with catastrophic long-term consequences. Eyewitness documentary evidence comes from Sweden, Ireland, and England; throughout much of Italy and Carthage, in North Africa; and Byzantium, Mesopotamia, Mongolia, and China. Almost everywhere it was reported, it coincided with failed crops and famines, often combined with the spread of disease, wars, migrations, and toppled regimes. Indeed, the list of human catastrophes attributed to this short episode is truly astounding (Keys 1999): a three-year famine in

DOI: 10.5876_9781607322801.c007

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Ireland; summer droughts and frosts that killed 70 to 80 percent of the population in the Northern Kingdom of China (Houston 2000:73); the disintegration of the political regime in the Southern Kingdom of China; desiccation of the Mongolian steppes, causing the expulsion of the Avar warrior pastoralists, who then established an empire in eastern Europe that encompassed 1 million square miles; and the spread of bubonic plague by merchant ships from East African ports to the Mediterranean and northern Europe, thus contributing to the decline of the late Roman Empire.

Although dates range from AD 533 to 539, paleoclimatologists have observed the onset of cold conditions in a variety of environmental indicators that include tree rings, ice cores, and stalagmites. Growth patterns in tree rings in Scandinavia, Siberia, Mongolia, Austria, the western United States, and Chile (Baillie 1995; Larsen et al. 2008) have demonstrated that retarded tree-ring growth persisted for as long as fifteen years. A stalagmite from Wanxiang Cave in northern China correlates the AD 536 event with an enormous spike in $\delta^{18}O$ (signifying dry conditions) (Zhang et al. 2008). It is not yet clear what caused this atmospheric disturbance. Some ice cores from Greenland and Antarctica exhibit peaks of sulfuric acid aerosols, implicating a huge volcanic eruption (Larsen et al. 2008),[1] but other chemical analyses of spherules in a Greenland ice core suggest that the dust veil was caused by oceanic impacts of extraterrestrial bodies (Abbott et al. 2008; Baillie 2006). Regardless of the origin(s) of the dust veil, it is important to appreciate that the AD 536 event had a more potent impact on the atmosphere than any other volcanic eruption during the last three millennia (Larsen et al. 2008).

Given the intensity, duration, and often devastating effects of this atmospheric disturbance throughout the Northern Hemisphere, the AD 536 event must have caused severe disturbances in both climate and cultural dynamics in the Southern Maya lowlands.

First Approximation Scenario

Evidence from the Southern Maya lowlands does, in fact, suggest substantial climatic change. A short but pronounced pulse of drought conditions is evident in sediment cores from Lakes Punta Laguna and Chichancanab circa AD 585 ± 50 (Curtis, Hodell, and Brenner 1996; see also Hodell et al. 2001) and from Lake Salpeten circa AD 500–550 (Rosenmeier, Hodell, Brenner, Curtis, and Guilderson 2002). In fact, the $\delta^{18}O$ values approximate those that mark the beginning of the eighth-century droughts that have been correlated with the earliest phase of the Terminal Classic collapse process.[2] Higher

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sea-surface salinities reached marked minima in sediments from the northeastern Caribbean (Nyberg et al. 2001, 2002), indicating cooler sea-surface temperatures and drier periods in Mexico. Growth rings in a stalagmite from Macal Chasm cave in Belize also show a seventeen-year peak of aridity at AD 517 (Moyes et al. 2009:199; J. Webster et al. 2007; see also Iannone, Chase, Chase, et al., Chapter 13 in this volume). Finally, cave sediments from Reflection Cave, in one subregion of the Vaca Plateau, Belize, show carbon isotope evidence of a cessation of agricultural activity and perhaps human occupation above the cave at about this time (Polk, van Beynen, and Reeder 2007; see also Iannone, Chase, Chase, et al., Chapter 13 in this volume). Thus, a variety of data sets agree that a short pulse of extreme aridity visited the Maya lowlands at some time during the sixth century—and given the vagaries of radiometric dating, it is highly probable that it was the AD 536 event.

According to all general atmospheric circulation models, changes in global climate associated with the AD 536 event would be consistent with the appearance of drought conditions in the Maya lowlands (see Gill 2000; Haug et al. 2001, 2003; Hodell et al. 2001; Nyberg et al. 2001, 2002). Seasonal rainfall fluctuations in the greater tropical Atlantic region are largely the result of latitudinal migrations of the intertropical convergence zone (ITCZ). The ITCZ is displaced to the South in colder winter months, bringing in the dry season (February through May). When the ITCZ is at its more northerly positions, it ushers in the rainy season (August through October). Thus, the abrupt and strong cooling so amply reported throughout the Northern Hemisphere beginning in AD 536 could mean a more southerly position for the ITCZ and a drier episode in the Maya lowlands (e.g., Lane et al. 2011).

The AD 536 event also coincided with a period of time traditionally labeled "the Maya hiatus," first observed by Sylvanus G. Morley (1938–39) as a pause spanning AD 534–693 in the erection of dated monuments in the middle of the Classic period. The onset of the hiatus was remarkably abrupt, especially as the previous ritual twenty-year period, or *katun*, produced the majority of the known Early Classic period hieroglyphic record. The hiatus also coincided with some significant stylistic changes in the manner in which people were portrayed on monuments (Proskouriakoff 1950), with marked differences in ceramic styles (Smith 1955) and in architectural techniques that involved a shift from block masonry to veneerlike treatment in some parts of the Maya area (Pollock 1980; Von Falkenhausen 1985). Thus, several data classes converge to suggest that the hiatus was associated with a massive change point in Maya culture. In a 1974 synthesis, Gordon Willey (1974:419–20) concluded that "the last half of the 6th century AD was, to put it conservatively, a disturbed time

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in the southern Maya lowlands. Old patterns were being disrupted; new ones presumably were in formation; but for several decades there was a hiatus in what had been the normal courses of cultural activity."

Willey attributed this cultural transformation to the severance of trade relations with the Mexican site of Teotihuacan. However, what is perceived to have been Teotihuacan influence had vanished from the Maya heartland prior to the beginning of the sixth century, and Teotihuacan itself may have collapsed from the pressures imposed by the AD 536 event (Keys 1999). The existence of changing political arenas, in combination with pervasive warfare, has since become an acceptable explanation for the hiatus (e.g., Chase 1991; Chase and Chase 1998b; Freidel, Escobedo, and Guenter 2007; see also Aimers and Iannone, Chapter 2 in this volume). We now also know that the Tikal data upon which much of the hiatus scenario was based tell only part of the story—a misleading one at that. It, and possibly other sites within its realm, certainly did not erect stone hieroglyphic monuments for more than one and half centuries (cf. Aimers and Iannone, Chapter 2 in this volume), but two other megasites—Caracol and Calakmul—experienced their major periods of growth and development. What, then, precipitated these huge, contrasting, nearly simultaneous cultural changes?

Richardson Gill (1994, 2000) was the first to imagine a causal connection between the AD 536 event and the developmental trajectories that Maya sites took. This proposed connection was also investigated by Richard Adams (1999), the Chases (2000), Joel Gunn (2000), and Hubert Robichaux (2000). However, the causal relationships between the AD 536 event and the processes of change at this culturally transformative moment deserve a more detailed examination. Thus, what follows is a synthesis of the relevant data concerning the potential effects of the AD 536 event on the intertwined histories of three great power centers in the "core" of Maya civilization. Calakmul, Caracol, and Tikal dominated events in the Southern Lowlands before, during, and for several centuries after the AD 536 event. These three sites also have generated a great amount of archaeological, iconographic, and epigraphic information.

A REGION AT RISK

As other contributors to this volume make clear, severe drought conditions are plausibly connected to potentially massive culture changes. Me-Bar and Valdez (2005) estimated that the Maya were more vulnerable to droughts lasting three or more years than to any other kind of environmental threat—and,

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according to Farriss (1984:61–64), historically painful droughts occurred on an average of one every twenty years (Table 7.1). It should, therefore, come as no surprise that several researchers view water as being at the heart of Classic Maya religion and politics (Lucero 2006a, 2006b; Scarborough and Gallopin 1991).

The majority of the roughly 68,000 km^2 of the Maya "heartland" falls within the Peten Karst Plateau (Dunning, Beach et al. 1998), upon which Tikal and Calakmul reside. During the dry season, easily accessible sources of surface water are few and far between. However, during the wet season vast *bajo* systems filled with water and could have been accessed (Fialko 1999, 2003). Even though annual rainfall is ample, approximately 1,350 to 2,000 mm—that is, approximately 80 percent of it—is confined to a seven-month wet (growing) season (May through November). Temperatures are high year round, with monthly maxima of 26.5°C to 31.5°C. Thus, evaporation rates are quite high. Seepage losses through the highly porous limestone are also high, as precipitation rapidly percolates ca. 200 to 400+ m down to the water table, well beyond the capabilities of a stone tool technology to tap with wells.

Pioneer colonists 4,000+ years ago found a quite different landscape (Scarborough and Gallopin 1991; Dunning et al. 2002; Dunning, Beach, and Luzzadder-Beach 2006; Chapter 6 in this volume; Beach et al. 2009; Luzzadder-Beach and Beach 2009; see also Ford and Nigh, Chapter 5 in this volume). Most early settlements were on the edges of broad, shallow, clay-lined depression features, or *bajos*, which constitute about 30 to 40 percent of the landscape. Today these bajos are seasonal swamps, but during the Preclassic (2000 BC to AD 250) and early Early Classic periods (AD 250 to 600) parts of these depressions contained perennial wetlands that have subsequently filled with colluvial clays due to massive deforestation of the uplands (Dunning et al. 2002). It is clear from the often meandering and discontinuous streambeds observable on maps and aerial photos that bajos today simply dry up before connecting with a tributary to one of the river systems feeding into the Gulf of Mexico on the West and the Caribbean on the East. For many of those inhabiting the Peten Karst Plateau, the only means of obtaining water to slake their thirst and water their crops during dry intervals was to construct and manage water impoundment systems (Scarborough 1993; Weiss-Krejci and Sabbas 2002), generally networks of collection surfaces, canals, and impoundments or reservoirs.

To the East of the Peten Karst Plateau the Vaca Plateau, upon which Caracol sits, lacks large bajo systems. Instead, the landscape is quite karstic, with occasional dry gullies and small to moderate amounts of drip or standing

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Table 7.1 Weather-related famines in Colonial Yucatan.

Year(s)	*Occurrence*	*Source*
1534–41	Drought (also locusts)	Diego de Landa Calderón, Relación de las Cosas Yucatán, 54–56
1564	Drought	Sherburne Cook and Woodrow Borah, Essays in Population History, 2:115
1571–72	Famine (drought?)	Diego Lope de Cogolludo, Historia de Yucatán, lib. 6, cap. 9
1575–76	Epidemic, famine (drought)	Molina Solis, 1:166
1627–31	*Famine, storm locusts	Cogolludo, lib. 10, caps. 7, 17
1650–53	*Drought	Cogolludo, lib.12, caps. 17, 21
1692–93	Famine, epidemic, locusts, hurricane	AGI (Archivo General de Indias), Mexico 369, Bishop to Crown, April 18, 1693
1700	Famine (drought?)	AGI, Mexico 1035, Definitorio Fransciscano, June 16, 1700
1730	Famine (drought?)	AGI, Mexico 898, Oficiales Reales to Crown, October 20, 1745
1742	Famine (drought?)	AGI, Mexico 898, Oficiales Reales to Crown, October 20, 1745
1765–68	Famine, drought locusts, hurricane	AGI, Mexico 3054, Governor to Julián de Arriaga; Mexico 3057, Encomenderos to Oficiales Reales, September 11, 1770
1769–74	*Famine, locusts, hurricane, drought	AGI, Mexico 3057, Governor to Audiencia, March 1, 1774; Informe Ayuntamiento Merida, 1775
1795	Famine (drought?)	AGN (Archivo General de la Nación), Intendentes 75, Autos sobre escaseces de víveres, 1795
1800–1804	*Famine, drought locusts	AGN, Intendentes 75, Governor to Viceroy, August 10, 1800; AA, Oficios y decretos 5, Cabido Merida to Bishop, July 31, 1804
1807	Hurricane	AGI, Mexico 1975, Comercio de Campeche to Crown, January 21, 1808

Source: From Farriss 1984:61–62.

Notes: ? = may or may not be weather related; * = severe.

water in some caves. The ancient inhabitants of the Vaca Plateau peppered the landscape with hundreds of small reservoirs that were associated with residential groups (Chase and Chase 1996a; Chase 2012; Crandall 2009).

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All three sites considered here are embedded in dry landscapes within regions bounded by water resources. Both the Peten Karst Plateau and the Vaca Plateau are bordered by physiographic provinces that, for the most part, had abundant and accessible groundwaters, probably throughout the Holocene: the Quintana Roo Depression and Central Hills to north of Calakmul; the Peten Itza Fracture region to the South of Tikal; the Macal and Chiquibul Rivers to the East and West of Caracol; the Rio Hondo region, the Three Rivers region, and the Belize River Valley, to the East of the Peten Karst Plateau; and the Rio Candelaria and Rio San Pedro regions on the West (Beach et al. 2008, Beach et al. 2009; Luzzadder-Beach and Beach 2009).

The availability of potable water on a daily basis was the most critical factor for the hundreds of thousands of people inhabiting the Maya heartland. This meant constructing and managing either reservoirs or, possibly, bottle-shaped cisterns known as *chultunes* (Hunter-Tate 1994; Puleston 1971). Cistern chultunes, however, are poorly represented in both Tikal's and Caracol's residential groups and were likely not used for water storage in the Southern Lowlands. Small bodies of standing water, such as reservoirs and cisterns, may also become grossly contaminated during periods of low water (see Doehring and Butler 1974). The potential for reservoir systems to maintain a sufficient, ready, and safe supply of potable water throughout a prolonged and severe drought epoch would be difficult, but the maintenance and even growth of large urban populations throughout the heartland after the AD 536 event indicate that such bodies of water must have been used.

Based on archaeological, ethnohistoric, epigraphic, and iconographic evidence, rain-fed corn is widely believed to have been the staple crop and a major source of calories in the Maya lowlands (Harrison and Turner 1978), as it has been throughout historic and modern times. Although there are innumerable ways to intensify corn production in upland areas using prehistoric technologies (e.g., Dahlin et al. 2005; Reyes G. and Sanchez G. 1990; Terán and Rasmussen 1994; Thurston et al. 1994; Zizumbo V. and García-Marín 1993;), there are few ways of improving soil moisture in the midst of a severe and prolonged drought (even when terracing acts to retain water). In fact, it is likely that in some cases Maya farmers exacerbated the drought by felling increasingly more forest so they could plant more maize in the hope that at least some would mature, resulting in deforestation that would have lessened the albedo effect, decreasing precipitation even further (see Griffin et al., Chapter 4 in this volume).

Although beans and squash would have been grown in conjunction with corn, other crops were also tended. Some were grown on terraced fields as part of multicropping practices, and others were grown in dooryard gardens. Many of these other plants were able to withstand moderate drought conditions better than maize; these included a multitude of root crops (Bronson 1966; Atwood 2009) and *ramón* (*Brosimum alicastrum*; Puleston 1968). Although some specialists feel that ramón fed the bulk of urban populations (Puleston 1968, 1982), both historic and modern Maya hold ramón in extremely low regard as a "famine food." Roots were probably focused on differentially depending on cultural traditions. Other crops could be grown vertically, in what are sometimes called "artificial rainforests," or "polycultural gardens," wherein economic species are substituted for uneconomic species in a structure replicating the natural forest ecosystem (Barrera, Gómez-Pompa, and Vázquez-Yanes 1977; Folan, Fletcher, and Kintz 1983; Gómez-Pompa, Flores, and Sosa 1987; McKillop 1994; see also Dunning et al. [Chapter 6], Ford and Nigh, Chapter 5 in this volume). Roots and ramón may have been among these crops, but the majority of crops in such a system tend to be fruits, vegetables, condiments, herbal medicines, and other inedible but otherwise useful products. These latter crops are insufficient to "fill the belly" unless they are valuable enough as cash crops to be exchanged for staple foods (Caballero 1992). Moreover, such systems require several years to establish: if households did not already have a vertical garden when a protracted drought hit, they probably would have perished waiting for a new one to mature and become productive.

Although it has been alleged that bajos were capable of producing one to three crops annually on raised platforms (raised fields) behind berms holding sufficient amounts of water year round, or at least throughout the growing season (e.g., Adams 1981; Dunning et al., Chapter 6 in this volume), this is unlikely to have happened. Despite a great deal of variability among bajos—and some of the smaller and moister ones are sometimes dry-farmed today (e.g., *escoba bajos*)—these vertisols are: deficient in phosphorus, potassium, and zinc; low in organic matter; poorly aerated; overly acidic; subject to seasonal shrinking and swelling; extremely hard when dry; and plastic and sticky when wet (Pope and Dahlin 1989, 1993). In short, they are not good agricultural soils. Often the clays also are underlain by deep layers of soluble gypsum (Dahlin, Foss, and Chambers 1980; Gunn et al. 2002), some of which translocates upward into the root zone with alternate wetting and drying, contaminating crop plants. Finally, bajos often have what are variously called *resumideros*, sinkholes, or "swallow holes." These sinkholes are chocked with debris most of the time, but they sometimes, and for unknown reasons, unblock and drain huge amounts of bajo water (see Puleston 1973:234). Thus, there are multiple reasons that the heartland Maya did not try to convert

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the bajos into perennial wetlands for the purpose of intensive agriculture. The only sure evidence for raised fields in the Peten Karst bajos has been found deeply buried in Bajo La Justa near the site of Yaxha, but that bajo had already silted up during the Early Classic period (Dunning et al. 2002; Kunen et al. 2000). As discussed below, the only significant raised field areas that have so far been confirmed during the Middle Classic and later are located in perennial wetlands at elevations lower than eighty meters above sea level (Pope and Dahlin 1989, 1993).

Finally, grain storage might have mitigated the effects of prolonged drought, especially as maize (unshelled) can be stored for up to three years (Freidel 2008b; Freidel and Shaw 2000; Smythe 1991). However, large constructed storage facilities are conspicuous by their absence in the Maya lowlands. Individual households might have stored greater reserves had they been able to anticipate the drought well in advance, which the AD 536 event did not allow. Roots can be "stored" in the ground while they are still growing and, then, harvested as needed. Ramón can be harvested twice per year and stored for about the same amount of time as maize. How much reserve storage, roots, and ramón actually contributed to the routine sustenance of urban dwellers remains controversial, as is the notion that these resources were sufficient to carry large urban and rural populations through severe and prolonged droughts.

CALAKMUL, CARACOL, TIKAL, AND THE MAYA HIATUS

Like the AD 536 event, what has been called the Maya hiatus occurs in the mid-sixth century, a time that marks the transition between the Early and Late Classic periods. A monument gap exists at Tikal between AD 557 and AD 692 (cf. Aimers and Iannone, Chapter 2 in this volume); at Calakmul, there are no monuments from AD 514 to AD 623; at Caracol, the hieroglyphic texts provide a fairly continuous recorded from AD 484 through AD 680. The archaeological records of these three sites reveal distinct responses during this transitional era in the Maya Southern Lowlands.

Tikal

Tikal was a power center without rival as early as AD 250 and was, without doubt, one of the largest urban centers in the southern lowlands prior to the mid-sixth century. Approximately 10,400 people inhabited its central 16 km^2 by circa AD 550 (Culbert et al. 1990). Population estimates for the 123 km^2 circumscribed by its defensive earthworks (see below) range from 15,000 to

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30,000 at the low end (D. Webster et al. 2007) to 62,000 to 75,772 on the high end (Rice and Culbert 1990:33; Turner 1990).

Although the Early Classic period residential population of Tikal may have been more centrally concentrated (Puleston 1974), the central portion of Late Classic Tikal built on its substantial Early Classic foundations. Its most impressive architectural features were its pyramids and acropolises on large open plazas, particularly the North Acropolis on the Great Plaza. A few broad *sacbeob* (causeways)—venues for public pageantry and processions in Tikal's case—connect the epicentral ceremonial precinct with outlying precincts and temple pyramids.

The ruling Jaguar Paw (Chak Tok Ich'aak) dynasty had been well established since the beginning of the third century (Coggins 1975), but Tikal's dynastic succession during the latter part of the fifth century and into the sixth is not entirely clear in its epigraphy. Most specialists accept the Jaguar Paw (Chak Tok Ich'aak) lineage head, Double Bird (Wak Chan K'awil), as Tikal's twenty-first ruler, starting in 9.5.3.9.15 or AD 537. However, there seems to have been a period of political instability prior to this, how long and how unstable is not formally known. Linda Schele and David Freidel (Schele and Freidel 1990:167) state that Tikal had six rulers in the previous forty-nine years (Schele and Freidel 1990:167). Christopher Jones (1991:115) and A. Chase and D. Chase (2000:62) note six rulers in the previous ten years (Jones 1991:115; A. Chase and D. Chase (2000:62) and Simon Martin (2003:24) say there were two rulers in the preceding twenty-nine-year period.

From the fourth century through the first half of the sixth, Tikal's hegemony extended minimally to Caracol, 76 km to the East; Waka, 80 km to the West; Rio Azul, 60 km to the Northeast, perhaps to Calakmul, 90 km to the North; and an unknown distance to the South (Adams and Robichaux 1992). Many of the larger Maya sites within Tikal's political ambit are considered kingdoms in their own right, but to the extent that they announced alliances with Tikal on carved and dated monuments erected in their public spaces, they were more likely client states during this time.

The cessation, or hiatus, of carved monument erections at Tikal and its client states can be dated to the erection of Stela 14 at the katun ending, 9.5.0.0.0, or July 3 AD 534. This date was also commemorated at Caracol, Yaxha, and Xultun within its realm, and at Piedras Negras and Copan outside of it. According to the hieroglyphic record, the first real hint that Tikal was losing power within its realm occurred in AD 546, when Naranjo appears to have switched allegiance to Calakmul (Martin and Grube 2000:72). Naranjo may have been an autonomous state in the early years of the Early Classic

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period, but nevertheless maintained familial ties with Double Bird (Wak Chan K'awil). Double Bird (Wak Chan K'awil) was still powerful enough in AD 553 to "supervise" the installation of a new governor at Caracol (Martin and Grube 2000:88–89). An "Axe event" between Caracol and Tikal in AD 556 indicates that cracks were occurring in any relationship that existed between these two sites. Real trouble was not far behind; by AD 562 Tikal was so weakened that Caracol attacked and subjugated it (Jones 1991:117; A. Chase and D. Chase 1998b, 2000; Martin and Grube 2000) in what is known as a "Star War" (see Rice 2003:163–67). This was associated with "a massive [monument] destructive campaign" initiated sometime between AD 557 and 568 (Chase 1991; Haviland 2003:141–42). Whether Tikal was dominated by Caracol during this time (e.g., Harrison 1999; A. Chase and D. Chase 2004a) or by Calakmul (e.g., Martin and Grube 2000; Martin 2003) depends on one's perspective and interpretation of the hieroglyphic records.

The construction of Tikal's earthworks has been dated ceramically between the middle of the Manik Ceramic Complex (ca. AD 450) and the Ik Ceramic Complex, ca. AD 600 (Fry 2003:144–47). Assuming that the latest ceramics date their construction, these earthworks may be correlated with the Tikal warfare event. It has been suggested that they functioned in a defensive way (e.g., Dahlin 2000; Puleston and Callender 1967). However, the Tikaleños built these features rather hastily and they appear to have never been completed. The lengthy earthworks do not always take defensive advantage of the terrain and do not demonstrate much input from knowledgeable military tacticians.

The Tikal earthworks are unique in the Maya lowlands in their length. They demarcate over 123 square kilometers of land, most of it cultivable, and may have served to define the limits of the formal Tikal state at the end of the Early Classic period. Smaller earthworks encompassing site cores are known from Dos Pilas (Demarest et al. 1997), Aguateca (Inomata 1997), and Chunchucmil (Dahlin 2000); interpolity earthworks are reported between the Yaxchilan and Piedras Negras polities (Golden, Scherer, Muñoz, et al. 2008:265). Thus, these features served boundary, as well as defensive, uses, but none are as massive as the ones at Tikal.

Dennis Puleston (1974:309) and Robert Fry (2003:148–49) mention abandonment of farming settlements during the middle to late Early Classic period near both the southern and northern Tikal earthworks (also see Haviland 2003:129–40). Some of these settlements were located in association with an *aguada* (reservoir) and excellent well-drained farmland. Geochemical data demonstrating extreme reductions in phosphorus loading in sediments have been obtained from Lake Quexil, sixty kilometers south of Tikal, suggesting

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much reduced land use around its shores (e.g., see Brenner 1983: 206) and again implying another potential population reduction during the mid-sixth century in an area having access to water. Construction of public buildings also ceased in the later part of the Early Classic period in some nearby subsidiary sites (e.g., Uolantun) and their surrounding communities (Fry 2003:149). By contrast, the "Vacant Terrain" survey of Bennett Bronson (1968) revealed a large Early Classic population living in perishable structures within Tikal's central nine square kilometers, implying a more nucleated pattern for this time (Puleston 1974) and possibly reflecting conflict at Tikal's boundaries.

Water and Land Management at Tikal

Tikal enjoyed ca. 1,880 mm of rainfall per year but, similar to the entire Maya lowlands, the precipitation was highly seasonal. Vernon Scarborough and Gary Gallopin (Scarborough and Gallopin 1991) and Scarborough (1993) delineated six major reservoir catchments and three different reservoir types within the central 9 km^2. The impervious plaza surfaces in the central-most 62 ha collected runoff, which was channeled into reservoirs via natural drainage features and broad paved causeways with parapets. This system provided potable water to Tikal's epicentral inhabitants, though, during periods of water shortages they could have served a broader population. Overflow from these reservoirs was directed through *arroyos* (intermittent stream or creek bed) to additional reservoirs lower on the landscape. Scarborough and Gallopin (1991:table 1) estimated the water storage capacity of this network at 105,108 to 243,711 m^3, but this larger figure may be inflated. Unpublished excavation notes by Nicholas Helmuth and others (on file, University Museum, University of Pennsylvania) of the three deepest reservoirs here (Palace, Hidden, and Causeway reservoirs) show that they penetrated extremely porous limestone and that only the bottoms of these reservoirs could be (and were) made impervious with limestone blocks embedded in clay. A second set of three large residential reservoirs served domestic consumption in a densely settled part of the urban community, though many individual households had their own small *pozos* (wells) or *aguadas* near central Tikal (Carr and Hazard 1961). The latter (n = 47, see Scarborough and Gallopin 1991:table 1) could not have held much water, and probably would have been dry for part of the year. Personal experience has shown that most clay-lined reservoirs are shallow, often less than 1.5 m deep, even after cleaning out accumulating sediments, which must be done every few years.

While sufficient potable water was evidently available, evidence for irrigation at Tikal is minimal. Dennis Puleston (1973:150) mentions seeing two

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shallow pools of more or less permanently standing water and two instances of water flowing in arroyos at Tikal, "and in each case that was for only two or three days after a heavy rain near the height of the rainy season." Fialko is said to have found some Late Classic dams and weirs in two arroyos southwest of Tikal, indicating attempts to manage water on a localized scale (cited in Dunning et al. 2002:277). Even the forty-seven or so reservoirs counted by Vernon Scarborough and Gary Gallopin (Scarborough and Gallopin 1991:table 1) were probably barely capable of providing potable water during prolonged droughts and would have been totally inadequate for pot or canal irrigation precisely when it was needed most. Scarborough and Gallopin (1991) also suggest that the four reservoirs on bajo margins were designed specifically to irrigate fields. They estimate that these reservoirs could have supported a total of eighty-five hectares. With a population of 15,000 to 62,000 people, an irrigation system dependent on precipitation and supplying water to only eighty-five hectares would seem wholly inadequate.

Finally, Jay Silverstein et al. (2009) hypothesize that Tikal's earthworks, found originally in 1965 (Puleston and Callender 1967), served as artificial limestone filtration trenches designed to intercept the flow of subsurface water as it travels down slope toward the water table, as well as to tap into an elevated phreatic zone. According to this scenario, the Maya directed the water into more than thirty-two catchment basins, each averaging about 14.5 hectares, where it was stored against drought, used to support off-season planting, or to mitigate the risk of crop loss during the growing season due to *canicular* ("dog days") episodes (Silverstein et al. 2009:51). However, if these trenches had proved effective as catchments for irrigation waters, one would expect the entire landscape to be laced with them, and that is not the case.

Thus, there seems to be some indication that Tikal built adequate facilities for potable water, primarily in its epicenter, but there is no convincing evidence for a centrally organized means to increase agricultural productivity throughout the site in the face of drought (or even in good times).

Caracol

The terrain on the Vaca Plateau upon which Caracol sits is a broad karstic plain off the steep slopes of the Maya Mountains in western Belize. Rainfall is relatively abundant, about 2,300 millimeters annually. Analysis of floor sediments from Reflection Cave (Polk, van Beynen, and Reeder 2007) to the North of Caracol have been used to suggest that severe drought conditions occurred in the Vaca Plateau sometime between the third century and the end of the

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sixth; this drought is believed to have been on a par with the megadroughts of the eighth and ninth centuries (Moyes et al. 2009; see also Iannone, Chase, Chase, et al., Chapter 13 in this volume).

Caracol was a "modest town" of perhaps 19,000 in the middle of the sixth century (A. Chase and D. Chase 2000). Its epicenter consisted of the usual main plazas and large architectural monuments, and it had likely gained control over the formally independent Hatzcap Ceel and Cahal Pichik to its East. As in the Late Classic era, its population was broadly distributed over a vast landscape. According to the hieroglyphs, its last Early Classic ruler, Lord Water, had acceded under the power of a Tikal lord. Caracol's independence from Tikal was achieved through its AD 562 Star War (A. Chase 1991; D. Chase and A. Chase 2002). Following its independence, the site exploded into a 177-square-kilometer metropolis with an urban population of over 100,000 people in less than 100 years (Chase and Chase 1994; Chase et al. 2011).

Caracol's cityscape was organized very differently from Tikal's. Caracol distributed public architecture throughout the landscape and connected these public plazas to the urban center by means of causeways. The landscape is almost entirely terraced to support agriculture, with residential groups regularly spaced over the entire landscape. The central core of Caracol appears more highly nucleated and densely packed than that of Tikal (A. Chase and D. Chase 2001; Healy 1983:401, 409). Caracol's most salient urban configurations achieved their greatest complexity after the mid-sixth century. Suffice it to say here that Caracol is best characterized as a highly visible and very practical network of agricultural terraces, reservoirs, avenues, and marketplaces that epitomize administrative power, statecraft, and economic efficiency.

Water and Land Management at Caracol

Although precipitation is generally greater on the Vaca Plateau, being about 2,300 millimeters per year, that does not mean that Caracol didn't experience some water stresses in the mid-sixth century. There is no running water within the site of Caracol, despite that rivers exist some twelve kilometers from the site epicenter to the Northeast and to the Northwest. The entire Caracol landscape was modified by humans and agricultural terrace systems, which would have retained water, and covered *entire* watersheds (Chase and Chase 1998a:figs. 5–7; A. Chase and D. Chase 2000:61). The Caracol landscape is also dotted with reservoirs. Both the site epicenter and almost every causeway termini to public space are associated with a sizable reservoir, many of which still hold water long into the dry season. Like Tikal, the larger reservoirs in the Caracol epicenter and at the causeway termini benefit from water that

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was channeled over constructed space and floored plazas. Unlike Tikal, which tended to use natural depressions, many of Caracol's large reservoirs were built into massive raised platforms. Moreover, there are "hundreds" of reservoirs (Chase 2012; Chase and Chase 1998a:68) associated with residential groups throughout the landscape; some are also located among terraced fields in the valley bottom, meaning that they could have been used for pot irrigation. Thus, though potable water was probably less of a serious problem at Caracol than at other Maya sites, serious drought would have had significant impact.

A critical part of Caracol's urban facelift was "thousands of kilometers" of stone terraces that completely cover many hills and valleys. These extend from the epicenter over most of the Vaca Plateau, covering an estimated 130 square kilometers. Despite the terraces' initial construction by local corporate groups (Murtha 2009), broader administrative control and management may have ensued over time as the landscape was completely infilled; some terraces run for up to a kilometer in length (Chase and Chase 1998a:68). Indeed, "There are no surveyed parts of Caracol where large areas of land exist without terraces" (Chase and Chase 1998a:66; see also Iannone, Chase, Chase, et al., Chapter 13 in this volume). These terraces inhibited soil loss due to erosion on the sloping terrains, but they also retained water and evenly distributed hill slope rainwater to terraced fields both on hills and in the valleys (Healy et al. 1983:405; see also Chase and Chase 1998a:70).

Although probably beginning in the Late Preclassic period, the majority of terrace systems at Caracol and throughout its region appear to have been finalized between AD 550 and 650 when the population grew to its maximum (Chase and Chase 1998a:72). Paleobotanical evidence suggests that maize was grown on these terraces from ca. AD 300 on (Webb, Schwarcz, and Healy 2004). The terraces may have been capable of producing more than a single crop per year (Murtha 2009), and the Caracol skeletal population is in relatively good health (Chase 1994). Thus, the Caracol landscape appears to have been more salubrious and centrally organized than that at Tikal.

Calakmul

Urban Calakmul covered some 70 km^2 (Gunn et al. 2002:298). From the Late Preclassic period on, it had some of the largest temple architecture found in the Maya lowlands. Much monumental architecture is interpreted as having been constructed between ca. AD 550 and 695 and placed in the reign of the Kaan dynasty, also known as the "Kingdom of the Snake" (Delvendahl 2008; Martin and Grube 2000). Calakmul boasts the most

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numerous carved monuments (n = ~120) of any lowland site, but there is a gap in dated monuments from AD 514 to 623. This gap may be in accord with regional patterns associated with the Maya hiatus or may have been created by monuments lost to nature due to the unusual solubility of the local limestone or monuments that were purposefully destroyed (Carrasco Vargas and Colón González 2005).

The earliest mention of The Kaan dynasty is not at Calakmul, but at Dzibanche in southern Quintana Roo (Velásquez García 2005), where a Kaan defeat of El Resbalon in AD 529 is recorded (Martin and Grube 2000:103–4; Velásquez García 2005:2). Nikolai Grube (2004) feels that the Kaan polity shifted its center of power to Calakmul sometime between AD 518 and 631, but there is no clear hieroglyphic support for this interpretation. However, some of Calakmul's Early Classic architectural facades display Dzibanche-style architectural motifs (Carrasco Vargas 1996:49).

Although the city of Calakmul is strategically located on a promontory that is circumscribed by a deep arroyo and a bajo that obviously provided some protection against attack, it also has a wall remnant that is 1 km long and 6 m high. Unlike Tikal's earthworks, it was not designed to protect agricultural land but rather the main ceremonial complex. A probable marketplace exists on the North Plaza just outside of this wall segment (Dahlin et al. 2010, and following). Seven intersite *sacbeob* (causeways) are also known, segments of one of which extended perhaps over 60 km (Folan et al. 1995:313). Like Caracol, these rather plain-looking causeways may have facilitated a solar market system or the movement of armed troops.

Water and Land Management at Calakmul

Annual precipitation at Calakmul is about 1,670 millimeters per year, slightly less than at Tikal. Like Tikal, tapping groundwater through wells was impossible, so reliance was on surface water. Calakmul is situated between two seasonal swamps: the El Ramonal and El Laberinto bajos. Both were once highly saline perennial wetlands, but had silted in by approximately AD 300. Parts of these swamps were only seasonally wet; other parts were permanently dry as indicated by the presence of domestic units on the bajo floors (see also Dahlin and Dahlin 1994).

William Folan et al. (1995:313) report thirteen reservoirs, with a minimal capacity of circa 200 million liters. A set of interconnected hydraulic features include bajos, arroyos, and canals that encircle 22 km^2 of the site. Improvements in these and at least two sets of central reservoirs were clearly the result of large-scale projects. One large (5.5 ha) rain-fed reservoir has an overflow

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channel leading to a smaller reservoir (1.5 ha); another set of smaller reservoirs is connected by a channel 280 m long. Groundwater quality was probably not great; a gypsum-clay deposit underlies the surficial Vertisols (Dahlin, Foss, and Chambers 1980; Gunn et al. 2002:300). Calakmul's large central reservoirs, like those at Tikal, were lined with slabs of masonry to make their floors impermeable. Besides the large centrally located reservoirs, which probably served a broader population, a number of smaller reservoirs are scattered about the urban landscape, each serving and apparently maintained by its own barrio or neighborhood (Gunn et al. 2002). Unfortunately, we do not know the dates of construction and use for these water management features.

It is also possible that larger reservoirs were used for pot irrigation of dooryard gardens during years of normal or abundant rainfall, but they probably would have been inadequate in supplying both potable and irrigation water during drought periods of any length. Joel Gunn et al. (2002:298) briefly mention the presence of some suspicious-looking elevated features in the bajos that might have been used for agricultural production, but they are not presented on a map and one gets the impression that there were not many of them, no doubt because of the heavily salinized and gypsiferous concentrations in the lower soil horizons. Moreover, if dams and raised fields were emplaced here, they would be visible on aerial photos, as similar features are in the bajos near El Mirador (Dahlin 1983). At El Mirador low (20 to 50 cm high) causeways and their shallow (20 cm deep) flanking canals dating to the Late Preclassic period are clearly visible on aerial photos and have been confirmed through excavation. No publications mention Calakmul as having employed terracing in upland zones. Thus, it appears that Calakmul invested in the capture of potable water for domestic usage, but like Tikal the site was not heavily invested in agricultural management.

RESPONSES TO THE AD 536 EVENT AT CALAKMUL, CARACOL, AND TIKAL

It is clear that Caracol's ascendancy in the mid-sixth century was based on developing local and regional self-sufficiency. Furthermore, its phenomenal growth rate attests to its success. In contrast, Tikal and Calakmul evince little to no evidence of agricultural intensification, and one can question their ability to sustain themselves on local and regional resources alone in the face of severe drought conditions. Given their high population levels, the possibility must be raised that both of these sites imported food surpluses from elsewhere, either through trade or tribute?

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The overwhelming majority of studies of ancient Maya trade have concentrated on luxury goods of high value and low volume, which tend to be made of durable materials and are often depicted as part of elite apparel on stelae, altars, and polychrome ceramics. Of this trade, most attention has been given to interregional or long-distance trade. However, geochemical (soils) analyses from a few select sites demonstrate that foodstuffs were routinely bought, sold, or bartered in marketplaces and that these came in bulk from fairly long distances as early as the Early Classic period (Dahlin 2003; Dahlin et al. 2007; Dahlin et al. 2010). Marketplace exchange was presumably fairly common at Classic period sites (A. Chase and D. Chase 1998c, 2004a; Dahlin et al. 2010; Freidel 2008b; Freidel and Shaw 2000; Wurtzburg 1991). A recently translated, but as yet unpublished glyph, on a Late Classic cylinder vessel, probably manufactured in the Naranjo area, has been read by David Stuart (personal communication, 2008) as *aj k'iwik*, or "he of the market/plaza." Also, there are eighteen murals at Calakmul that depict marketplace activities of bulk food items. These data suggest that the effects of a severe drought could have been averted or mitigated by the importation of basic food stuffs, assuming they were available elsewhere within the Maya area. These same data also suggest that market exchange could have acted as an adaptive response to sudden, severe, and protracted drought conditions.

Tikal

The status of Tikal's sixth-century economy is difficult to determine. No central marketplace(s) are known from this time; the famous galleried market in the East Plaza was constructed during the site's renaissance long after the AD 536 event and its attendant aftermath (Jones 2003:215). Tikal's array of short intrasite causeways and the total absence of any intersite causeways make it difficult to argue for the existence of a centrally controlled solar marketing system (see Smith 1976a, 1976b), though Robert Fry deduced the existence of decentralized, intrasite peripheral markets from distributions of ceramic types and varieties (Fry and Cox 1974). When a market economy is present (Garraty and Stark 2010; Hirth 1998), there is usually a more even distribution of wealth and status goods. However, William Haviland (1967) found osteological evidence for a growing food insufficiency that had set in among the bulk of the population at least by AD 550; Robert Fry (2003:166) found that class distinctions, as measured by the distributions of ceramics, were most pronounced during the Ik ceramic complex, circa AD 550–650. However, these interpretations are at odds with statements made by Hattula Moholy-Nagy (2003)

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to the effect that all manner of goods were imported from the surrounding region and from throughout Mesoamerica at this time and that these goods were found in both elite and common domestic contexts. The lack of a readily identifiable central market and of causeways geared toward ordinary pedestrian transportation (e.g., A. Chase and D. Chase 2003) suggest that Tikal's central government followed a rather laissez-faire policy in helping to create a complex economy as a response to scarcity until long after the AD 536 event.

Caracol

Caracol provides an interesting contrast. It has a dendritic array of some thirty-six causeways, totaling over 75 km of intrasite roads (Chase and Chase 2001). This internal road system connects the epicenter to an inner ring of outlying public plazas, some 3 km distant, that were built in conjunction with the terrace systems and reservoirs in the middle of the sixth century (A. Chase and D. Chase 2000:60; Chase et al. 2011). Whereas Tikal's causeways internally link public architecture, many of Caracol's causeways link with distant large plazas lined with smaller linear structures. Elite residential groups are usually linked to these termini by "spur causeways" (Chase and Chase 2001:276). These specially constructed Caracol termini plazas appear to have served some special-function administrative purposes at the neighborhood or barrio level. Included among these functions were marketplace activities (Chase and Chase 1998c), presumably taking place within a more elaborate solar market system (A. Chase and D. Chase 2004a). This interpretation is supported by abundant evidence for craft specialization within residential households and by the broad distribution of wealth and prestige goods (e.g., jade, obsidian, polychrome ceramics) across Caracol's residential groups (A. Chase and D. Chase 1996a, 2009b; D. Chase and A. Chase 2004a) belonging to a thriving middle level of society ("Middle Men," or *azmen uinic*, in the terminology of Chase and Chase 1992:11).

The Caracol archaeological data (Chase 1992; A. Chase and D. Chase 1998a, 2004a; Chase et al. 2011) suggest that many wealthy middle-level residential compounds are closely associated with terraces rather than being concentrated exclusively in the Caracol epicenter. This arrangement would suggest that at least some of this emergent middle group derived its wealth from their cultivation of terrace systems. It would seem that the boundary between a subsistence economy and the exchange sphere, in which preciosities circulated exclusively, was breached. Thus, Caracol's array of capital and labor-intensive causeways, terraces, and reservoirs—and the expansion of the midlevel of its

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society—give the impression that strong, centralized governance maximized local modes of production and exchange during the mid-sixth century, as a highly successful response to food demands.

Calakmul

A centrally directed, intraregional solar marketing system is also implied at Calakmul. Its large (> 4 ha) North Plaza not only resembles a central marketplace in its layout, but also contain a pyramid substructure that exhibits eighteen murals depicting everyday marketplace activities. In fact, glyphs associated with each mural identify different kinds of merchants (e.g., "He of the Corn," "He of the Atole," etc.). Ramón Carrasco Vargas and Marinés Colón González (Carrasco Vargas and Colón González 2005) and Sylviane Boucher and Lucia Quiñones (Boucher and Quiñones 2007) have dated the construction of the substructure with the murals to the latter part of the Early Classic period. The formal arrangement of permanent galleried structures in the site center gives the strong impression that it was constructed and managed under central direction. Calakmul's causeway system was not as well developed as Caracol's, but it had at least three known intrasite causeways; four intersite causeways are believed to have extended out from the site center to distances of 38, 24, 16, and 8 km (Folan et al. 1995:313). Other measures of market exchange (e.g., craft specialization, artifact distribution, and diversity among households) are not available, and it is unclear how deeply and broadly market exchange penetrated Calakmul's social order. Nevertheless, the North Plaza layout and murals suggest the existence of well-entrenched market activities at least at the intraregional scale.

Discussion: Interregional Exchange, Perennial Wetlands, and Bulk Transportation

Caracol appears to have been alone in supporting itself primarily by maximizing local resources; Calakmul much less so; and Tikal hardly at all. In the absence of solid evidence for agricultural intensification at Tikal and Calakmul, especially in terms of irrigation, the question remains as to whether or not they could have provided for themselves from within their respective regions. Or did they have to import food from further away?

Admittedly, there is no reliable metric to distinguish intra- from interregional exchange in highly perishable items such as food, but even the most conservative estimates of maximum tumpline distances (150 km according

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to Sanders and Santley 1983:246) would be sufficient to import foods from drought sustainable wetlands off the Peten Karstic and Vaca Plateaus. Robert Drennan (1984a, 1984b) suggests that importation was possible for food stuffs coming from up to 275 km away; and Andrew Sluyter (1993) suggests an even greater distance (however, see Gill 2000:76–79). Again, the question is not whether long-distance trade in basic commodities was practiced during normal times, but whether it was practical during periods of protracted scarcity and famine. Under such circumstances, the cost/benefit ratios would increase dramatically, making long-distance transport and market exchange attractive. Strong militaristic governments also would have been more amenable to conquest and coercion of taxes and tributes in the form of commodities and transport services.

Many of the previous estimates of the costs of transportation assumed that it was primarily autonomous producers who transported their own goods on their backs. This would have been an arduous and dangerous way to carry out voyages and portages. It is far more likely that caravans were organized and implemented by strong governments or midlevel merchants striving for efficiency and greater profitability. Transport costs would have been cut at this scale—that is, through the use of nonvoluntary and expendable porters and boatmen (slaves) who ate less and consumed fewer costly amenities of travel. Moreover, shelled corn would have been much less bulky to ship, but shelling would cut the shelf life of core by two-thirds—to only a year as compared to three years for unshelled corn (Freidel 2008b; Freidel and Shaw 2000; Smythe 1991). This meant that there had to be a constant flow of this commodity, rather than trade just during a single harvest season, and that there had to be mechanisms to rapidly disperse such goods to consumers in the absence of state-run or commercial granaries. That constant flow and rapid dispersal may have been facilitated in part because some strategic resources, maize, for example, were fungible and used as currency within the wealth-exchange sphere. Governments and wealthy and powerful merchants could accumulate wealth through trade, tribute, and taxation and then convert those wealth items back into food (Freidel 2008b; Freidel and Shaw 2000). Finally, "It is hard to imagine trade caravans in Classic Mesoamerica moving securely without the kind of military backup implied for the Postclassic and Contact-period professional traders, particularly in light of the clear evidence of endemic war in the Maya case" (Freidel, Escobedo, and Guenter 2007:192).

But where could huge amounts of food surpluses have been generated during drought episodes? Throughout the Maya lowlands, the only terrains that were insulated from drought were perennial wetlands lower than approximately

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eighty meters above sea level (Pope and Dahlin 1989, 1993). Water that percolated through the porous limestone in the center of the peninsula is mounded and forced through deep subterranean caverns through hydrostatic pressure to ultimately drain out of punctures (springs) through a thin confining limestone layer or from river waters near sea level (Perry, Velázquez-Olimán, and Socki 2003; Villasuso and Ramos 2000). Seasonal changes in water levels here are of low amplitude, leaving perennial wetlands along river flood plains and low spots amenable to producing two to perhaps three crops annually on raised fields. Thus, substantial quantities of food surpluses might have been generated in raised field zones along the lower courses of all the karstic rivers and other low-lying wetlands on both the Caribbean and Gulf of Mexico sides of the peninsula (Dunning et al. 2002; Siemens and Puleston 1972; Siemens 1982; Turner and Harrison 1983).

Canoes are a more efficient mode of transporting bulk commodities; they can go swiftly and more easily over vastly longer distances than human tumplines, but they have rarely entered Mayanists' calculations. Ross Hassig (1985) estimated that small canoes in the lakes of the Central Plateau in Mexico could carry forty times what a man could carry on his back with a tumpline. Bartolome Colon reported in 1502 that he had encountered dugout canoes almost three meters wide that easily carried crews of twenty-five (Edwards 1978:201; Piňa Chan 1978:39); Cortes reported that lake- and sea-going canoes carried as many as sixty-four men (Richard Adams 1978). Not only would the volume of goods be immensely greater in cargo canoes, but the distances over which food could be transported also would be increased. Lenore Santone (1997:84) estimated a 200 percent increase in the mean distance that Colha chert could travel by waterborne transportation. Scherer, Vásquez

The Usumacinta is essentially a nonkarstic, seasonally fast-moving river that has enormous water-level fluctuations over much of its length; changes in water levels after rains can be as great as twenty-five meters in a single day (Gunn and Folan 2000:235). Portages are necessary between the falls and rapids below Piedras Negras from the Gulf of Mexico. From Piedras Negras, it was possible to go to Seibal on the Pasion River before a four-day portage to Tikal and perhaps another three days more to Calakmul (see also Demarest, Chapter 9 in this volume). Continuing on riverine routes from the Pasion up the San Jan River could get to within a three-day portage of Caracol (A. Chase and D. Chase 2012; Laporte et al. 2008). Today a trip from the Gulf coast to Tikal would take about twenty-one days (Richard Adams 1978:33). However, trade along the Usumacinta also depended on amicable relations between the sites along the way, especially between Piedras Negras and

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Yaxchilan, which were increasingly antagonistic around AD 600, to the point of seriously restricting riverine trade here (Golden, Scherer, and Vásquez et al. 2008; Scherer and Golden, Chapter 10 in this volume).

Well before the rapids near Piedras Negras, a gentler Usumacinta is fed by the San Pedro Martir. Early Classic Tikal had access to its headwaters via a port at Waka or El Peru (Freidel, Escobedo, and Guenter 2007). Calakmul also had access to a northern branch of the San Pedro via La Corona. It would be interesting to see how far these rivers were actually navigable when today's surrounding wetlands were less silted in during the sixth century. We would guess that it was much shorter, less costly, and less risky to get to Tikal and Calakmul by means of the San Pedro Martir than by the twenty-one days required by the Usumacinta/Pasion/overland route. Interestingly, raised field complexes have not yet been reported along the San Pedro Martir River. Calakmul, however, was located approximately 92 to 100 kilometers from numerous complexes of raised fields on the Rio Candelaria (Gunn and Folan 2000; Siemens and Puleston 1972).

All three sites had roughly equal riverine access on the Caribbean side of the peninsula to perennial wetlands and navigable rivers via the Belize, Hondo, and New Rivers. The trip to Tikal would take approximately 12 days on the river, plus 4.5 days for the final portage, for a total of about 17 days (Richard Adams 1978). The trip to Caracol was probably a bit faster, 12 or 13 days up to the final portage, which is estimated to be only fifteen kilometers away, for a total of perhaps 14 or 15 days (see also Cunningham 2011). Kathryn Reese-Taylor (2003) also observed a navigable passage between the New and Belize Rivers during rainy seasons; thus, it seems possible that the end portages of these voyages might have been shortened if their bajo headwaters were not as silted in as they are today.

In sum, the riverine routes most amenable to bulk transport of foodstuffs were the Candelaria and San Pedro Martir on the Gulf of Mexico side, and the Hondo, New, and Belize Rivers on the Caribbean side. Well-managed fleets of cargo canoes and porters could have carried large amounts of food—perhaps several times a year—up these rivers to Tikal, Caracol, and Calakmul, within a matter of two or three weeks.

Significant questions remain concerning the institutional mechanisms by which these food supplements would have been obtained from drought-protected raised field zones. Given their potentials for yielding two or even three harvests per year, one would expect to find dense settlements ringing these perennial wetlands if these crops were consumed locally or regionally. However, with the possible exception of Lamanai, extremely large and dense

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settlements are not in evidence, even in the largest areas in Quintana Roo, strongly suggesting that either they were not farmed intensively or that crops were produced primarily for export. Another paradox is that if enormous amounts of food were traded out of the raised field areas, one would expect to find extraordinary wealth in caches, burials, and refuse; certainly at the elite level, and almost certainly at lower levels as well. With the possible exception of Altun Ha (Pendergast 1979, 1982, 1990), evidence for such wealth is not overwhelming in the eastern coastal lowlands of Belize. It is also not in evidence with respect to Colha's and La Pedernal's well-known long-distance trade in chert eccentrics, stemmed macroblades, and thin bifaces (Speal 2009), even though both sites have easy access to riverine and coastal trade routes. Similarly, Patricia McAnany et al. (2002:134–35) wonder whether cacao production along the Xibun River in central Belize was for exchange or whether it was coerced and expropriated. Because of the heavy investment in transportation and security, it is possible that the large inland sites managed to control the terms of trade and impose their own price controls on corn, eccentric cherts, cacao, and other items, thus, keeping productive populations in the perennial wetlands both small and poor. Another possibility asserts itself, however: these areas may have been conquered and forced to produce food for export to foreign entities.

Discussion: Warfare and the AD 536 Event

Intersite warfare was both episodic and endemic during the Late and Terminal Classic periods, as indicated in dated inscriptions on public monuments (e.g., Rice 2003:table 8.2). The reasons for instigating these wars, and even their lethal nature, are a matter of some debate (Rice 2003). Although many researchers have concluded that most wars are, and were in premodern societies, fought over material resources (e.g., Ember and Ember 1992, 1994; Keeley 1996), Maya archaeologists have emphasized disputed dynastic succession, status rivalry among elites, ritual combat on and off the ballcourt, and protection of trade routes along which preciosities were transported (however, see A. Chase and D. Chase 1989, D. Chase and A. Chase 2002, 2003a; Dahlin 2000; see also Demarest, Chapter 9 in this volume).

There are reasons to believe that the wars of the sixth century were motivated by material concerns. First, the defensive earthworks at Tikal demonstrate a unique desire to protect an urban population's agricultural resource base within an area of 123 square kilometers, not just the living and ceremonial spaces of a small elite faction in the site nucleus. Second, ca. AD 530, the

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palaces and homes at Rio Azul were burned and abandoned, its elites publicly executed, tombs looted, and its monuments mutilated and burned (Adams 1999:144, 168). Rio Azul had been a key port (Andrews 2008) presumably under the direct control of a Tikal-appointed governor prior to this time. Moreover, the population inhabiting the Three Rivers region downstream plummeted from an estimated 130,320 to 34,761 people—a 73 percent reduction (Adams et al. 1999:196). Third, the conquest of Tikal in AD 562 resulted in the effective disappearance of that site's elite and the rise of an even stronger Caracol polity.

It may be speculated that the carnage at Rio Azul and in the Three Rivers region resulted from Calakmul gaining control of the Rio Hondo and its access to raised field zones on the Caribbean side. The depiction of many captives at El Resbalon as early as AD 529 near the Kaan's Early Classic power base at Dzibanche demonstrate the existence of such warfare in this area at this date (Velásquez García 2005). A series of other major war events are noted through the Southern lowlands in the sixth century (Chase and Chase 1998b; Martin and Grube 2000:72, 104; Mathews 2000; Sharer and Traxler 2005:358; Schele 1994:1–2;). These events suggest both the existence and interaction of a series of highly militarized states in the last two-thirds of the sixth century (see Chase and Chase 1996b; 1998b; Chase, Chase, and Smith 2009). Upland zones could be controlled by political alliances or deploying armies of occupation within reasonable logistical ranges (see Chase and Chase 1998b), as well as by periodically deploying smaller "strike forces" to terrorize more distant peoples into complying with tax and tribute standards (Chase, Grube, and Chase 1991). Thus, public beheadings—possibly such as Tikal's enactment of an "axe" event at Caracol in AD 556—or massacres and the desecration and sacking of sites on a horrific scale—such as that at Rio Azul and in the Three Rivers region—would serve as terrifying object lessons for those who might contemplate rebellion or not paying their tributes or taxes (also see A. Chase and D. Chase 1989, 2000:62; Robichaux 2000:51).

Calakmul's most ostensible strategy for development was to control navigable waterways and agriculturally productive perennial wetlands. The first appearance of the Kaan dynasty at Dzibanche is particularly telling as it is situated between Bajo Morrocoy and Bajo Acatuch, which at 2,460 square kilometers together contain the largest raised field complexes in the entire Maya lowlands (Harrison 1978:251). At Calakmul the dynasty would have gained easier access to the Rio Candelario's raised field complexes and the gulf coast maritime trade route. It could also avoid the inherent problems of moving goods along the Usumacinta through its use of La Corona (and possibly Waka) near the headwaters of the San Pedro Martir. Furthermore, it put itself

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in a better position to control the Hondo and New Rivers. Thus, Calakmul's control of these waterways would have enabled it to exercise military hegemony over large and highly productive areas from which tribute in food could be extracted and transported, especially during extended drought periods.

CONCLUSIONS

What is called the "Maya hiatus" came into the literature largely as an accident of archaeological research. Although the lack of dates from this time were recognized early within the carved stone record (Proskouriakoff 1950), archaeology at Tikal—the most intensively investigated lowland Maya site from the 1950s through the 1970s—seemed to confirm the existence of this problematic period. Generally, the sixth century was a turning point architecturally, ceramically, and in other artifact categories at Tikal. Nonetheless, virtually nothing was known about the cultural dynamics of Caracol and Calakmul until the 1980s and 1990s. However, at this point archaeological data and environmental contexts suggest that each of these site's variant developmental trajectories in the sixth century can ultimately and plausibly be attributed to the AD 536 event.

Early Classic Tikal was ill prepared for drought and failed to respond effectively. In spite of the fact that families, kin groups, and neighborhoods may have responded individually, the aggregate of these small-scale responses are hardly visible in the archaeological record. There is also little evidence that a central government responded to the onset of severe and prolonged drought conditions through practical measures, beyond some evidence for systematically improving potable water collection and distribution capacities in the epicentral reservoirs. Nor is there any convincing evidence for agricultural intensification on a communitywide scale. Market exchange does not seem to have been strengthened by government efforts at building and managing marketplaces or constructing networks of roads. For example, the East Plaza did not serve as a central marketplace until much later. Instead, during the sixth century, Tikal market exchange seems to have been relegated to small decentralized peripheral marketplaces. Even the partially constructed earthworks look like they were built by amateurs who knew little about warfare. And, by AD 562, Tikal had been reduced to a client state.

Tikal's own populace was probably complicit in its fall. In the ancient world, divine state rulers were almost universally believed accountable for all that happened in the natural, spiritual, and social realms. To that extent, Tikal's Jaguar Paw (Chak Tok Ich'aak) dynasts, who for centuries loudly proclaimed sacred powers on their public monuments, must have been blamed for the

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weird, unprecedented atmospheric events during the first three years of the AD 536 event and their devastating effects afterward (see also Aimers and Iannone, Chapter 2 in this volume). The political elites of subject sites probably severed their ties and ritually destroyed, defaced, or hid the public monuments that once had publicly celebrated their alliances with the now-impotent power center. Epigraphic records suggest that just ten years after the AD 536 event, Tikal proved itself incapable of holding on to the strategic site of Naranjo. Within another fifteen years, it was itself subjugated by Caracol.

On the other hand, the cities of Caracol and Calakmul used the crisis as an opportunity to build more elaborate and sustainable infrastructures. Caracol's response pattern was centered on gaining food security for its people by blanketing the city with new water storage and distribution systems, improving the area that could be cultivated by focusing on the construction of terraces, stimulating reserves and surpluses destined for intraregional market exchange, and improving intraregional transport through a new network of roads. It may also have increased imports of some bulk foods from beyond the region, either through trade or tribute, from raised field areas down river on the Caribbean littoral. Calakmul's most pervasive and ostensible response to the onset of severe drought was warfare, conquest, alliances (perhaps forced), and exacting tribute from the relatively unaffected perennial wetlands along the lower courses of the rivers on both the Gulf coast and Caribbean coastal plains, in the interior bajos of Quintana Roo, and along waterways that it would virtually monopolize. It went further than Tikal in improving its potable water management system, but did not fully intensify agricultural production within its surrounding area. And, like Caracol, it developed a solar market system to generate, attract, and distribute agricultural reserves and surpluses. Unlike Caracol, whose solar road system was internal to that primate site, Calakmul's road system largely ran between sites and integrated a broader region.

This first approximation scenario challenges some long-held assumptions about Classic Maya political economies. Perhaps one of the most troublesome challenges is that this scenario conceives of the majority populations of these three cities as at least partially dependent on economic exchanges with "outsiders," rather than comprising what are normally perceived as more or less self-sufficient "island states" or "isolated states" on some idealized version of a von Thünenian uniform plain. Indeed, if one's database is confined to glyphs and iconography on public monuments and elite artifacts, one could be easily beguiled into thinking that the primary or exclusive interactions between such centers took place only at the elite level—for example, elite warfare, elite marriage alliances, and access to trade routes in which only precocities traveled

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for elite consumption. However, the desperation that the AD 536 event likely caused on all societal levels should stimulate the application of more bottom-up approaches that are more likely to be supported by the archaeological, paleoenvironmental, and geochemical records, as well as more capable of helping us imagine a more interconnected, interdependent, but less-homogenous Maya world.

This long "just-so" story is admittedly fraught with data and interpretive problems; that is to be expected of a first approximation model. Despite these difficulties, however, the temporal proximity of such a demonstrably abrupt, broad-scale, intense, and potentially devastating drought as the AD 536 event to the momentous culture changes that occurred in the mid-sixth century argues that this is not mere coincidence. No other interval witnessed such cultural convulsions except the infamous Terminal Classic collapse. The divergent responses of the three cities further demonstrate that the interaction between climate and culture cannot be reduced to a simple cause-and-effect relationship. Instead, the juxtaposition of these radically different response patterns to virtually the same climatic event shows clearly that key characteristics of social, political, and economic systems are equally as important to adaptive outcomes—if not more so—as the environmental event itself (e.g., Dahlin 2002; Oliver-Smith 2009).

ACKNOWLEDGMENTS

Bruce Dahlin originally sent a draft of this paper to Arlen Chase, who commented on it, had lengthy phone conversations with Bruce over the content of the paper, and suggested its placement within this volume. Dahlin's untimely death precluded his being able to revise the text in response to reviewer's comments and critiques. Arlen Chase, with editorial assistance from Diane Chase, restructured and edited the paper; hopefully, this final version has stayed true to Bruce's original intent while strengthening the arguments that he made. In his original acknowledgment, Bruce Dahlin gave credit and thanks to Arlen Chase, William Folan, Richardson Gill, Joel Gunn, and Lisa Lucero for making important criticisms and comments. Bruce's scholarly contributions to the field of Maya studies will be sorely missed.

NOTES

1. Also see R. B. Stothers 1984 and C. A. M. Nooren et al. 2009. The latter study documented an eruption of Volcan Chichon in Chiapas with a Volcanic Explosivity

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Index (VEI) of 2–3 in sediments from the Usumacinta-Grijalva river delta ca. AD 539, which might have exacerbated the AD 536 atmospheric disturbances but probably did not cause them.

2. The event is not seen in other lake cores in the lowlands at this time, but this short climatic episode could have been easily missed for a variety of reasons, including sampling or the obscuring of evidence by human disturbance factors (Deevey et al. 1979), or the drought might have affected some areas more than others.

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