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Evolution of Maya Polities in the Ancient Mesoamerican System

Claudio Cioffi-Revilla

University of Colorado

and

Todd Landman

University of Essex

The analysis of politics in antiquity presents new opportunities for political science and international relations, particularly the ancient New World (*c*. 2000 B.C. to A.D. 1521). Governance through leadership and institutions, collective action, war and peace, alliance dynamics, regional hegemonies, interstate rivalries, and other universal patterns of world politics existed in Mesoamerica, antedating the modern state system. We report findings from a study to record systematically the rise and fall of Maya polities in the Mesoamerican political system, using sources from archaeology and epigraphy. Based on tests of competing hypotheses and new distribution statistics and hazard rates (survival analysis) for 72 Maya polities, our findings support a model of Maya political dynamics based on Preclassic origins, punctuated phases of development, multiple cycles of system expansion and collapse, and weaker political stability for increasingly complex polities. We draw two main implications: (a) a new theory of the Maya political collapse(s), based on their failure to politically integrate; and (b) confirmation for a new periodization of Maya political evolution, different from the traditional cultural periodization, based on several cycles of rise-and-fall, not just one. Our findings may also make possible future investigations in areas such as the war-polarity and war-alliances hypotheses.

When and how did world politics begin in the New World? How did the first polities form? Which were the first "states" of the New World and how did they interact? What can political science in general, and comparative and international politics in

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particular, contribute to a better understanding of these and related puzzles? With respect to the Maya, why did the system collapse when it did? Why did it collapse in such a precipitous mode? Did it collapse just one or several times? The Mesoamerican system of Maya polities was one example of a system of sovereign, autonomous, interacting polities in the New World, a "proto-political" (pristine) system. Other early examples were Monte Albán and Teotihuacán in the New World. In the Old World, Mesopotamia and China also spawned pristine polity systems. As one prominent Mayanist notes, "since 1960 we have moved Maya archaeology and texts from myth to history" (Marcus, 1996). Although much speculation has characterized our thinking on the evolution of Maya polities, few if any studies have measured and compared their evolutionary rise and fall as a cohesive political system, using the most valid and reliable data available today. The systematic measurement and comparison of Maya polities are important because they will advance our understanding of early political dynamics and their comparison with the modern system of world politics. In the last thirty years, archaeology, epigraphy, and ethnohistory, together with other allied sciences and humanities, have begun to show a more precise (albeit disciplinarily fragmented) understanding of the long-range evolution of the Maya and other early polity systems.[1] Our new data set and analysis builds on these earlier efforts from anthropology and proposes some new ideas for testing competing explanations using political science theory and research methods.

In this six-year study we developed a new data set to measure and compare the rise and fall of individual Maya polities, including all those that eventually evolved into major states, obtaining the first distribution statistics and associated survival analysis results. Our measurement used primary, secondary, and tertiary sources, provided by contemporary archaeological, ethnohistorical, and epigraphic evidence. Our main findings and tests of competing hypotheses, based on the identification of 72 Maya polities with sufficiently accurate dates of formation and termination, support a model of Maya polities based on Middle Preclassic origins, punctuated phases of development, multiple cycles of expansion and collapse, and weaker political stability for more complex polities (Classic period states). Some Maya polities—called "emblem glyph" sites for their prominent political ranking—may have been comparable to modern "major" or "medium" powers, although their political stability was lower than that of lesser polities. As in other regional political systems elsewhere in the ancient world (viz., in the Near East or China), Maya polities in the Mesoamerican system formed, evolved, and conducted comparable patterns of governance, trade, rivalry, warfare, hierarchical relations, and alliances, and had other defining hallmarks of world politics. On the basis of our empirical findings and comparative considerations about other polity systems, we also propose a new political theory of the ninth-century Maya collapse, as well as a new periodization of the Maya system history based on its political evolution.

[1] We use the term *polity* in the strict sense of political science, meaning a society's system for governance (often akin to "political system"), as explained in greater detail below; it includes what anthropologists call "chiefdoms" and "states," but not less complex polities. This should not be confused with the use of the term *polity* in archaeology and social anthropology, where it can also mean a far more complex, hierarchical, multi-urban political system (a regional and territorial unit that comprises many sites) based on locational and gravity models from economic geography (Renfrew, 1984:24–77; Sharer, 1988). A polity can be as simple as a chiefdom or as complex as an empire.

Background

Chiefdoms, city-states, territorial states, kingdoms, empires, and other sedentary polities or systems of government—our study does not cover nomadic societies—have existed for millennia before the emergence of the modern nation-state system (Cioffi-Revilla, 1991, 1996; Frank and Gills, 1993; Hall and Chase-Dunn, 1995). Politics as defined by political scientists—social behavior concerning the governance of collectivities (Riker and Ordeshook, 1973; Brams, 1985), including the authoritative allocation of values and the solution to collective action problems—originated with the first chiefdom-level sedentary societies that formed in the Near East (Mesopotamia and Egypt), China (Yellow River basin), Mesoamerica (Mexico and Central America), and South America (Chavín). In the Middle East, the fortified foundations of Jericho—dated *c*. 8000 B.C. (Roper, 1975; Kenyon, 1979)—are among the oldest still in existence, indicating a minimal antiquity of *c.* 10 millennia. Extensive warfare and political interactions among polities in the Old World certainly existed by 4000–3000 B.C., by which time *Homo sapiens sapiens* began the transition away from hunting and gathering and formed the first stable polities (Stein and Rothman, 1994; Cioffi-Revilla, 1996). A conservative estimate for the earliest existence of regional political systems or earliest international systems—areas of civilization containing several organized polities with regular interaction among them—is therefore *c*. 4000 B.C., beginning in the Sumerian area (present-day Iraq; Algaze, 1993). Wesson (1978:vii, 11) calls such a regional cluster of polities a "state system," defined as "a group of closely interacting and therefore competing independent sovereignties that collectively dominate their world . . . and for whom interrelations are comparable in importance to domestic affairs." However, the earliest regional polity systems originated with chiefdoms and later included states and eventually empires.[2]

Contemporary political science in general and the fields of comparative and international politics in particular have paid only scant attention to these pre-modern polity systems (Modelski, 1964; Taagepera, 1968; Hernes, 1975; Wight, 1977; Brams, 1980; Wilkinson, 1986; Thompson, 1988; Midlarsky, 1992, 1995; Cioffi-Revilla, 1991; Russett and Antholis, 1992; Buzan and Little, 1994; Ferguson and Mansbach, 1996), although we are beginning to discover that they manifested the same universal features of world politics as the modern international system—warfare, alliances, rivalries, hegemony, diplomacy, summitry, deterrence, or trade.[3] This gap is lamentable, and in the case of Maya polities, even prominent historical atlases incorrectly report their chronology (Hammond's *Historical Atlas of the World*), or fail to report their existence altogether (Rand McNally's *Atlas of World History*). Until recently, these pristine regions of politics were viewed as too difficult or impossible to analyze with any scientific accuracy. A major deficiency has been a basic data set of actors and system membership, as comprehensive as possible, to serve as a framework for adding more theoretically significant variables as new information becomes available.[4] Recent advances in chronology, epigraphy, remote

[2] By convention, a "chiefdom" is a polity (political system) with centralized power (held by a chief), ranked status differences, a ritual or ceremonial center, 2- or 3-tier settlement hierarchy, unreliable control of surrounding territory, and population in the range 5–20,000 persons; in addition, a "state" has centralized institutions, hereditary rulers, reliable control over its own territory, coersive use of force by leaders, and a settlement hierarchy with 4 or more tiers (Service, 1971; Earle, 1991, 1997; Stein and Rothman, 1994; Wasson, 1994; Marcus and Flannery, 1996; Rothman, 1998).

[3] Studies by Austin (1893), Carneiro (1970), Eisenstadt (1985, 1993), Eisenstadt, Abitol, and Chazan (1987), Ferrill (1985), McNeill (1993), Wesson (1978), and Wittfogel (1957)—most of them not produced by political scientists—are among the few existing works on the origins of polities in the ancient world. Some are outdated (empirically and conceptually) by recent research advances (Wright, 1977; Spencer, 1990; Willey, 1991; Marcus, 1992; Midlarsky, 1996, 1998).

[4] Earlier attempts to assemble data sets are found in Culbert (1991) and Lowe (1985), both important at the time but now in need of updating.

sensing, DNA scanning, computer-enhanced photogrammetry from satellite reconnaissance, and other interdisciplinary efforts in allied disciplines (e.g., archaeology, anthropology, history, and ethnography), together with advances in political science theory and methodology, now make it possible for comparative and international politics researchers to analyze for the first time some of the earliest space-time regions of politics, to better understand the present world system, how it first formed, and its past evolution.

Similar to modern international systems, ancient international systems also consisted of polities and relationships among them, but lacked international institutions and other modern structures. Mesoamerica witnessed the first international systems in the New World, initially during the rise of the Zapotec (Marcus and Flannery, 1996), followed by the rise of the Teotihuacán state (Millon, 1981, 1988). The rise of the earliest Maya polities began with chiefdoms around 800 B.C., in the so-called Middle Preclassic period (Hammond, 1988, 1992; Sabloff, 1989; Sharer, 1994; Adams, 1996), a pattern that we measured with basic statistical techniques and methods from survival analysis.[5] Polities such as El Mirador, Copán, Tikal, Kaminaljuyú, Uaxactún, and Lamanai were among the first powerful polities ("chiefdoms," archaeologically) of this early period. After A.D. 200–300 states emerged at Tikal and Calakmul, while others like Quiriguá, Chichén Itzá, Mayapán, and Tulum flourished much later, during the Classic and Postclassic periods. Of these, only Tulum and a few others were still inhabited when the Europeans arrived in the sixteenth century A.D.

> How large were the great cities in terms of size and population? Tikal and Calakmul are the largest of all Maya sites and have been completely mapped down to the last house mound, although in view of the difficulty of drawing boundaries around any settlement of the lowlands it is hard to say exactly where it ends. At Tikal, within a little over 6 square miles, there are about 3,000 structures, ranging from lofty temple-pyramids and massive palaces to tiny household units of thatch-roofed huts. Estimates of the total Tikal population in Late Classic times vary all the way from 10,000 to 90,000 persons. If one accepts the latter figure, which many Mayanists think is the most likely, this would mean a density higher than that of an average city in modern Europe or America. (M.D. Coe, 1993:93)

Sharer (1994:1) estimates that "some 100,000 people lived in and around Tikal during its prime, twelve hundred years ago."

In addition to generating one of the earliest regional political systems in the Western Hemisphere—the Olmec and Chavín polities developed earlier, but are not as well documented, and the Aztec and Inca empires developed approximately five centuries later—Maya polities are also important to the study of organized warfare, alliances, summitry, and other political patterns in Mesoamerica (Hassig, 1992). As recent empirical evidence confirms, at different times in history, human society spawned several pristine areas of world politics; in Mesopotamia, China, Mesoamerica, South America, and perhaps a few other areas (Indus Valley, Nile

[5] Although Olmec chiefdoms and Zapotec chiefdoms antedate the Maya, not enough is known about Olmec polities to permit much systematic investigation (Grove, 1997). By contrast, the Maya polities constituted a genuine political *system*—comprising both chiefdoms and states after A.D. 250—because these polities were not only organized with internal cohesion, authoritative institutions, and a resource base, but were also mutually interrelated (systemically organized) through common forms of world politics relationships such as rivalries, warfare, alliances, commercial trade, diplomacy, and regional hegemonic hierarchies.

Valley). As pristine (as opposed to diffused) areas, these consisted of independent regions of the world, Mesoamerica being the most recent, where international politics first spontaneously occurred. These regions were also "innovation areas" in human history (McNeill, 1979), consistent with contemporary theories on polity formation and political evolution (Carneiro, 1970, 1987). Among these universal patterns, "conflict is regarded as an important mechanism in the generation of 'pristine' states, including Highland Mexico, Mesopotamia, China and Peru" (Webster, 1977:335–36; see also Marcus, 1993; Keeley, 1996).[6] Therefore, Mesoamerica in general—and the Maya system of polities in particular—warrants greater attention by political scientists, as one of the few pristine areas of international politics in human history.

From a comparative perspective, the Maya system of polities (chiefdoms and states) never produced a single integrated political unit, or "empire," unlike the Aztecs and Incas in the same hemisphere, or other civilizations in the Old World. From its beginning with chiefdoms during the Preclassic period (the first states date from the Early Classic) up to the time of the Postclassic period and the European conquest, the Maya system of polities fluctuated like a kaleidoscope of regionally centralized and decentralized local polities, perhaps somewhat like the Chinese warring states system (464–222 B.C.) or the Italian city-states system, although considerable debate endures about these analogies. Significant exceptions to this general political situation occurred with instances of regional conquests (e.g., by Aguateca–Dos Pilas, Caracol, Mayapán, or Tikal) and several vassal relationships (as perhaps between Tikal and Cobá, or Copán and Quiriguá). According to Marcus, the evolution of Maya polities was characterized by "many rises and many falls" (1993:168), such that "at least four [regional] polities had major capitals, such as Palenque, Calakmul, Tikal, and Copán. For a while, after A.D. 752, Yaxchilán administered a similar [regional] polity. At various times the Petexbatun region was administered by Dos Pilas, by a confederacy headed by Dos Pilas and Aguateca, or by Seibal" (1993:151). In the northern Maya Lowlands, powerful regional polities included the Puuc polities (*c*. A.D. 950), Chichén Itzá (*c*. A.D. 900–1000), and Mayapán (*c*. 1400). Thus, the Maya system represents a regional international system that operated in isolation from the rest of the Old (Afroeurasian) World until the sixteenth century A.D., but not in isolation from the rest of Mesoamerica (Hammond, 1991a:254). This was a system composed of chiefdoms and states, where multipolarity and enduring rivalries, along with policies of deterrence and compellence, were common throughout its history and where a unipolar hegemonic empire never formed.

When did the first Maya polities of the ancient Mesoamerican system first form? How did the pattern of Maya system size or membership evolve over time? How would such a pattern in political evolution compare with the extant periodization of Maya history? What do these new findings suggest for the enduring puzzle of overall Maya civilizational collapse? This study offers some preliminary answers to these and related puzzles, based on a newly collected data set and the application of political science perspectives to broaden and advance our disciplinary horizons.

[6] Warfare also played an important role in the origin of the Zapotec (Monte Albán) polity system (Marcus and Flannery, 1996; see also Ferguson, 1984:13–14, and Fiedel, 1992, for overviews of the opposite "diffusionist hypothesis" that warfare resulted from learning as an "invention" [Mead, 1964].

Method

Data and Measurement

Methodologically, this study consisted of a cross-sectional and cross-temporal comparative analysis. The geopolitical area consisted of the Maya lowlands and highlands—that is, the Yucatán Peninsula, the Mexican state of Chiapas, northwestern Honduras, and all of Guatemala, Belize, and western El Salvador (Coe, Snow, and Benson, 1986:126; National Geographic Society, 1989a, 1989b; Marcus, 1993; Stuart and Stuart, 1993:14–15). The total territory covers nearly 250,000 km^2 consisting of tropical jungle, marshlands, and mountain forest (Hammond, 1991a:2). Our definition of the Maya area is thus based primarily on the distribution of Maya languages at the time of the Spaniards' arrival in the sixteenth century, given the problems presented by other criteria (e.g., material culture or system of writing).

The time period covers a span of 2,500 years, from *c*. 800–900 B.C. when the first reliably measured Maya polities were founded (chiefdoms in the Copán Valley and Maya Lowlands), to *c*. A.D. 1700 when the last Maya polities fell (Tayasal and Tulum). Following the traditional Mayanist periodization, this long era covers three cultural periods: Preclassic or Formative (1500 B.C. to A.D. 250), Classic (A.D. 250 to 900), and Postclassic (A.D. 900 to 1530). In turn, the Classic period is divided into Early and Late Classic, divided at A.D. 600. This traditional periodization of the Maya civilization is based on "dirt" archaeology (viz., ceramic chronology and architectural stratigraphy), radiocarbon dating, epigraphy, and native traditions (ethnohistory) recorded during the Late Postclassic period.

The cases in our data set consist of Maya polities with simple (chiefdoms) and complex (states) levels of political development. Operationally, each case shows evidence of public life (civic or ceremonial), often including urban layout, indicative of social ranking, centralized government, and collective action problem-solving. Chiefdoms and states are simple and complex polities, respectively, based on these ordinal dimensions. Thus, Maya polities constitute a small subset of the thousands of presently known and officially recorded Maya sites.[7] Included in our study were all known Maya polities (not merely sites) for which we were able to obtain sufficiently reliable formation and termination dates. As detailed below, a total of 72 polities (archaeological sites) were identified and within this set, 28 had the rank of "emblem glyph" polities—politically prominent centers with their own "place name," or *toponym* (Marcus, 1976, 1992a, 1993; Mathews and Willey, 1991:19–29; Stuart, 1992).[8] The other 39 cases were polities with no known emblem glyph. Given some lingering uncertainty among Mayanists on the precise meaning of emblem glyphs, we cautiously use such information only as a plausible indicator of higher political status, not as a basis for drawing any stronger inferences (such as boundaries between polities).

As detailed in the Appendix, we used primary, secondary, and tertiary sources to measure the dates of polity formation and termination. When inconsistent or contradictory information was encountered, greater credibility was given to the more specialized or detailed source. For example, Sharer (1994) was weighted more

[7] Non-polity sites (other archaeological locations that do not meet our operational definition, also called "features" within a "site") excluded from this study include stone walls, water holes, cultivation fields, stone quarries, roads, raised causeways, port facilities, bridges, and other archaeological remains scattered across a vast area, including some named sites such as Chichén Itzá's seaport at Isla Cerritos, the Naj Tunich cave in the Maya Mountains, and the Montículo de la Culebra in Guatemala City.

[8] An emblem glyph denotes both a political title and a place name, such as "Lord [*ahau*] of Place *X*" (Marcus, 1976, 1992a:182 et seq., 1996:7; Stuart, 1992:43), so we urge caution in the interpretation of emblem glyph polities as having greater power.

heavily than Villacorta (1938), and Marcus (1993) over both Berlin (1958) and Marcus (1973), without denying the latter's seminal value. Data were also collected by the first author in separate field trips to the Yucatán Peninsula, Chiapas, Guatemala, and Honduras between 1991 and 1995.

The entire data set was reviewed by a panel of collaborating Mayanists, often more than once, making corrections as necessary (see acknowledgments in Table 1). However, two limitations of our data must be considered, given the nature of archaeological and epigraphic information. First, we made every attempt to be as accurate as possible, but complete accuracy cannot be guaranteed in this type of measurement. We estimate the average accuracy of our dates to be within an acceptably small range of the dates reported, based on the extant evidence. This margin of error (at most ± a few decades) is sufficiently small for the statistical analyses we conducted, considering that the total span covers over 2 millennia (i.e., approximately 3.8 %), and the nature of the aggregate, system-level hypotheses we tested. Second, Maya studies are undergoing significant developments, so a similar study conducted several years from now may yield new results. Nonetheless, the accuracy attainable today warrants this first study.

Variables

Based on rise and fall dates, we measured four variables directly linked to the evolution of polities in a political system: (1) the *duration* of polities, denoted by D; (2) the *system size* N, or number of existing polities in the system; (3) the *hazard rate* of polities relative to their duration $H(\delta)$; (4) the *stability* of polities based on the *exponential ratio* of uncertainty, σ^2/μ, which measures the stochastic structure of D (i.e., the hyper-exponential, exponential, or hypo-exponential form of the distribution);[9] and (5) the *half-life* (median value) of polity duration ψ. Note that duration alone is not a measure of stability, which is a more dynamic property. Together, this set of variables describes the evolution of a political system across epochs, providing a basis for theoretically explaining why, how or when change occurred.

The first three of these variables are the most important since the stability coefficient σ^2/μ and the half-life ψ are derived from these. The *duration* δ_i of a polity i—a value of the stochastic variable D—is defined as the length of time elapsed between its formation and termination dates (t_f - t_0), where $i = 1, 2, 3, \ldots, n$. For example, using W.R. Coe, 1990,

$$\delta_{\text{Tikal}} = \text{A.D. 919–200 B.C.}$$

$$= 1{,}119 \text{ years.}$$

In turn, using the principle of operational substitutability (Most and Starr, 1989; Cioffi-Revilla and Starr, 1995), the formation date (t_0) is operationally estimated by the occurrence of equivalent morpho-political events that indicate the presence of an authoritative government or collective action problem-solving (whether imposed or voluntary) at a politically significant level, normally chiefdom level. Equivalent events in the formation of a polity include the erection of public monuments (e.g., stelae and other lithic works), the construction of civic structures (temples, palaces, plazas, ballcourts, terraced platforms), fortifications (walls, moats, towers, ramparts), or other comparable developments (large-scale hydraulic engineering works, elaborate burials). For example, the formation date for the Becán polity (case no.

[9] The statistic σ^2/μ provides a measure of stability for a set of durations, in addition to the form of the empirical hazard rate function, similar to the way in which various statistics measure the central tendency of a distribution.

28 in Table 1)[10] was established at *c*. 150 B.C. because this is somewhat prior to the date when the first elite center was constructed and Structure IV-sub, some 15 meters high, was built (Andrews, 1976; Andrews et al., 1979; Thomas, 1980). The mere construction of household dwellings or the existence of agricultural fields does not qualify as evidence for the rise of a polity—concrete evidence of authoritative government or collective action problem-solving is necessary.

Similarly, the fall or termination date (t_f) is defined by events such as abandonment (the most frequent mode of Maya polity termination that can be recognized archaeologically), social or physical destruction, or the termination of any available historical record or further archaeological evidence of centralized political activity. For example, the polity termination date for Becán was established at *c*. A.D. 850 because this is the date when it was abandoned. The polity termination date for Cuello was estimated at A.D. 450, although it continued to be occupied by a smaller, politically decentralized population into the Postclassic period. These measurement strategies from political science, based on "multiple substitutable indicators," are roughly equivalent to similar empirical strategies from archaeology, based on "multiple lines of evidence."

Duration was measured in years, although in some cases dates were measurable with a greater accuracy of months or days (e.g., for Mayapán, Tayasal, and other Postclassic cases).[11] Note that, although the preservation of structures and artifacts can be biased toward the more recent and better excavated cases, our multiple indicator strategy offers a way to compensate because it relies on a set of indicators to estimate dates for a single site. Thus, whereas the probability of artifactual or structural detection decreases (exponentially) with increasing age, the probability of site detection (i.e., the level at which we are estimating polity formation and termination) increases by the power of the number of artifacts and structures at a given site, which compensates for the effect of antiquity.

The second variable measured was *system size N*, defined as the number of existing polities at calendrical time *t*, as derived from rise and fall dates.[12] Over time, $N(t)$ therefore describes the evolution of the Maya political system in terms of membership size and resulting political complexity (recall that, theoretically, total interactions $= N^2 - N$).

The third variable measured was the *hazard rate* $H(\delta)$ with respect to duration, defined by convention as the conditional probability that a polity will fall (terminate) in the next time instant $(\delta + \varepsilon)$, given that it has endured until time δ. Thus, H measures a polity's probability of imminent fall, a dynamic property linked with stability, as given by the statistical odds against continued survival beyond a duration δ.[13] Formally, the hazard rate function is defined as

$$H(\delta) = \mathbf{Pr}(\delta < D \leq \delta + \varepsilon \mid D = \delta),$$

[10] These data are available at the *International Studies Quarterly* web site (http://www.public.iastate.edu/~isq) or directly from the authors.

[11] In the process of recording dates, the authors also developed a computer-based algorithm (in Lotus 123 software) for converting Maya Long Count dates (in Baktuns, Katuns, Tuns, Uinals, and Kins) into their Gregorian equivalents. The algorithm is available from the authors.

[12] Although *N* differs from systemic polarity in the modern structural-realist sense (polarity is always much smaller than system size), an approximate measure of polarity is the number of polities with emblem glyph, since these may have been more politically prominent—they exacted tribute, controlled trade, and retained vassals—and they include almost all the largest polities (Marcus, 1973, 1976, 1992b, 1993).

[13] Other studies that have used the hazard rate in political science include those by Cioffi-Revilla (1998), Damgaard-Petersen (1987), Horvath (1968), King (1989), Vuhinich and Teachman (1993), and Weiss (1963). The hazard rate is also known by other names in different fields, such as "intensity function" (signal processing and systems analysis), "exit force" (sociology of organizations), "instant mortality rate" (demography), or "instant failure rate" (systems reliability).

where ε denotes "the next instant," to capture the notion of "imminent fall." In other words, informally, the hazard rate measures the chances of a polity terminating if it exists for one more year. The hazard rate function $H(\delta)$ of a set of polities can be: (i) *constant* (i.e., the Poisson case, $dH/d\delta = 0$), (ii) *increasing* ($dH/d\delta > 0$), or (iii) *decreasing* ($dH/d\delta < 0$), depending on the survival characteristics of the set of polities. Conversely, from a dynamic standpoint, stable or increasingly stable polities will have a decreasing hazard of termination (because these have a decreasing probability of imminent fall), whereas unstable or increasingly unstable polities will have an increasing hazard (rising probability of imminent fall). *Thus, the form of the hazard rate function for a set of polities shows the stable (decreasing) or unstable (increasing) nature of those polities in terms of their termination propensity.*

Operationally, the hazard rate is measured by the empirical probability density function $p(\delta)$ and the cumulative density function $\Phi(\delta)$ obtained for the observed realizations $\delta_1, \delta_2, \delta_3, \ldots, \delta_n$ of the polity duration variable D. This yields

$$H(\delta) = p(\delta)/[1 - \Phi(\delta)]$$

as the operational expression for estimating the values of the empirical hazard rate function based on observed values of D (Kaplan-Meier estimate).

Analysis

Univariate and survival analyses were the principal statistical procedures used (Coleman, 1981; Tuma and Hannan, 1984; King, 1989). We limit our analysis to the simple implicit model of the hazard rate function for duration $H(\delta)$, because data for a more complex explicit multivariate model, $H(\delta, x_1, x_2, x_3, \ldots, x_n)$, are as yet unavailable for most Maya polities. The same procedures were applied to cross-polity and cross-temporal analyses, including (1) the entire population of cases ($N = 72$ Maya polities in the whole era); (2) the epochal subpopulations of traditional periods in Maya history (cross-temporal); and (3) the emblem glyph vs. lesser polities comparison (cross-polity). For each set of cases, we obtained the distribution statistics, associated values of the hazard rate function, stability coefficient values, and half-life values. The graphic form of the empirical hazard rate function $H(\delta)$ was also obtained to evaluate the termination risk of Maya polities.

In terms of statistical inference, our sample structure is roughly comparable to an iceberg: we are certain to have measured all of the largest and politically important polities, in addition to numerous other lesser polities. However, many other smaller polities existed for which the extant formation/termination data are still incomplete. Therefore we also examined some measures of statistical significance (standard deviations, standard errors, confidence intervals).

Competing Hypotheses

The data and procedures just described allowed us to conduct a preliminary test of several sets of competing hypotheses concerning the following aspects of Maya political evolution:

1. Origin and pattern of Maya political evolution: when and where did it start, and linear (H_{10}) vs. punctuated phases of development (H_{11}).
2. Timing and magnitude of the political collapse: single (H_{20}) vs. cyclical or fluctuating model of expansion and collapse (H_{21}).
3. Effect of birth-order on political stability: greater political stability of Classic polities compared to Preclassic polities (H_{31}), based on their state-level complexity.

4. Effect of emblem-glyph status on political stability: greater political stability of emblem-glyph polities (H_{41}), based on their greater power both as capability and influence.

We discuss the results of testing these and other competing hypotheses below, following the presentation of our main empirical findings. However, one must recall that some tests may yield different results with future improvements in the basic data, so alternative explanations should not yet be rejected with the same confidence as with comparable data for a modern political system.

In turn, we used these results to (i) re-examine the traditional Maya periodization, proposing an alternative periodization for political purposes (not for *all* of Maya culture); and (ii) formulate a new theory of the Maya collapse based on *political principles* as an alternative to the extant theories based on multiple ecological and social disasters. Our proposed periodization is based on our new empirical findings, whereas our proposed theory is based on a new application of well-established political principles.

Empirical Findings

Table 1 reports our findings for the set of Maya polities identified in this study, including the political (emblem glyph) status, dates of rise and fall, and the corresponding durations.[14] Maya polity names are given in their Spanish transliteration to reflect their intonation in the Mayan language (Coe, Snow, and Benson, 1986:228–36; Schele and Freidel, 1990; Marcus, 1992a). All durations and years are rounded to the closest whole number.

We found a total of 72 Maya polities for which it was possible to measure their formation and termination dates with acceptable accuracy ($N = 72$ polity durations). The polities in Table 1 include 27 cases with emblem glyph—the more politically prominent actors in the system.[15] Other polities also existed, and hundreds of minor polities scattered throughout the Maya region are identified by name. However, most other polities beyond this set of 72 were minor by comparison and fewer data concerning them are available. Therefore the set of polities in Table 1 represents the most complete data that can be reliably recorded today.

As shown in Table 2, there was a weak association between the historical period of polity formation (rise date) and the political rank of polities (Cramér's V and $\lambda \approx 0.33 \pm .03$), so historical period and political status were mostly independent controls.[16] The relationship was not strong enough to make the two controls spurious ($V^2 = 0.14$), as discussed in the next section.

Figure 1 shows the number of polities in existence over time, $N(t)$, as derived from the dates reported in Table 1. The graph of $N(t)$ shows at least two distinct cycles of political development, not just a single "rise and fall," consisting of a "major cycle" (900 B.C. to A.D. 1200) and a "minor cycle" (A.D. 1200 to *c*. 1700). During the major cycle, the Maya political system showed an initial steady increase in the number of polities over a 700-year-long era—during the Middle and Late Preclassic periods—followed by a steady-state, a sharp rise, and an even sharper decline during the Classic period—"the Maya collapse." Note that the ninth-century collapse in the

[14] Although it is unusual to report raw data, we do so in order to make our data set available to others, particularly those who may wish to use it and improve upon it as new information becomes available in the future.

[15] The emblem glyph status of Kabah (case no. 58) is still uncertain, so we did not include it in the set of 27 polities with emblem glyphs.

[16] Cramér's V (sometimes called Cramér's ø) and λ are standard measures for the degree of association between two nominal-level (categorical) variables.

TABLE 1. Political Status and Evolution of Maya Polities, 900 B.C. to A.D. 1697

Case no.	*Polity*	*Emblem Glyph*	*Formation Date*	*Termination Date*	*Duration (years)*
		PRECLASSIC PERIOD, 900 B.C.–A.D. 250			
01	Cuello		–900	450	1,350
02	Abaj Takalik		–800	200	1,000
03	Los Mangales		–800	–500	300
04	Chalchuapa		–700	1540	2,240
05	Kaminaljuyú Las Vacas[a]		–700	200	900
06	Komchen		–700	250	950
07	Lamanai		–700	1675	2,375
08	Nakbe		–700	100	800
09	Río Azul 1		–700	530	1,230
10	Seibal[b]	G	–700	905	1,605
11	Preclassic Copán		–650	–200	450
12	Cobá		–600	1400	2,000
13	Altar de Sacrificios	G	–500	950	1,450
14	Preclassic Dzibilchaltún		–500	1100	1,600
15	El Portón		–500	–100	400
16	Uaxactún		–500	1100	1,600
17	Calakmul[b]	G	–400	840	1,240
18	El Mirador		–400	150	550
19	Naranjo	G	–400	879	1,279
20	Santa Rita Corozal/Chetumal		–400	1540	1,940
21	Edzná		–300	900	1,200
22	Yaxuná		–300	1100	1,400
23	Altun Ha	G	–200	900	1,100
24	Cerros		–200	50	250
25	El Perú		–200	900	1,100
26	Itzan	G	–200	859	1,059
27	Tikal[b]	G	–200	919	1,119
28	Becán		–150	850	1,000
29	Classic Copán[b]	G	100	825	725
30	Nohmul		150	1000	850
31	Kaminaljuyú Solano[c]		200	900	700
		CLASSIC PERIOD, A.D. 250–900			
32	Xultún	G	250	919	669
33	Yaxchilán	G	290	838	548
34	Yahxá	G	300	823	523

TABLE 1. Continued

Case no.	*Polity*	*Emblem Glyph*	*Formation Date*	*Termination Date*	*Duration (years)*
35	Bonampak	G	400	809	409
36	Caracol	G	400	889	489
37	Nakum		400	879	479
38	Palenque[b]	G	400	810	410
39	Machaquilá/Tres Islas	G	425	871	446
40	Arroyo de Piedra/Tamarindito	G	442	820	378
41	Comalcalco		450	850	400
42	Quiriguá	G	450	900	450
43	Piedras Negras	G	484	840	356
44	Toniná	G	495	939	444
45	Anonal		500	870	370
46	Chicanná		500	900	400
47	Xpuhil		500	830	330
48	Los Higos	G	548	852	304
49	Ucanal	G	550	879	329
50	El Chorro		600	800	200
51	Lubaantún		600	875	275
52	Dos Pilas/Aguateca[b]	G	640	850	210
53	Xunantunich		675	1000	325
54	Río Azul 2	G	680	855	175
55	Cancuén	G	700	830	130
56	Motul de San José	G	701	879	178
57	Chichén Itzá[b]	G	800	1200	400
58	Kabah	G?	800	1000	200
59	Labná		800	1000	200
60	Sayil		800	1000	200
61	Uxmal	G	800	1000	200
		POSTCLASSIC PERIOD, A.D. 900–1697			
62	Postclassic Dzibilchaltún		1200	1500	300
63	Tulum		1200	1600	400
64	Mayapán[b]		1220	1441	221
65	Tayasal		1221	1697	476
66	Mixco Viejo		1250	1525	275
67	Zaculeu		1250	1525	275
68	Utatlán/K'umarcaaj		1400	1524	124
69	Maní		1441	1542	101

TABLE 1. Continued

Case no.	*Polity*	*Emblem Glyph*	*Formation Date*	*Termination Date*	*Duration (years)*
70	Tecoh		1450	1540	90
71	Tibolon		1450	1540	90
72	Iximché		1475	1526	51

Source: Compiled by the authors. A *polity* is a territorially-based political system providing governance and solutions to collective action problems to a society that resides in at least one urban center (see text). We wish to thank the following Maya scholars for their helpful comments and corrections: Anthony P. Andrews, Michael D. Coe, T. Patrick Culbert, Norman Hammond, Joyce Marcus, Payson D. Sheets, David Webster, and Gordon R. Willey. We are especially grateful to Joyce Marcus for her advice on emblem glyphs and Maya political history, and to Marion Popenoe de Hatch for her advice on Kaminaljuyú. However, only the authors are responsible for the data used in this study.

[a] The local Las Vacas Tradition ceramic complex, from the Valley of Guatemala, is associated with this first polity formation at Kaminaljuyú (Popenoe de Hatch, 1997).

[b] Copán, Seibal, Tikal, Calakmul, Palenque, and Aguateca/Dos Pilas were capitals of powerful regional states (great powers) in the southern Lowlands, whereas Chichén Itzá and Mayapán were capitals of regional states in the northern Lowlands (Marcus, 1993).

[c] The foreign Solano Tradition, from the Solano site and the region northwest of the Valley of Guatemala, is associated with the second polity formation at Kaminaljuyú (Popenoe de Hatch, 1997).

TABLE 2. Distribution of Maya Polities by Political Rank and Historical Period of Formation

		Rise Period		
		Preclassic	Classic	
Political Rank	Emblem glyph	8	19	27
	Subordinate	23	11	34
		31	30	61

Source: Calculated by the authors.

$V = 0.38$, $\lambda_B = 0.30$, $\lambda_A = 0.37$, $\chi^2 = 8.70$, d.f. = 1, $p < .01$. See footnote 8.

number of Maya polities consisted of a truly politically destructive event that was marked by abandonment, migrations, death, and other terminal modes of political extinction—*not* by consolidation or integration into fewer, larger, or more complex polities. The collapse was followed by a minor cycle, which showed a remarkably symmetrical qualitative pattern (approximately on a 4:1 scale) ending in a "second collapse"—just prior to and during the Spanish Conquest. As discussed later, each cycle peaked with 49 and 13 polities, respectively, but a much smaller number of powerful regional states.

The rate of change in the number of existing states is shown in Figure 2, as derived from Figure 1. The figure shows the values of yearly change (thin fluctuating graph, $dN(t)/dt$) and a filtered 21-year moving average (MA) of the original yearly values (bold graph $dN(t)/dt$ S21). The filtered MA-graph highlights two detectable pulses of change, corresponding to the periods of peak activity in each cycle. The first pulse of change (1) began around A.D. 300, at the start of the Classic period; (2) peaked around A.D. 500 in the Early Classic; (3) bottomed out around A.D. 900, at the transition between Classic and Postclassic periods; and (4) ended around A.D. 1200. The second pulse of change, occurring all during the Postclassic, began around A.D. 1200 and peaked around 1400.

Cross-temporal and cross-polity univariate and survival statistics are reported in Table 3 and Figure 3 for all polities in the whole era, Preclassic vs. Classic vs. Postclassic periods, and emblem glyph vs. non–emblem glyph ("lesser") polities. For each set of cases, we report the corresponding number of polities in the set, the date of rise and fall (mean value, standard error, and standard deviation), the duration of polities, the stability coefficient, and the half-life value.

Figure 4 shows the empirical hazard rate functions of Maya polities, as derived from the duration data reported in Table 1. The graphs show overall increasing hazard rates in each of the five sets of cases. However, polities founded during the Classic and Postclassic periods, and those with emblem glyphs, show steeper functions than those founded during the Preclassic period and those without an emblem glyph, consistent with lower stability values (Table 3, column 5).

Discussion

We draw three sets of implications from our findings: (1) specific implications of our findings for the competing hypotheses; (2) broader theoretical implications on the rise and fall of the Maya political system compared to other systems; and (3) some implications for future research.

Specific Implications for Competing Hypotheses

First quantitative area-wide results on the aggregate evolution of Maya polities in the Mesoamerican system. Earlier studies have reported findings on the formation and termination of individual Maya polities, as noted in the introduction (e.g., Lowe,

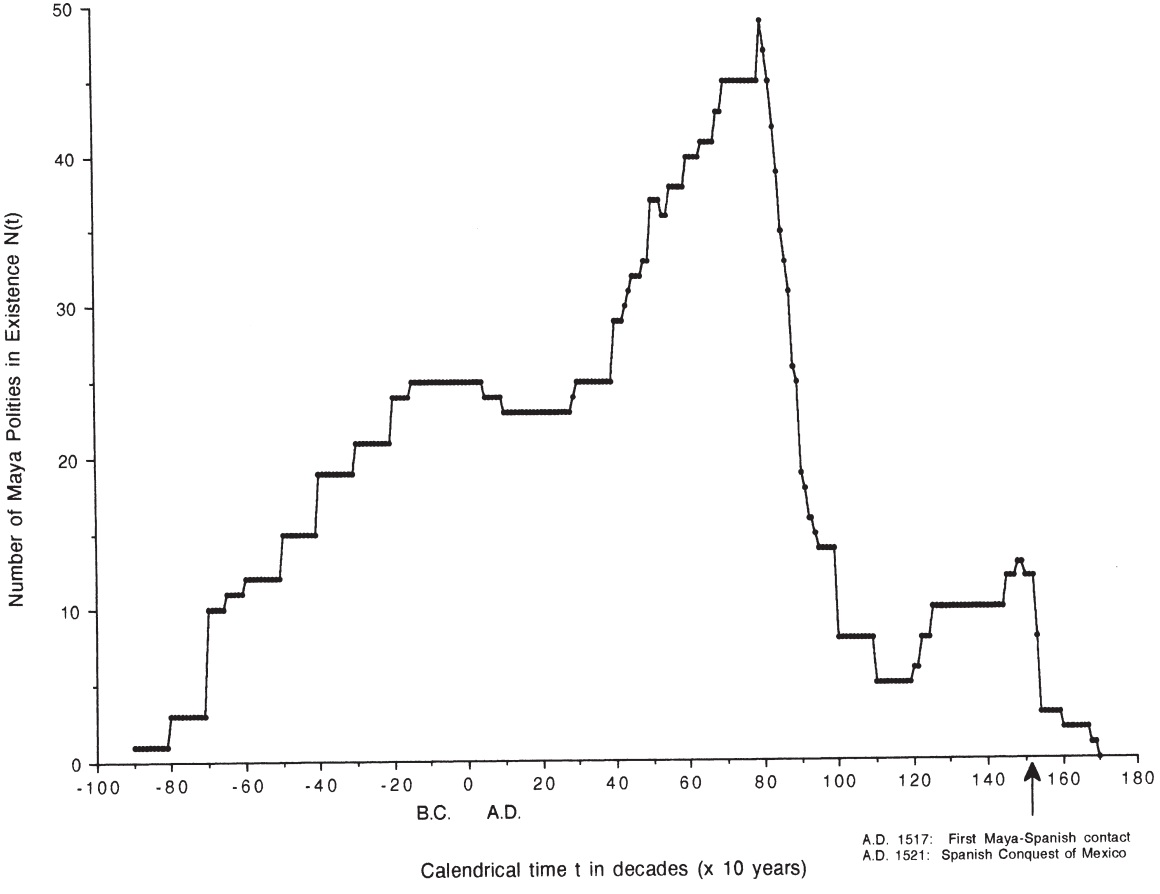

FIG. 1. Maya Polities in the Mesoamerican System, 900 B.C. to A.D. 1697

TABLE 3. Distribution Statistics of Maya Polities

Number of Polities (*N*)	*Date of Formation* (t_0)	*Date of Termination* (t_f)	*Duration* (*years*)	*Stability*[a] (s^2/μ)	*Half-life* ψ (*years*)
		WHOLE ERA: 900 B.C.–A.D. 1545			
72	A.D. 241 ± 81 (685)	A.D. 916 ± 53 (451)	675 ± 65 (555)	Hyper-exp 456	445
		PRECLASSIC PERIOD: 900 B.C.–A.D. 250			
31	437 B.C. ± 52 (288)	A.D. 717 ± 96 (536)	1,154 ± 96 (535)	Hyper-exp 248	1,100
		CLASSIC PERIOD: A.D. 250–900			
30	A.D. 546 ± 30 (163)	A.D. 894 ± 16 (85)	348 ± 24 (131)	Hyper-exp 49	363
		POSTCLASSIC PERIOD: A.D. 900–1545[b]			
11	A.D. 1323 ± 35 (117)	A.D. 1542 ± 19 (64)	218 ± 42 (140)	Hyper-exp 90	221
		EMBLEM GLYPH POLITIES			
27	A.D. 269 ± 82 (427)	A.D. 884 ± 15 (78)	616 ± 82 (426)	Hyper-exp 295	448
		NON-EMBLEM ("LESSER") POLITIES			
45	A.D. 225 ± 120 (806)	A.D. 936 ± 85 (568)	710 ± 93 (662)	Hyper-exp 617	425

Source: Calculated by the authors using data in Table 1 and sources detailed in the Appendix.
Note: All years are rounded off to the closest digit. Each cell in columns 2 (formation date), 3 (termination date), and 4 (duration) contains the observed mean value (μ), plus or minus the standard error (ε), and the standard deviation (σ), as follows:

$$\mu \pm \varepsilon$$
$$(\sigma)$$

[a] Values of the stability coefficient are *hypo*-exponential when $\sigma^2/\mu < 1$ (small variability and unstable in polity duration D) or *hyper*-exponential when $\sigma^2/\mu > 1$ (large variability and stable). The threshold case ($\sigma^2/\mu = 1$) has the following properties: (i) the hazard rate $H(\delta)$ of polity duration D is constant κ, equal to the reciprocal of the mean value μ; (ii) the probability density $p(\delta)$ equals a simple negative exponential function

$$p(\delta) = \kappa e^{-\kappa\delta},$$

where $\kappa = 1/\mu$; (iii) the distribution is Poisson ($\mu = \sigma^2$); and (iv) the equilibrium is indifferent (between stable and unstable). Note that these measures are standardized with respect to historical range and to number of cases, N.

[b] Includes Mayapán, Tayasal, and a few other Late Postclassic Maya polities that terminated by Spanish conquest. See Table 1 and the Appendix.

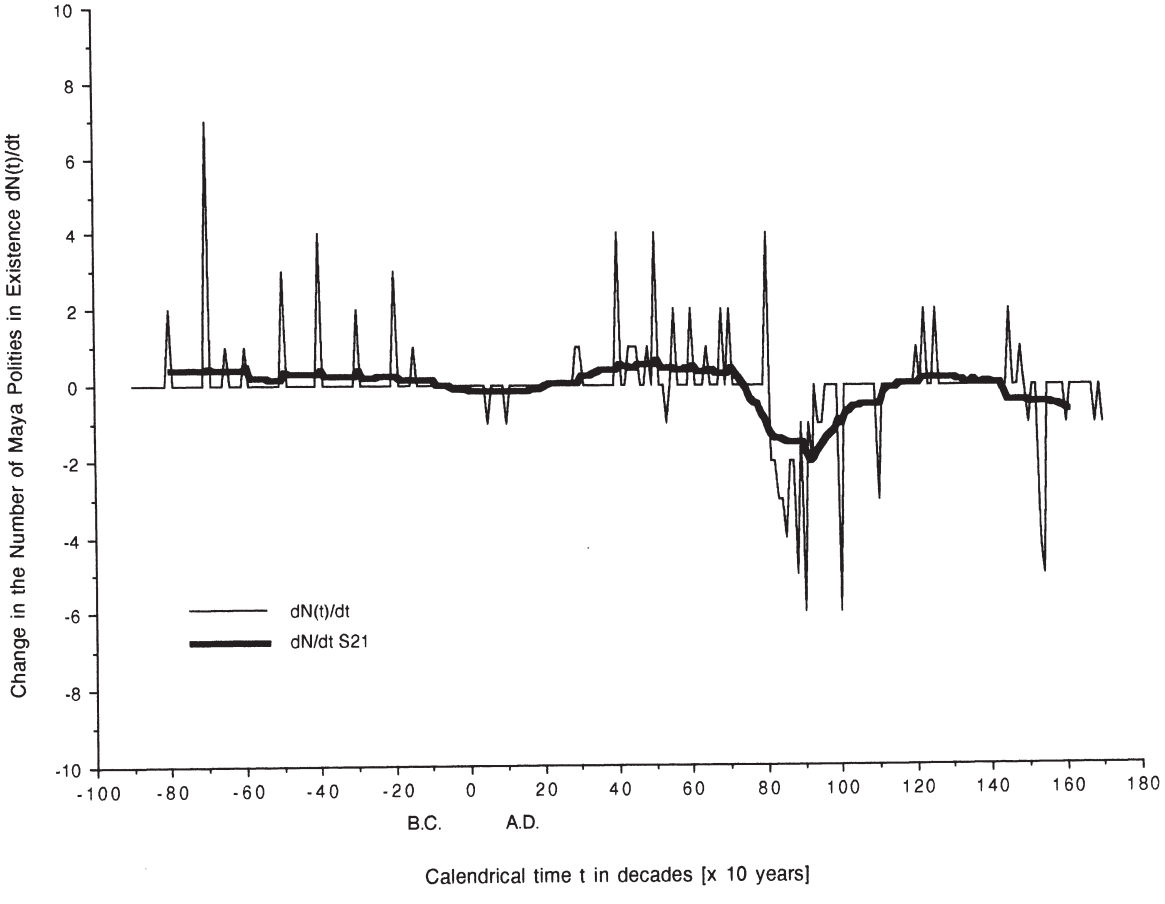

FIG. 2. Change in the Number of Maya Polities in the Mesoamerican System

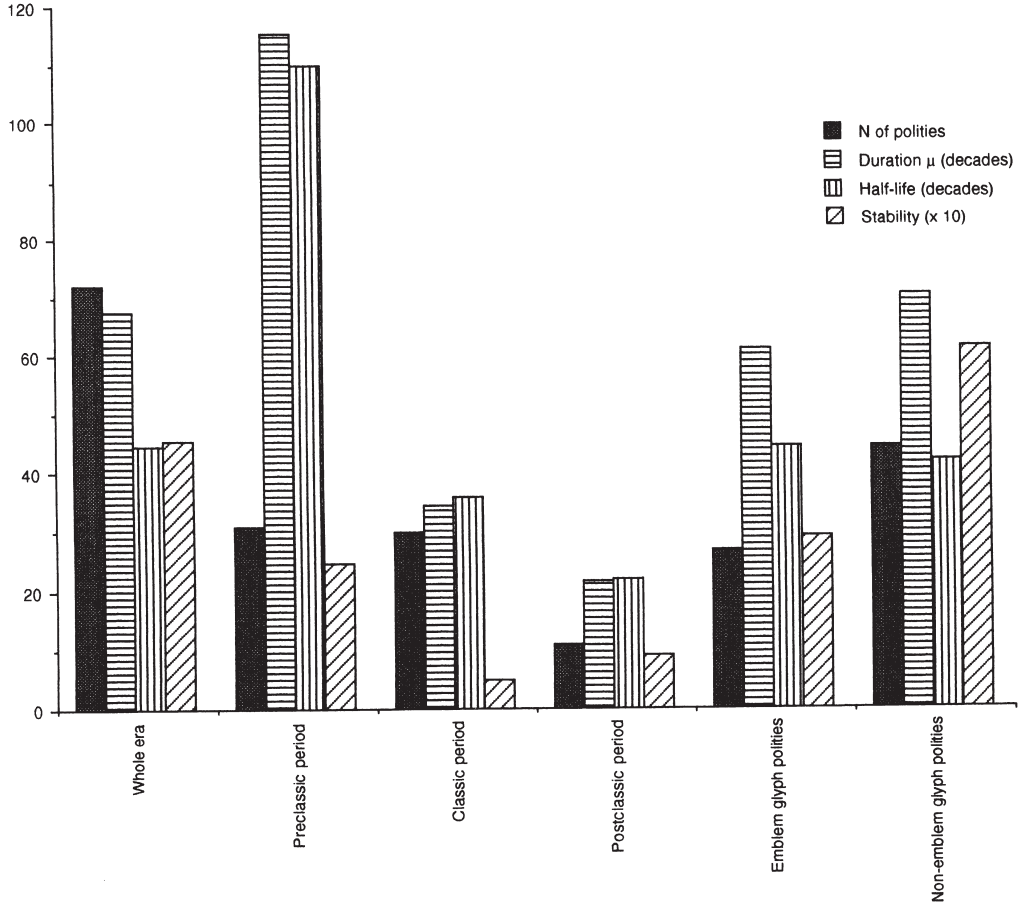

FIG. 3. Distribution Statistics of Maya Polities

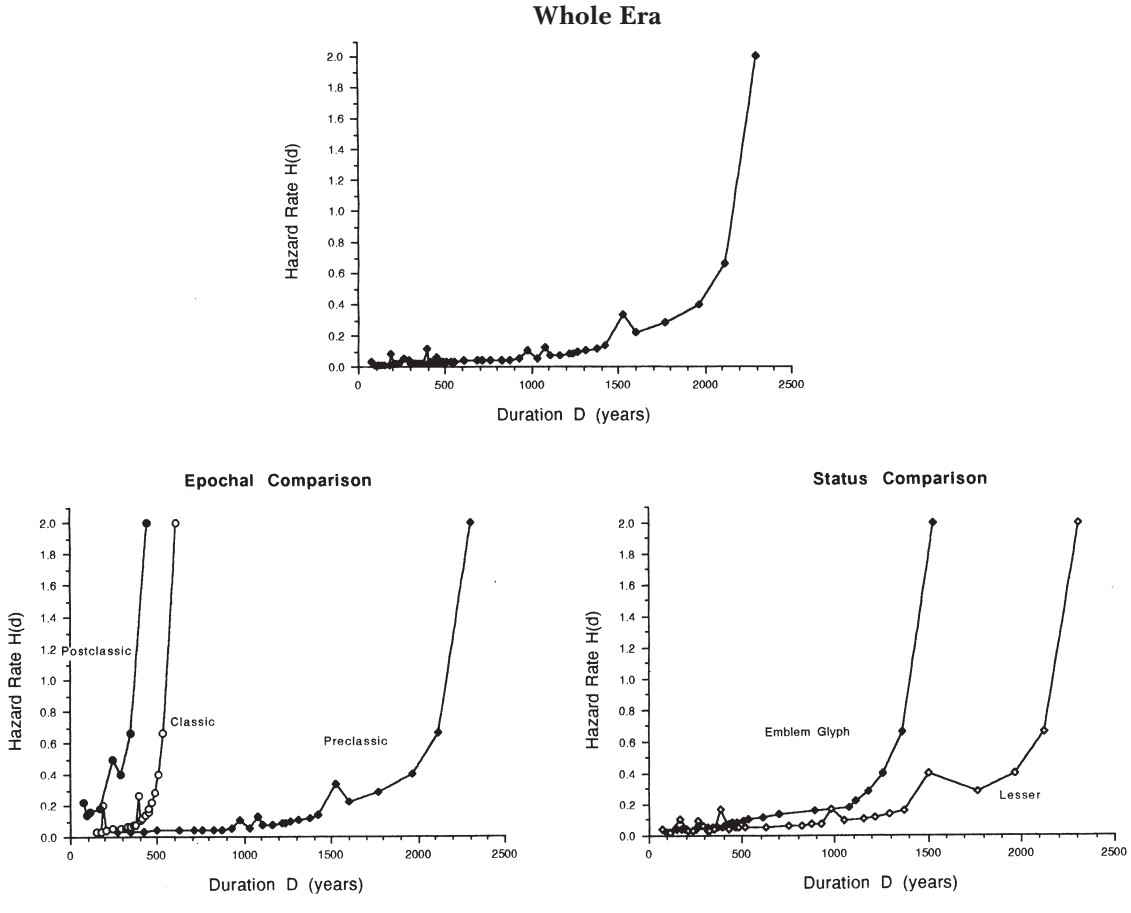

FIG. 4. Hazard Rate of Maya Polities

1985; Culbert, 1991). Our findings are the first to report in a systematic way the long-range, aggregate empirical pattern of rise and fall of Maya polities for the whole area and the entire time span, based on the most reliable political data available today from the extant archaeological, epigraphic, and ethnographic material. Our measurements show the quantitative and qualitative evolution of a complex political system that originated at *c*. 900 B.C. (initial settled village life) and consisted of dozens of interacting polities scattered across both lowlands and highlands, and that experienced intense warfare, alliances, trade, and other characteristic political interactions over a span of 2.5 millennia.[17] As demonstrated in Figure 1, the growth of the Maya polities system was not linear (H_{10}), but instead was punctuated by phases of development (H_{11}), roughly similar to the earlier pattern reported by Lowe (1985:17 passim) based on a smaller sample of monument dates. Allowing for the necessary differences that exist between various forms of polities—that is, quantitative and qualitative differences in territorial scale, available resources, and governance structures (Sartori, 1991)—the findings reported in Table 1 for the development of Maya polities in the Mesoamerican system are comparable to parallel findings on the rise, fall, and system membership of states in the modern era (e.g., Russett, Singer, and Small, 1968; Wycoff, 1980). Similarly, our findings for the higher ranked Maya emblem glyph polities are roughly comparable to parallel data on the rise, fall, and system membership of major powers (Levy, 1983:46–49). Our findings provide "a new line of evidence" in the "conjunctive approach" used in modern archaeology (Marcus, 1995).

New cycles of Maya political evolution. Our findings indicate that the Maya political system underwent at least two distinct cycles of political development (H_{21}; Figure 1), as opposed to a single process of expansion and collapse (H_{20}), a new feature which has not been previously reported in a precise way. The prevalent view among Mayanists (H_{20}) was that the Maya rose, fell, and "never recovered" after the Classic collapse (Sabloff, 1994:118–19; based on Culbert, 1973, in turn based on Willey and Phillips, 1958). Our new findings, by contrast, support the view of a few scholars (Marcus, 1992b, 1993; A.P. Andrews, 1993) according to whom the Postclassic "was a period of 'rebound,' which was accompanied by new forms of political organization which were taking shape when the Spanish arrived" (A.P. Andrews, 1994). The existence of at least two distinct cycles in Maya political history, at least in terms of system size and membership, is strongly supported by our findings. These cycles of the Maya political system resemble other cases of "pulsations" in world system history (Wilkinson, 1986; Willey, 1991; Frank and Gills, 1993; Thompson, 1995; Chase-Dunn and Hall, 1997), making the Maya more comparable and less unique (Marcus, 1995) with respect to other Old and New World political systems. Moreover, both cycles are marked by punctuated phases of development (H_{11}), not just the major cycle.

During the first cycle, the Maya political system initially employed approximately a millennium to develop from a small core of a few polities ("chiefdoms," archaeologically); it then suddenly boomed to its peak size (many as "states") and shortly after collapsed in 2–4 centuries, like a sudden pulse (Figure 2). In comparative terms, the rise of states in the Maya area took longer than in the Old World (Mesopotamian and Chinese states antedate Maya states by millennia) but their collapse period had a span comparable to that of the Roman Empire or the Byzantine Empire. Although the Maya political system did not vanish after collapsing around A.D. 900, our findings show that the system contained only a few Maya

[17] From a narrower perspective—considering only *states* from after A.D. 200 to 1500—this yields a span of 1.0–1.3 millennia for the Maya system (Marcus, 1996:15).

polities at the time of the Spanish Conquest of Mesoamerica (see Figure 1), with Tulum, Tayasal, Iximché, Utatlán, and some in Belize, among those still active.[18]

During the second cycle, beginning around A.D. 1200, a similar pattern was repeated but on a smaller scale (approximately 4:1). As shown in Figure 5, a detailed enlargement of the A.D. 1200–1700 time period in Figure 1, the precise chronology of the second cycle is also interesting, particularly from a causal standpoint. In the second cycle the growth stages (from six to thirteen polities) were marked by local political centralization under the rule of the powerful Mayapán state (A.D. 1220–1450), which extended its hegemony over most of the northern lowlands. Thus, albeit using a different line of evidence, the extant literature is correct in noting that the Maya "experienced a final blossoming during the heyday of Mayapán" (Sabloff, 1994:135). On the other hand, our findings also show that the collapse in the second cycle began in the 1490s—that is, shortly *after* the fall of Mayapán and *continued* through the Spanish Conquest in the 1520s and after. The prevailing view among Mayanists and historians is that the conquistadors, through outside intervention, destroyed all remaining Maya civilization during this second "blossoming." Clearly, the Spanish Conquest of the 1520s ended the autochthonous development of Maya political evolution, but at the time of contact with the Spaniards the future of that evolution was at best uncertain. The fall of Mayapán had generated considerable chaos in the northern lowlands, inducing migrations, disrupting trade, and increasing political uncertainty. Therefore, the Spanish Conquest could not have caused the second Maya collapse (or "reorganization," according to Marcus, 1996:17) which began in the 1490s, three decades earlier, although it certainly accelerated it. Accordingly, the following common views are perhaps in need of some revision: (1) "Without this outside intervention, which destroyed most of its native institutions, Late Maya Civilization *would have continued its own evolutionary course*" (Sharer, 1994:50); this may be true, but the "evolutionary course" in 1520 was at best uncertain after the fall of Mayapán (Figure 5). (2) "How would the Maya political landscape have evolved had it not been so brutally and suddenly truncated by outsiders?" (Sharer, 1994:512). Our findings indicate that the second Maya collapse may already have been well under way by the time of the Spanish Conquest (Table 1 and Figure 5).

Taking together the whole era with both cycles, our results therefore confirm and add greater precision to the generally accepted view of Maya political evolution as consisting of a "slow-rise-and-rapid-collapse," or "take-off-and-crash," phenomenon—but in at least two cycles, not just one. Our findings therefore support hypotheses H_{11} (punctuated phases of political development) and H_{20} (cyclical or fluctuating model of expansion and collapse), not the alternative hypotheses. Below, we propose a new explanation for this descriptive finding, based on the political evolution of states and their regional interaction as a system (*qua sistema*). Among the minority of Mayanists who have questioned the single-cycle paradigm, our findings therefore support Marcus's (1993:168, Figure 26) "dynamic model" with several rises and falls, particularly her claim of two major political cycles, the first dominated by "The Four on High" in the southern lowlands (Calakmul, Copán, Palenque, and Tikal) and the second dominated by the northern lowlands (Chichén

[18] Tulum, the Late Postclassic fortified polity on the Caribbean coast of the Yucatán Peninsula, had a population estimated at 500–600 inhabitants and was dominated by the regional state of Mayapán, as were several other polities nearby. After the second revolt and fall of Mayapán (A.D. 1451), "the northern-lowland political landscape fragmented into the many small, diverse polities that the Spaniards encountered" (Sharer, 1994:512), with each of the "sixteen rival statelets . . . jealous of the power and land of the other, and only too eager to go to war in asserting its claims" (M. D. Coe, 1993:158; see also Marcus, 1993, and Roys, 1957).

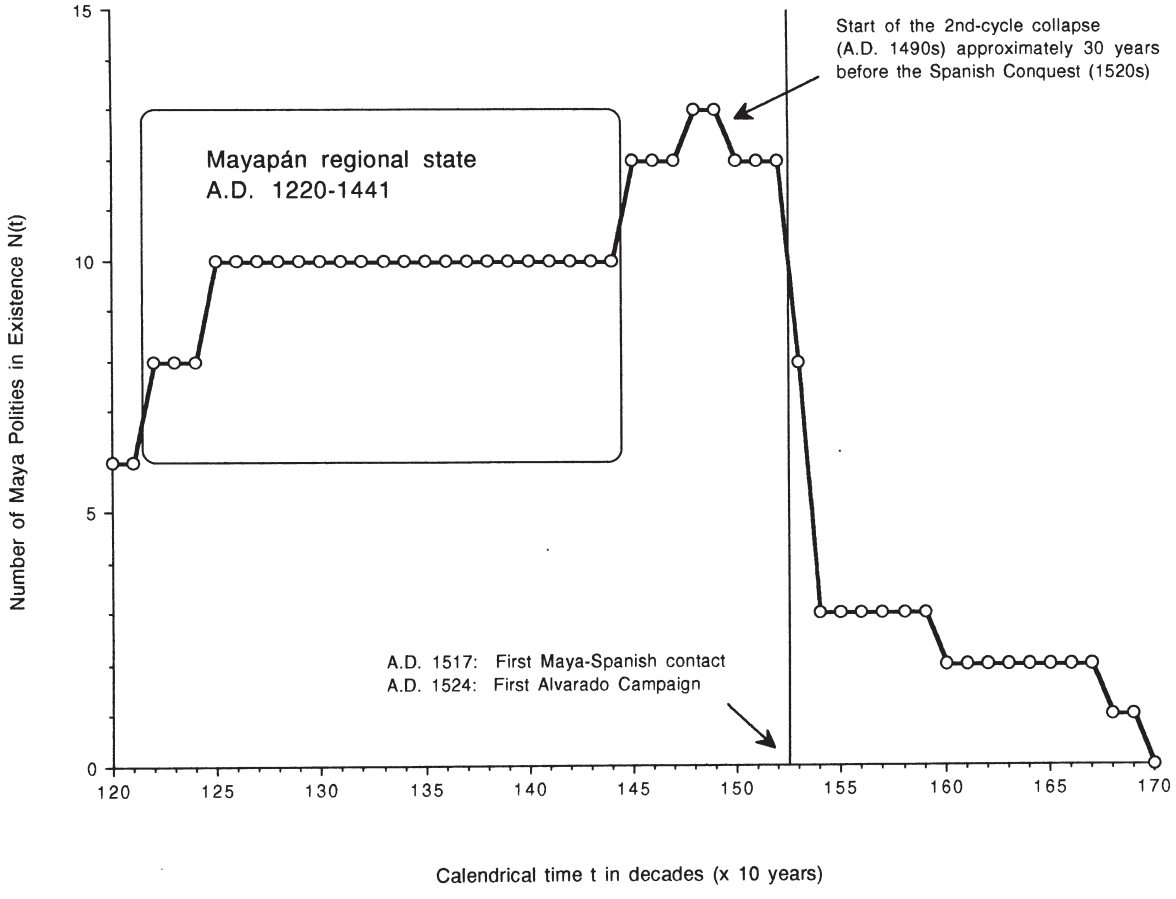

FIG. 5. Maya Polities in the Mesoamerican System, A.D. 1200 to 1697: Detail of the Second Cycle

Itzá and Mayapán) and the Guatemalan highlands (Iximché, Utatlán, and others). Marcus's dynamic model has been regarded as a hypothetical model (Fash, 1991; Sabloff, 1994; Sharer, 1994), but not demonstrated with as large a data set as presented here.

Duration of Maya polities. Considering the whole era, the average duration of a Maya polity was quite long (675 ± 65 years, Table 4), even by the standards of modern nation-states in the international system. However, duration varied significantly between those polities founded during the relatively calm Preclassic period (1,154 ± 96 years) and those founded during the more interactive and competitive Classic period (348 ± 24 years), demonstrating a significant "birth order" effect (Somit, Peterson, and Arwine, 1993). Polities founded during the Classic period had 70 percent less longevity. Our findings therefore refute H_{20} (greater stability of Classic polities). We explain this difference in terms of political development and the weakening consequences of interaction and turmoil for the long-term stability of political structures (authority, roles, institutions, norms, and values). The older Preclassic polities—for example, Uaxactún, Lamanai, Copán, Tikal, and others—were established and consolidated at a time of greater parity, less hierarchy, weaker interactions, and less competition among polities in the system, allowing their political structures to stabilize and develop greater resilience before many more polities came into existence. Also, "many were ideally situated on great land, key trade routes, etc." and their population size was "mid-size to moderate-size, while some of the huge ones dropped out earlier" (Marcus, 1996:18). By contrast, the latter polities—for example, Yaxchilán, Bonampak, Uxmal, Xunantunich, and others—were established during a time of significantly greater interaction and turmoil in the system, with a lesser chance of attaining a level of political consolidation and stability comparable to that available to the older polities. In fact, as shown by our findings (Table 1, Figure 1), most of the polities that survived the regional collapse and endured an average of approximately 2,000 years into the Postclassic period (i.e., Chalchuapa, Cobá, Dzibilchaltún, Kaminaljuyú, Lamanai, Uaxactún, and Yaxúna) were founded in the Preclassic period. Our findings therefore show that the duration of Maya polities was inversely proportional to their date of establishment—*the earlier the foundation, the longer the duration* and *the later the foundation, the shorter the duration.*[19] Note that this is not a tautology, because a different pattern in the data can produce no relationship at all between date of polity formation and polity duration (i.e., H_0). The fact that a pattern does exist is consistent with the massive collapse, because the great majority of polities terminated almost simultaneously.

Our findings also show that many Maya polities lasted much less than the average for the whole set (σ=555 years), particularly those founded later, such as Bonampak, Palenque, Quiriguá, Cancuén, and Dos Pilas. Polities founded during the Classic period had an average duration (348 ± 24 years) much closer to the duration of modern nation-states. From this perspective, these short-lived polities were similar to new modern states such as Pakistan, Jordan, South Africa, Mexico, Australia, Canada, and the United States. Old and enduring Maya polities such as Dzibilchaltún, Lamanai, Cobá, Tikal, Copán, and Uaxactún—all established several centuries B.C. and lasting many centuries—are comparable to similarly old and enduring nation-states today, such as China, Japan, Korea, India, Iraq, Iran, Ethiopia, Greece, Spain, and Russia.

[19] A simple OLS regression analysis of duration D on foundation date t_0 also supports this finding. Kaminaljuyú, in modern Guatemala City, had two distinct periods of occupation (the Las Vacas chiefdom and the Solano state), each representing a separate polity (Popenoe de Hatch, 1996a, 1997; Sanders, 1974). Other sites with two chronologically distinct polities were Copán and Río Azul.

Emblem glyph polities had a significantly different pattern of duration and collapse. Significant differences also existed between the duration and fall date of emblem glyph polities—prominent polities like Bonampak, Caracol, Chichén Itzá, Copán, Naranjo, Palenque, and Tikal—and the duration and fall date of lesser polities with no known emblem glyph—such as Yaxuná, Cerros, Izapa, and Dzibilchaltún. As shown in Table 3, emblem glyph polities lasted significantly less longer than lesser polities (616 vs. 710 years; $t = 17.02$, $p < .01$), and they also collapsed significantly earlier (A.D. 884 vs. 936; $t = 13.02$, $p < .01$). Therefore our findings refute H_{41} (greater stability of emblem glyph polities). These differences are also consistent with our earlier explanation for the observed differences in the duration of Preclassic vs. Classic polities in terms of power consolidation, political stability, and temporal longevity (H_{31}). Emblem glyph polities were apparently unable to survive the intense turmoil of the Classic period for as long a period as could the lesser polities, in spite of perhaps being more powerful and able to control more resources (including significant economic capabilities and perhaps military capabilities as well). All emblem glyph polities were ruled by a dynasty (as were Mesopotamian and Chinese states) and therefore, *ceteris paribus*, one would also expect them to have enjoyed greater political stability. Several emblem glyph polities—viz., Uaxactún, Copán, Seibal, and Tikal—were also founded during the Preclassic period. Thus, our findings on the shorter duration (and smaller half-life values) of emblem glyph vs. non-emblem polities support a related hypothesis, namely, that emblem glyph polities were generally politically dominant and more powerful (Marcus, 1973, 1976, 1993), albeit they were more rapidly worn out by intense competition or by performing beyond capacity, a hypothesis that until now had not been examined with these data.[20] Other findings from our survival analysis also demonstrate this, based on hazard rates.

Survival results and stability. Findings from our survival analysis (stability coefficients, hazard rates, and half-life values) also shed new light on the stochastic properties of Maya polities (Table 3, columns 5 and 6). For the whole set, the distribution of duration D shows a stability coefficient much greater than 1.0 (in the range $\sim 10^2$), indicating a marked hyper-exponential distribution ($\sigma^2 >> \mu$), or relatively high stability.[21] This finding is also consistent with the nearly constant, albeit slow-rising hazard rates plotted in Figure 4 (top) for the whole period. Thus, Maya polities as a whole (i.e., weak and powerful, old and new) had a low and nearly constant hazard rate for the first four centuries of their existence, beyond which their hazard rate began to increase slowly at a rate of approximately 0.15 downfalls per century. However, significant differences were observed between polities founded during Preclassic and Classic–Postclassic periods (bottom left), as well as between emblem glyph polities and lesser polities (bottom right).

As reported in Table 3, the duration of all polities showed a hyper-exponential distribution ($\sigma^2/\mu > 1$), or relative stability. However, the stability of polities founded during the Preclassic period was a whole order of magnitude greater than the stability of polities founded in later periods. This finding again refutes H_{31}, consistent with the earlier result. In this sense, the period of a polity's foundation was a significant stochastic discriminant in distinguishing Preclassic from Classic and Postclassic polities. Similarly, as shown in Figure 4, the hazard rate is another significant discriminant: the older polities (founded during the Preclassic period) had a hazard rate that grew relatively slowly over a long time, whereas the hazard rate of the later polities (founded during the Classic or Postclassic periods) shows a

[20] The literature on system performance and decay is extensive in political science and sociology (Almond and Powell, 1996). Some recent selective topics are found in Cioffi-Revilla, 1998:ch. 8, Kopstein, 1996, and Midlarsky, 1986.

[21] Recall that *duration* per se is not an indication of *stability*, which is a dynamic and emergent property.

sharp increase over a much shorter period.[22] Classic polities faced a sharply increasing hazard rate about 400 years after their establishment and quickly thereafter they surpassed the slowly rising hazard rate of the older polities. The half-life value was also a discriminant stochastic factor, being shorter for the Classic polities (363 years) than for the older Preclassic polities (1,100 years). Classic and Postclassic polities lived more intense and shorter lives than did the Preclassic polities, contrary to H_{31}.

Similar differences were observed between emblem glyph polities and lesser polities, albeit less pronounced. As reported in Table 3, the duration of the two types of polities had different stochastic structure, with emblem glyph polities again showing less stability ($\sigma^2/\mu = 295$) than lesser polities (617). These findings refute H_{41}, consistent with earlier results. Therefore, political rank—the difference between an emblem glyph polity and a lesser polity—was a secondary stochastic discriminant. The hazard rate (Figure 4) was another secondary stochastic discriminant, as was the half-life (Table 3, column 6). Emblem glyph polities had a more accelerated increase in hazard. The observed form of $H(\delta)$ indicates significantly greater hazard for emblem glyph polities, a finding that we explain in terms of the greater political interaction and exposure of emblem glyph polities, which were engaged in more trade, wars, alliances, diplomacy, and other power interactions in comparison to the lower activity of lesser polities. These new findings may contribute to clarifying the nature of emblem glyph polities in the enduring debate among Mayanists.

Comparing the two controls, by formation period and by political rank, the former showed greater discriminatory power in terms of stochastic properties (compare both graphs, Figure 4). Paradoxically, the emblem glyph vs. lesser polities comparison implies a substantive political distinction between polities (in terms of their political status), whereas the Preclassic vs. Classic comparison is merely chronological (not substantive). The chronological dimension may therefore subsume other important processes as yet unidentified.

In sum, in terms of competing hypotheses, our findings support a model of Maya political dynamics based on Preclassic origins, punctuated phases of development (H_{11}), multiple cycles of expansion and collapse (H_{21}), and weaker political stability for more complex polities (the opposite of H_{31} and H_{41}).

Broader Implications

We can draw two broader implications from our findings. The first is a new theoretical explanation for the Maya political collapse. The second is a new periodization of Maya civilization based on its political evolution.

Failure in political integration as the cause of collapse. The interesting scientific question about the Maya collapse is not *why* did it occur, because it is a truism that given enough time, all political systems eventually collapse (Olson, 1982; Kennedy, 1987; Willey, 1991; Eisenstadt, 1993). Rather, as noted at the outset, the questions are, first, why did the system collapse *when* it did (i.e., around A.D. 800) and, second, why did it collapse in such a *precipitous mode*, as opposed to some other way. Moreover, why did it collapse *at least twice*?

According to current theoretical explanations illustrated in Figure 6 (there exists no single, unified explanation of the Maya collapse; Culbert, 1973), the collapse was caused by multiple independent variables, some of which may have been interactive, including (1) the intensification of agricultural land use, (2) extensive ecological

[22] Note that all three graphs in Figure 4 have the same coordinate scales, to permit direct cross-polity and cross-temporal comparisons.

degradation, (3) increase in the frequency and intensity of revolution and warfare, and (4) escalating religious violence (viz., human sacrificing).[23] In this view, agricultural, environmental, war, and religious variables have been seen as *causes* of the Maya political collapse, sometimes implying rough parallels to the predicament of our own contemporary system.[24]

By contrast, our findings on the pattern of polities over time, $N(t)$, suggest a different and quite opposite explanation for the Maya political collapse. Most of the Maya political system collapsed around A.D. 800—as opposed to earlier or later—*because it failed to develop a pan-Maya political integration or unification that would have been necessary to sustain the growing number of polities already containing millions of inhabitants*. Instead, the Maya political system remained a set of numerous independent polities—some large, most small—that fluctuated between multipolar aggregation into a few powerful regional states (e.g., Tikal, Calakmul, Palenque, Copán, Petexbatun in the southern lowlands and Chichén Itzá and Mayapán in the northern lowlands) and disintegration into small local polities. Warfare played a central role throughout these pulsating cycles, even during the Preclassic period (Webster, 1977; Marcus, 1992b:408, 1993).

According to the new data we report, just before the beginning of the collapse in A.D. 800 the system was growing at a rate of at least approximately one new polity every two decades, growing in interaction complexity from 600 possible dyads in A.D. 300 to 2,000 by A.D. 800. (This is obviously a conservative estimate because other polities are yet to be recorded.) *This booming growth could not be sustained indefinitely without a re-organization of government on a larger and more complex imperial scale, even discounting for remote, noncontiguous polities and relations*.[25] However, unlike what occurred in other expansive political systems (viz., Mesopotamia, Egypt, China, Rome, Greece, Peru, and central Mexico), the Maya never attained—perhaps they never even attempted—a stage of integration consistent with sustaining effective governability, harmony, and prosperity in a civil society with a vast and growing population. The powerful albeit regional Mayapán state was possibly the closest (Marcus, 1996:24), and was a candidate unifier based on the marcher state theory of political integration (McNeill, 1963; Collins, 1978, 1995; Quigley, 1979; Wilkinson, 1991; Chase-Dunn and Hall, 1997). "Alliance, confederacy, perhaps even a loosely structured joint polity ruled by members of a single family, are all *possibilities*" (Culbert, 1991:145, emphasis added), but the evidence available today refutes the integration hypothesis. Even Marcus's (1993) "dynamic model"—arguably the most sophisticated and empirically referenced model available—is based on a regional multipolar view, not on a single pan-Maya polity. Therefore, we propose a new and opposite explanation to the current view: *failure* to achieve some form of pan-Maya political integration, a system of governance capable of significant economies of scale that would sustain an expanding population base with many separate hierarchical polities (a complex state), was the root cause of the multifaceted disaster that manifested itself in the areas of agriculture, ecology, warfare, and religion. This means that, as illustrated in Figure 7, the traditionally alleged *causes* of the collapse were actually the secondary *effects* of failed political integration—the true cause of

[23] Similar causal variables also appear in Lowe's (1985) computer simulation model of the Maya collapse, one of the few attempts to link several variables together, as well as in Marcus's (1993) "dynamic model" encompassing (1) economic competition, (2) disease, (3) overpopulation, (4) political competition, and (5) political instability. We note that Sabloff (1994:118) relies on Culbert, 1973, as the most influential work to date on the Classic Maya collapse.

[24] For example, according to one popular account, "what researchers have now found . . . may be, among other things, reasons for admonishing today's world: at a time when tribal fratricide is destroying Bosnia and farmers are carving through the rain forest, the lessons yielded by the Maya have a disturbing resonance" (Lemonick, 1993:46; see also Wilford, 1991).

[25] Willey and Shimkin (1973:490) have also noted that perhaps the Maya did not even perceive the need to respond to the collective crisis that they faced in the ninth century, a causal prerequisite to any actual response.

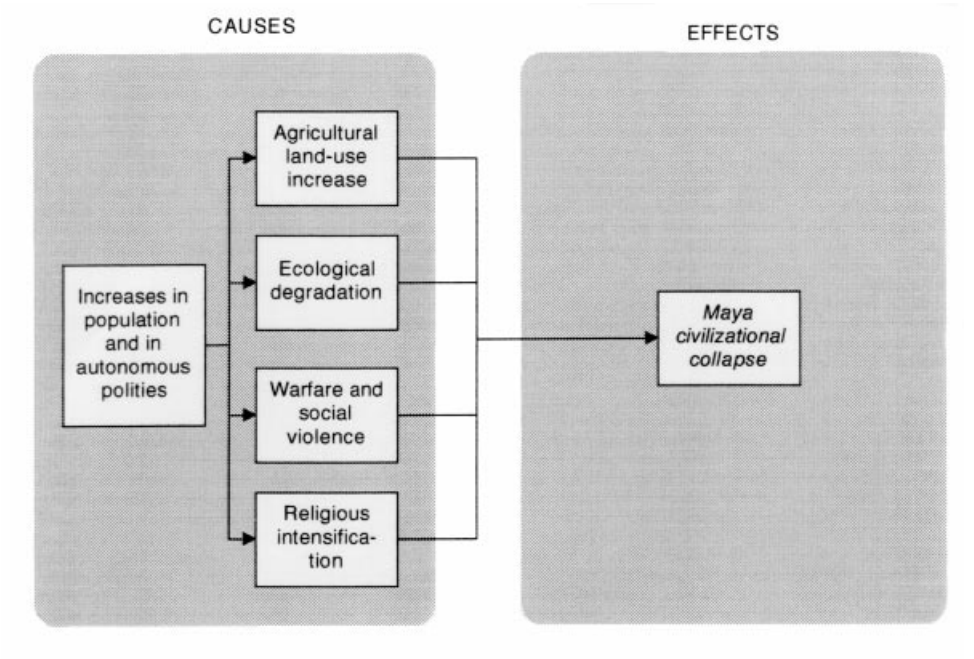

FIG. 6. Traditional Theory of Maya Collapse

collapse—so the traditional theory has the causality *backward*. Failed political integration manifested itself through increased warfare and competition, fewer marriage alliances, and fewer mechanisms for consolidating a large-scale political community.

A pan-Maya state similar to other large bureaucratic empires of antiquity—including the Aztec and the Inca in the New World—never formed.[26] Significantly, the number of polities in those other imperial areas did not collapse, as did the Maya, but instead continued to grow. Having failed to integrate their large regional states into a single unified political system capable of sustaining an even larger number of polities, the separate polities that composed the larger Maya regional states fought only destructive wars, raiding and destroying each other in a sanguinary spiral of violence that combined human sacrifices, environmental devastation, and large-scale, irreparable destruction of human and material capital resources. A pan-Maya state may have been capable of sustaining an even larger number of polities and also may have increased the prosperity of the Maya—as occurred among Mesopotamian, Egyptian, Chinese, European, and, significantly, Aztec and Inca states.[27]

Given this new explanation, the next question is *why* did the Maya fail to attain political integration? Theoretically, we can assume that at least two events were necessary to attain integration: (1) sufficient political willingness had to be exercised by one or more hegemonic states for establishing unity (willingness to solve the

[26] As Culbert has noted, "for such a society not to make territorial and resource aggrandizement a major priority of military activities would be almost without anthropological and historical precedent" (1991:144). Citing our theory of failed political integration, Cordell (1997:395) has recently noted that a similar mechanism may account for the Anasazi collapse in the American southwest: "reliance on and subsequent destabilization of regional social networks, without the ability to either increase food production or develop a larger, more integrated political system [*sic*], were factors important to abandonment or collapse in both regions."

[27] The archaeologist Gordon R. Willey had this acutely political insight 25 years ago: "As a result of these internal stresses and external pressures, the Classic Maya polity, a level of sociocultural integration encompassing the lowlands and maintaining a partially urbanized population of as many as five million people at its peak, was no longer viable" (Willey and Shimkin, 1973:491).

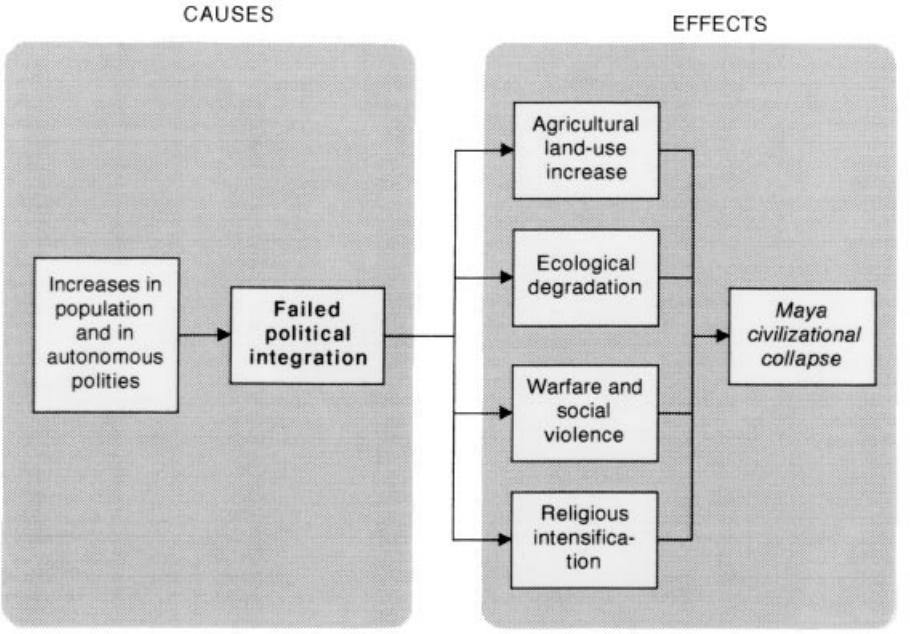

FIG. 7. Proposed Theory of Maya Collapse

"collective action problem" of unification and overcome the decentralizing forces of the "cooperators' dilemma"; Lichbach, 1996); and (2) the material opportunity or capacity to construct and maintain such a pan-Maya polity had to exist (capability to solve the problem).[28] Other conditions may have been necessary as well (e.g., popular agency or mass support), but these two never materialized when they were critically needed. In terms of willingness, the first major condition for integration, there is no evidence of the existence of any expansive Maya state analogous to, say, Ur, Memphis, Rome, or Tenochtitlán, in their respective areas of civilization, although cases of limited regional hegemony did occur with Tikal, Copán, Calakmul, Palenque, and Petexbatún in the southern lowlands and Chichén Itzá and Mayapán in the northern lowlands. Thus, "the large expansionary polities did not develop in the lowlands. Various cities [e.g., Calakmul, Chichén Itzá, Copán, Lamanai, Mayapán, Palenque, and Tikal] did, from time to time, conquer other cities, but the prevailing political pattern was one of independent states with spatially limited surrounding dependencies" (Hassig, 1992:71). Nor is there any evidence of a unifying coalition of states (Chichén Itzá and the Mayapán confederacy were confined to the northern lowlands), nor of the same dynasty governing a large number of states. As the number of states grew, cooperation became more difficult and—in terms of Olson's theory of collective action—the public good of unified government was never produced.

[28] Our explanation is founded on the classic willingness-opportunity principle of political science, as developed by Starr (1978) and Cioffi-Revilla and Starr (1995), based on earlier work by H. Sprout and M. Sprout. Recent works on the emergence of political cooperation under a range of anarchy conditions include those by Axelrod (1997), Cioffi-Revilla (1998:ch. 8), Cederman (1997), Rosenau and Czempiel (1992), Lichbach (1996), and Starr (1997). Webster (1977) presents an alternative and compatible explanation for the Maya failure to attain political integration. Sabloff (1996:12) identifies several sufficient conditions which "helped *block* the growth of a strong central authority," including "dispersed populations," "the seeming independence of Maya farmers from state control," and "the relatively low number of non-food producers" (emphasis original), which are obstacles to political opportunity. We have not seen the willingness-opportunity principle used by Mayanists, although it can contribute to theoretical archaeology (Dark, 1995).

In terms of the opportunity or capacity for greater political unity, the second major condition for political integration, the torrid environment of the tropical jungle (> 300,000 km^2) offered many obstacles for attaining and maintaining the necessary governmental forces and communications to rule the whole pan-Maya area, or even separate highland and lowland sectors. Logistically, Maya military and engineering capability was sufficient to establish local states, wage numerous wars, and sustain millions of inhabitants scattered across the area. However, without beasts of burden or metal tools it was no match for the dense forests, high temperatures, and high humidity of the lowlands, or for the difficult terrain of the highlands. As a result, any attempt to establish a pan-Maya state consistently faced a very steep "loss-of-strength gradient," based on Boulding's (1962) principle of viability ("the further the weaker"). Even the relatively efficient system of roads linking several major polities (e.g., the 100 km. Cobá-Yaxuná causeway) would have been insufficient for deploying and supplying the required level of security forces.[29]

In sum, our findings suggest that the Maya political collapse occurred because the number of states and their population reached such large numbers—approximately 20 and 5,000,000, respectively (Willey and Shimkin, 1973:491)—that they could no longer survive without further political consolidation in the form of a unified pan-Maya state. We also argue that such a development in Maya political evolution never took place because of unresolved difficulties in willingness, opportunity, and collective action among competing dynasties of comparable power.

New periodization of Maya political history. The distinctive evolutionary pattern of the Maya political system (Figure 1) also suggests a new periodization for its political history—a different "clock" to understand political evolution. As noted in the introduction and shown in Figure 8 (top), the traditional periodization is marked by three transitions: from Preclassic to Early Classic (A.D. 250), from Early Classic to Late Classic (A.D. 750), and from Late Classic to Postclassic (A.D. 900). However, from a political perspective (this is not so from archaeological, artistic, or epigraphic perspectives), the first two of these transitions do not correspond to any observable changes in the system, as reported by our measurements.[30] This means that the traditional periodization has doubtful political meaning for about three-quarters of the whole span of Maya history. As already noted for Figure 1, in terms of number of existing polities, $N(t)$, there was no detectable change in the transition from Preclassic to Early Classic (A.D. 250), or in the transition from Early to Late Classic (A.D. 600). Furthermore, the apogee of polities at approximately A.D. 600–A.D. 800—certainly one of the most significant moments in the evolution of the Maya or any other political system—is not marked by anything in the traditional periodization. Not even the demarcation between the Late Classic and the Postclassic at A.D. 900 seems valid, except for a small change in the slope of the first major (Classic) collapse. As indicated earlier, there is also no explicit acknowledgment of the second cycle in the traditional periodization.[31]

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[29] Very few intercity road systems have thus far been discovered in the Maya lowlands, but we do have them radiating from Calakmul, Cobá, and El Mirador (Folan, Marcus, and Miller, 1995).

[30] Our argument is not against the traditional periodization as a framework for archaeology, art history, or culture, but rather against its limited value for understanding the politics. As archaeologists themselves point out: "The Classic period . . . is defined by the first appearance of formal documentary records, presently thought to be *c*. A.D. 200, and by their cessation, in any form that survives today, *c*. 910. Polity formation and maintenance occurred throughout this period, but the temporal limitation imposed by the presence of written records does not constrain the archaeological evidence for the emergence of a complex society with an undoubted political dimension among the lowland Maya, which occurred several centuries earlier in the Late Preclassic period" (Hammond, 1991a:253). Similarly, "the Classic in fact can only be defined accurately as that span during which the lowland Maya were using the Long Count calendar on their monuments" (M. D. Coe, 1993:71).

[31] Sabloff (1989, 1994) has proposed a more advanced, developmental periodization, noting that "the older chronological terms and periods need a major overhaul in the coming years" (1994:129). However, Sabloff's new alternative periodization also seems based on the traditional assumption of a single rise-and-fall.

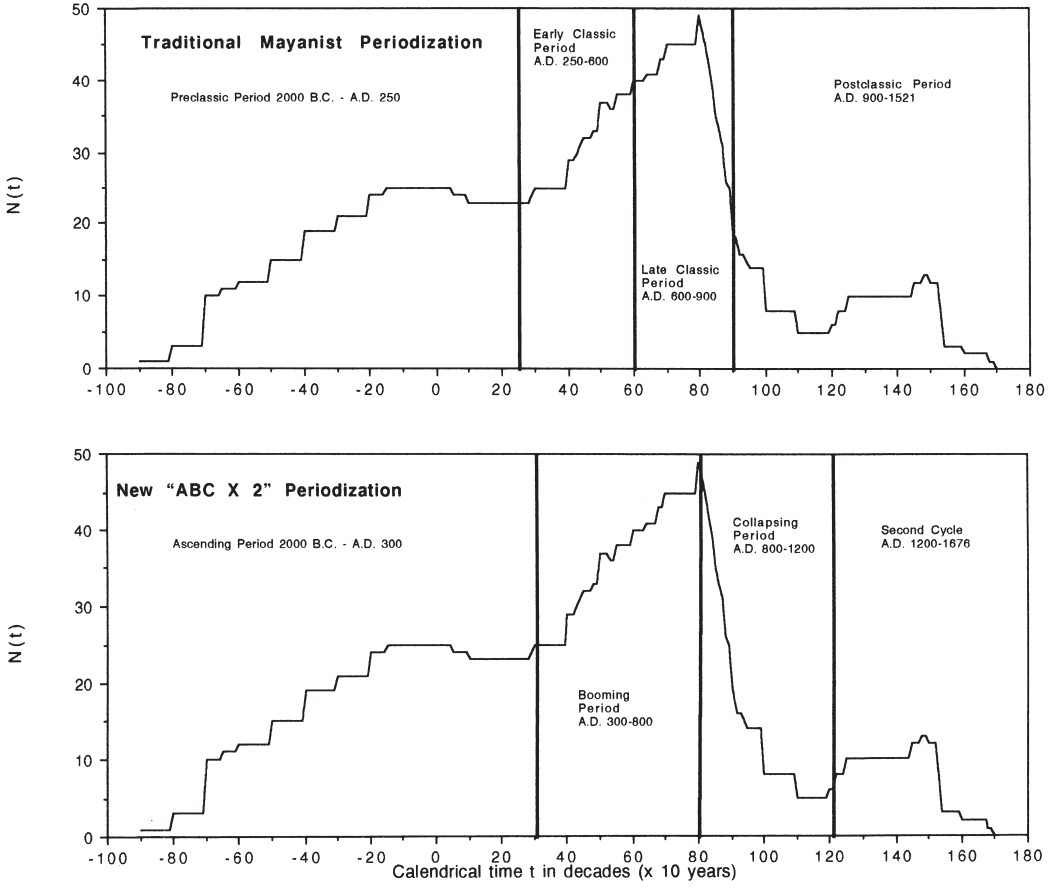

FIG. 8. Traditional and Proposed Periodizations of Maya Political History

Based on our findings, we propose a new political periodization with at least two cycles, each with three periods. As shown in Figure 8 (bottom), the first period in the first cycle was an "Ascending Period" from 900 B.C. to A.D. 300, during which time the system expanded at a relatively slow rate of approximately 22 polities in a thousand years.[32] (Interestingly, perhaps there was another cycle that peaked during the Late Preclassic, but which cannot yet be determined with the extant data.) This was followed by a "Booming Period" from A.D. 300 to 800, when the system expanded at a rate of approximately one new polity every two decades and the population peaked at approximately 5 million. The third stage was a "Collapsing Period" from A.D. 800 to 1200 in the first cycle, which produced a sharply decreasing rate of one polity falling per decade. The second cycle repeated a similar pattern of ascension (A), boom (B), and collapse (C).

This new "ABC × 2 model," defined by the sequence of developmental stages

$$\text{Ascending} \rightarrow \text{Booming} \rightarrow \text{Collapsing},$$

provides a more accurate periodization for the evolution of the Maya political system—a more appropriate "political clock"—because transitions between periods now correspond to empirically observed changes in the composition of the political system, as well as corresponding to major political events known to have affected the system's evolution. Accordingly, the first major transition in A.D. 300 is marked by: (1) a sharp increase in the number of existing polities (Figure 1); (2) internally, the emergence of local social ranks and political hierarchy (Webster, 1977:349; Marcus, 1993); and (3) externally, a major outside hegemonic influence on the system—the Teotihuacano penetration of the Maya highlands (viz., the Solano culture at Kaminaljuyú; Popenoe de Hatch, 1997) and its trade influence in the Petén region itself (e.g., in Becán, Tikal, Uaxactún, and elsewhere). Moreover, these major events may have been related, such that Teotihuacán's influential expansion from the Valley of Mexico may have been caused by increasing anarchy in the Maya area to the south. Conversely, the sharp increase in Maya polities may have been caused by Teotihuacán's trade and long-range commercial influence in the region, allowing for the accumulation of sufficient wealth for political development to have occurred.[33] In either case, the ABC model's transition around A.D. 300–350 (from the Ascending to the Booming period) is more tenable from a variety of political perspectives, including the rise of the first state-level polities (emergence of earliest pristine states), than the traditional transition in A.D. 250, when not much of political significance was occurring.

Similarly, the second major transition in A.D. 800 (not the traditional A.D. 600) is marked by (1) a steep decrease in the number of existing polities (Figure 1); (2) internally, the failure to politically integrate with escalating "militaristic warfare" (Webster, 1977:371–72); and (3) externally, another major exogenous political event—nine hundred miles away, the powerful Teotihuacán state, Mesoamerica's hegemon at that time, also fell during the early eighth century (Millon, 1981, 1988; Hassig, 1992:85–86). As we have argued above, these events may have been related, with failed political integration causing the civilizational collapse, but in any case the ABC model's cycle-1 transition around A.D. 800 (from the Booming period to the Collapsing period) is more politically meaningful than the traditional transition

[32] During this time, population is estimated to have increased from approximately 1,000 people in *c*. 1500 B.C. to well above one million (Webster, 1977:343; see also Hammond, 1992, and Sharer, 1992).

[33] The reverse effect was also true: "From A.D. 200 to 600, the city [of Teotihuacán] continued to flourish with long-distance trade becoming an important factor in its prosperity" (Carlson, 1993:62). The peak of Teotihuacán's influence in the Maya area occurred at A.D. 300–400 (Marcus, 1996:30).

in A.D. 600. The ABC model captures these political changes, explaining them better than the traditional cultural periodization.

The end of our first political cycle in A.D. 1200, and the beginning of the second cycle, is marked by the fall of Chichén Itzá, another politically significant landmark that is absent from the traditional periodization, but which is recognized by many as important (Marcus, 1993; Sabloff, 1994; Sharer, 1994). After 1200, the second cycle underwent a similar A → B → C sequence, with period transitions marked by the rise and fall of the Mayapán state, until eventually all major Maya governments vanished by A.D. 1700. Among Mayanists, our empirical findings and the ABC × 2 model lend strongest support to Marcus's (1993) "dynamic model" with multiple cycles, even more so if an additional Late Preclassic peak (Figure 1, first relative maximum) is confirmed.

Some Implications for Future Research

The new understanding of the Maya political system derived from this study, combined with other measurements that are becoming increasingly available, will permit future analyses comparing the Maya political system with (1) other ancient polity systems (e.g., Mesopotamia, China, and Greece) and (2) the modern nation-state system. For example, the failed-integration theory we propose for the collapse of the Maya political system may be tested in other systems where integration *did* in fact occur (e.g., Sumer, Babylon, Macedonian Greece, Italy, Andean region, as well as elsewhere in Mesoamerica) and the component states did *not* vanish but instead were successful in managing their crises and flourishing with a growing population—after incorporation within one or another empire. Not only is this type of cross-polity synchronic research fruitful and necessary, but we also need to address the perpendicular dimension—viz., temporal or longitudinal research for testing cross-time hypotheses and dynamic theories of politics (Bardolini, 1993). The disciplinary and interdisciplinary benefits of long-term longitudinal analyses such as this can be substantial, for political science as well as for allied disciplines such as archaeology, history, and related fields.

Our new data set on the composition of the Maya political system (improved by future data that may become available in the not-too-distant future) also brings us one step closer to investigating several classical hypotheses and theories of world politics that so far have lacked sufficient comparative testing. Long-term historical data can provide us with additional laboratories for refining, testing, and evaluating many of our basic models, concepts, and hypotheses. For example, with additional reliable data on Maya warfare and alliances, the data on the Maya political system reported in this study should permit an investigation of the war-polarity and war-alliances hypotheses (Midlarsky and Hopf, 1993; Russett and Starr, 1995:ch. 5). Geopolitical aspects of interstate conflict (e.g., location and proximity) are another promising direction for future investigation. Using emblem glyph polities with populations over 10,000 as rough equivalents to poles or great powers, the following Maya polities would qualify in various epochs: Becán, Bonampak, Caracol, Chichén Itzá, Copán, Naranjo, Palenque, Tikal, and Yaxchilán. Alliance data are also becoming more accessible, including summitry data (e.g., Marcus, 1974, 1976; Mathews and Willey, 1991), which can be combined with our duration data to develop and test explicit hazard rate multivariate models (Cioffi-Revilla, 1998:ch. 4). The addition of new political variables on the chiefdom → state transition may soon become feasible (Peregrine, 1998), an exciting prospect for comparative international research. These and other future investigations will advance our knowledge of the structure and evolution of polity systems in world politics based on a long-term historical approach and multidisciplinary collaboration.

Appendix: Sources and Dates

Polity formation ("rise") and termination ("fall") dates were measured using the operationalizations detailed in the *Method* section. The sources used to reconstruct a polity's (pre)history and estimate its dates of rise and fall differ by levels of chronological precision and proximity to the field evidence. *Primary sources* consist of (a) structural, architectural, or other *archaeological* evidence (e.g., Webster, 1976; Inomata, 1994; Folan, Marcus, and Miller, 1995); as well as (b) textual information in the Mayan language, including hieroglyphic, paleographic, or other *epigraphic* records pertaining to social and political events (e.g., Berlin 1958; Schele and Freidel, 1990; Schele and Mathews, 1991; Marcus, 1992a). Thus, both archaeological and hieroglyphic bodies of evidence were used in this study, unlike previous studies that rely almost exclusively on epigraphic dates (Hamblin and Pitcher, 1980; Lowe, 1985; Mathews, 1985). In general, archaeological evidence chronologically precedes epigraphic evidence in the *formation* of a polity. By contrast, the opposite is generally true in the termination of a polity; archaeological evidence usually—albeit not always—postdates the epigraphic evidence (assuming any extant epigraphy). Therefore, most dates of formation and termination—albeit not all—are archaeologically determined. In some cases the last archaeological *and* epigraphic records for termination are coeval. In general, epigraphic data (e.g., Schele and Grube, 1994) are more critical for estimating events *within* a polity's lifespan (e.g., wars, alliances, royal visits) than for formation or termination events. However, whenever the last terminal event is epigraphic (15 polities, or 21% of the cases),[34] without subsequent archaeological information for determining polity termination, then the polity termination date was estimated at *c*. 30 years (one political generation) after the last extant epigraphic date, which is within the ± 100 year accuracy range of most other dates. Otherwise, archaeological evidence was used.

Secondary sources contain more interpretation and analysis concerning a particular site or cultural trait (e.g., W. R. Coe, 1990; Fash, 1991; Folan, 1992; Houston, 1993), including discussions of primary material (archaeological or epigraphic). *Tertiary sources* are general works with broader spatio-temporal scope (e.g., Coe, Snow, and Benson, 1986; M. D. Coe, 1993; Stuart and Stuart, 1993; Sharer, 1994; Marcus, 1995; Adams, 1996). As a procedure, data coding began with tertiary sources, to establish an overall chronological framework for each polity, and then proceeded to the more detailed secondary and primary sources.

Numerous primary and secondary sources were used to determine events and dates of polity formation and termination, in addition to communications with the panel of Mayanists acknowledged in Table 1. To provide some examples of the materials used for each polity case, the estimation of formation and termination events and dates for several cases from among the set of 72 polities listed in Table 1 was based on the following sources, in addition to general works:

- *Becán* (case no. 28): Adams (1975), J. M. Andrews (1976), Andrews and Andrews (1979), Ball (1974; 1977), Thomas (1980), and Webster (1976; 1977; 1993).
- *Calakmul* (case no. 17): Folan (1992), Folan, Marcus, and Miller (1995), Folan and May Hua (1984), and Marcus (1976, 1987, 1995, 1996).
- *Copán* (case nos. 11 and 29, for Preclassic and Classic polities at Copán, respectively): Agurcia Fasquelle and Fash (1989), Fash (1991), Fash and Stuart (1991), Freter (1992), Stuart (1989), Webster and Freter (1990a; 1990b), and Williamson, Stone, and Morales (1989).

[34] These data are available at the *International Studies Quarterly* web site (http://www.iastate.edu/isq) or directly from the authors.

- *Cuello* (case no. 1): Andrews and Hammond (1990), Hammond (1977; 1982; 1985; 1991b; 1994), Hammond et al. (1976), and Housley, Hammond, and Law (1991).
- *Dos Pilas/Aguateca* (case no. 52): Demarest and Houston (1989a; 1989b; 1990), Demarest, Inomata, and Escobedo (1992), Houston (1993), Houston and Mathews (1985), Inomata (1994), and Mathews and Willey (1991).
- *Kaminaljuyú* (case nos. 5 and 31, for Las Vacas and Solano polities at Kaminaljuyú, respectively): Kidder (1961), Kidder, Jennings, and Shook (1946), Popenoe de Hatch (1996a; 1996b; 1997), Sanders (1974), Sanders and Michels (1977), Sanders and Murdy (1982), and Villacorta (1938).

Similar specialized coverage was used for each polity, but focusing only on those sources containing relevant information for estimating formation and termination. (Obviously the literature on each site contains numerous other aspects, such as ecology, stratigraphy, population estimates, or processes during the lifetime of a polity, some of which are only indirectly relevant for measuring duration.)

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