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Conceptualizing Prehistoric Water Scarcity in the Central Maya Lowlands: The Influence of a Critical Resource on Settlement Patterns and Political Economy

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The dispersed settlement pattern of the Ancient Maya may have evolved in part as a consequence of the limited amount of permanent water available on the Karstic landscape (Scarborough 1996, p. 314).

The Ecological Setting

Many years of research by archaeologists, geologists, and climatologists have resulted in a better understanding of the ecological setting of the Yucatan Peninsula, on which the central Maya lowlands rest. One aspect of the landscape that is now more fully understood is the availability of water in this tropical forest ecological zone. In fact, because of the characteristics of the landscape, water is virtually unavailable several months out of the year in interior regions, unless it has been conserved in some way on the surface.

The Yucatan Peninsula rests on limestone bedrock, and is characterized by naturally formed depressions, caves, and sinkholes (*cenotes*) which collect water. Rainfall in the central lowlands ranges from 2,000 mm to more than 3,000 mm annually, with pronounced wet and dry seasons (Rice et al. 1985: 91; Escoto 1964). The region is transected by a series of low ridges running in an east-west direction, with several lakes in the low-lying areas, and perennial rivers along the eastern and western perimeter of the lowlands (Ford 1996: 300). In the interior Petén region, north of lake Petén Itzá, there are no permanent water sources. The area does have many large swampy catchment areas, but these dry up completely into hard-packed clay in the dry season, which lasts four to five months (Ford 1996).

Maya scholars have not reached a satisfactory explanation for why the largest, densest and seemingly, most complex and elaborate manifestations of human culture in the central lowlands arose in an area which was, and still is, the region's most difficult environment in which to live. This is the area to the north of lake Petén Itzá, in the northeastern corner of Guatemala and along the northwestern border of Belize. Some researchers, after gathering more detailed information about settlement patterns, paleoclimatology and limnology, along with other archaeological data, have proposed that control over a single critical resource–water–shaped settlement patterns and may be one explanation for the development and dénouement of what is traditionally known as the "Classic Maya" civilization, dating from 250 AD to 900 AD (Ford 1986, 1996; Scarborough 1996; Matheny 1982).

Singling out water availability as a critical factor in the shaping of ancient Mayan culture and environment is due in part to a lack of attention to its importance in the past. It was most likely one factor involved in the formation of the complex "Classic Maya" socio-cultural system. However, for the purpose of this paper, water scarcity will be presented as an ultimate climatic and geographic variable which exerted influence on the development of a heterogenous, locally-variable, complex system of social, political, economic, and ecological components. Water is not *the* answer to all of *the* questions regarding this transformation, However, exploring the influence of its scarcity on the human ecosystem of the lowlands from the Early Classic to the Early Postclassic provides an opportunity to focus upon patterns of human-environment interactions across space and time.

Maps and Graphic Conceptualizations

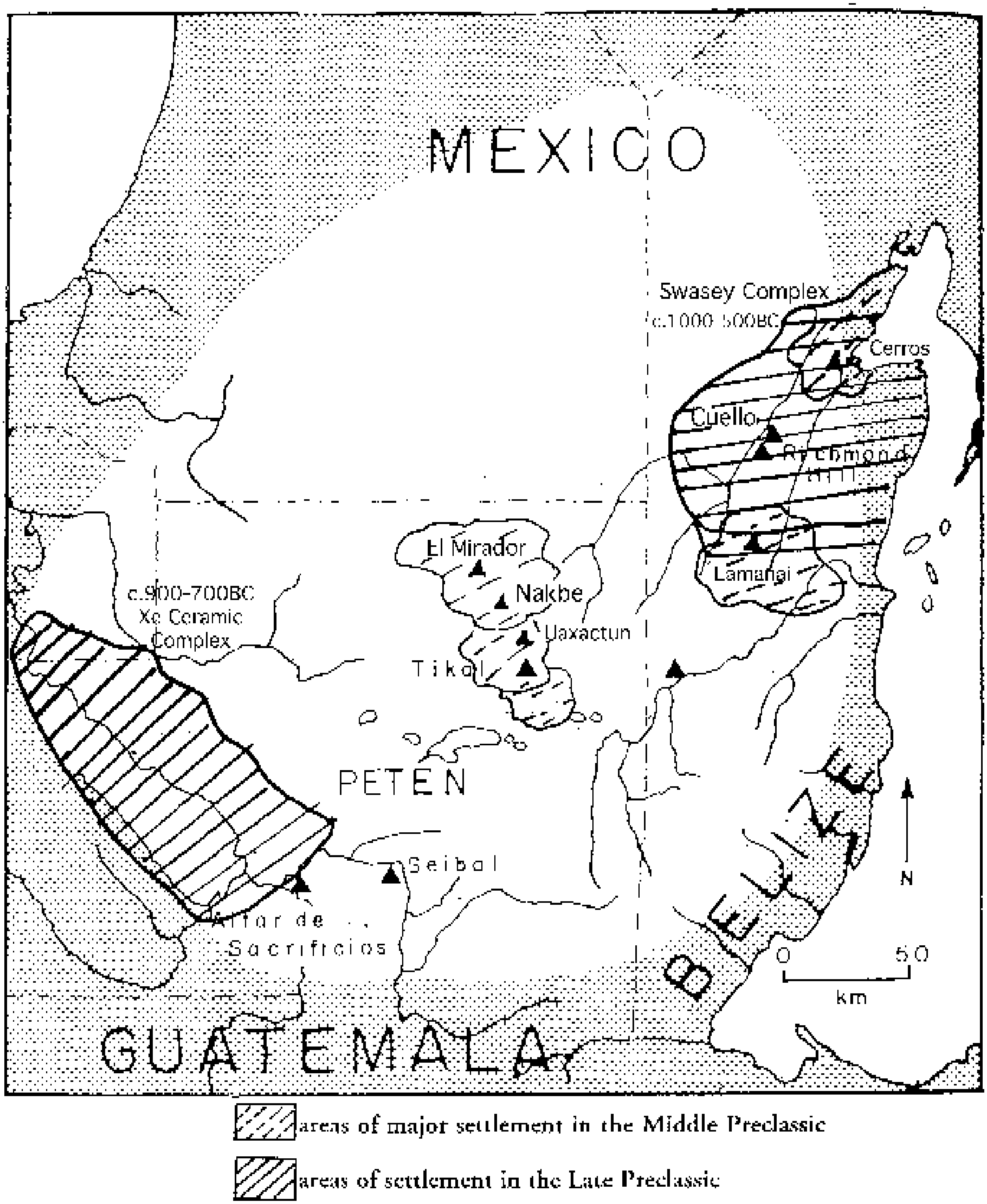
Settlement Patterns

In order to represent visually the impact of water scarcity on the Maya landscape, maps are utilized to depict the way that permanent water sources were related to settlement patterns throughout the Preclassic, Classic, and Postclassic (1000 BC to 1150 AD), in a very broad and gestalt sense. Maps 1, 2, and 3 illustrate this effort. Map 1 shows that settlements in the early portion of known human history in the area were located primarily on permanent sources of water, with the coastal areas among the first to be settled upon human occupation. By the Early Preclassic, the earliest agricultural villages were spread along riverine environments and lacustrine environments. As the transition to the Middle Preclassic occurs, one site which typifies settlement patterns is found at Cuello (c. 1000-800 BC). Here, the people were living in structures constructed of wood, exploiting the rich riverine ecosystem, and growing maize (Hammond 1991). For the Middle Preclassic, there are two major complexes recognized in the lowlands: the Xe Complex in the Usumacinta river valley; and the Swasey Complex in Northeastern Belize (Hammond 1992). Note that the interior region of the Petén is virtually unexploited, until the Late Preclassic, when populations begin to move away from permanent water sources, and into the less reliable interior (Ford 1986, Culbert and Rice 1990). This was accompanied by the beginnings of public works, such as reservoirs, or *aguadas*, at sites such as El Mirador (Matheny 1981: 168), extensive monumental architecture, and intensification of subsistence strategies.

Map 2 depicts the expansion of a growing population into most available areas in the central lowlands, although in varying densities–with concentrations of people around regional centers with intraregional exchange networks (Adams 1977). It is during the Classic period that the most widespread settlement occurs. At this time, population densities increase most dramatically in the well-drained uplands, such as those found near the major polities of the Early Classic period: El Mirador; Tikal; Uaxactun; etc. (Ford 1996). This shift in settlement trends is accompanied by several other developments: trade with far-removed regions, including Teotihuacan; a varied subsistence strategy which exploited differing micro-evironments across the region; a writing system; elaborate ritualization of exotic objects; and monumental architecture. These influences will be made more apparent in the graphical representations to follow. It is during this time that population reaches its highest levels and urban cities of an estimated 60,000 inhabitants appear in the lowlands (Turner 1990; Culbert et al. 1990). Some of the major sites are designated by triangles on Map 2.

Map 3 illustrates the drastic change in settlement patterns in the transition from the Classic period to Postclassic times. The so-termed "Mayan Collapse" is broadly characterized by a rapid decrease in population (some estimates are 90% of the population), and a retreat by those lucky remaining few to the various permanent water sources across the region (Culbert 1973). Eventually, almost all of the largest urban centers slowed any construction of monuments or stelae and subsequently were abandoned. The senescence of Maya civilization was not a uniform process, it occurred over a hundred and fifty year period, and in some areas, such as Lamanai in central Belize, collapse and abandonment never occurred (Adams 1991). At the top right corner of this map are arrows indicating the rise of the northern polities in the Yucatan Peninsula at this time.

Settlement Patterns in the Preclassic; 1500 B.C.-A.D. 250



Map 1: Settlement Patterns in the Central Lowlands.

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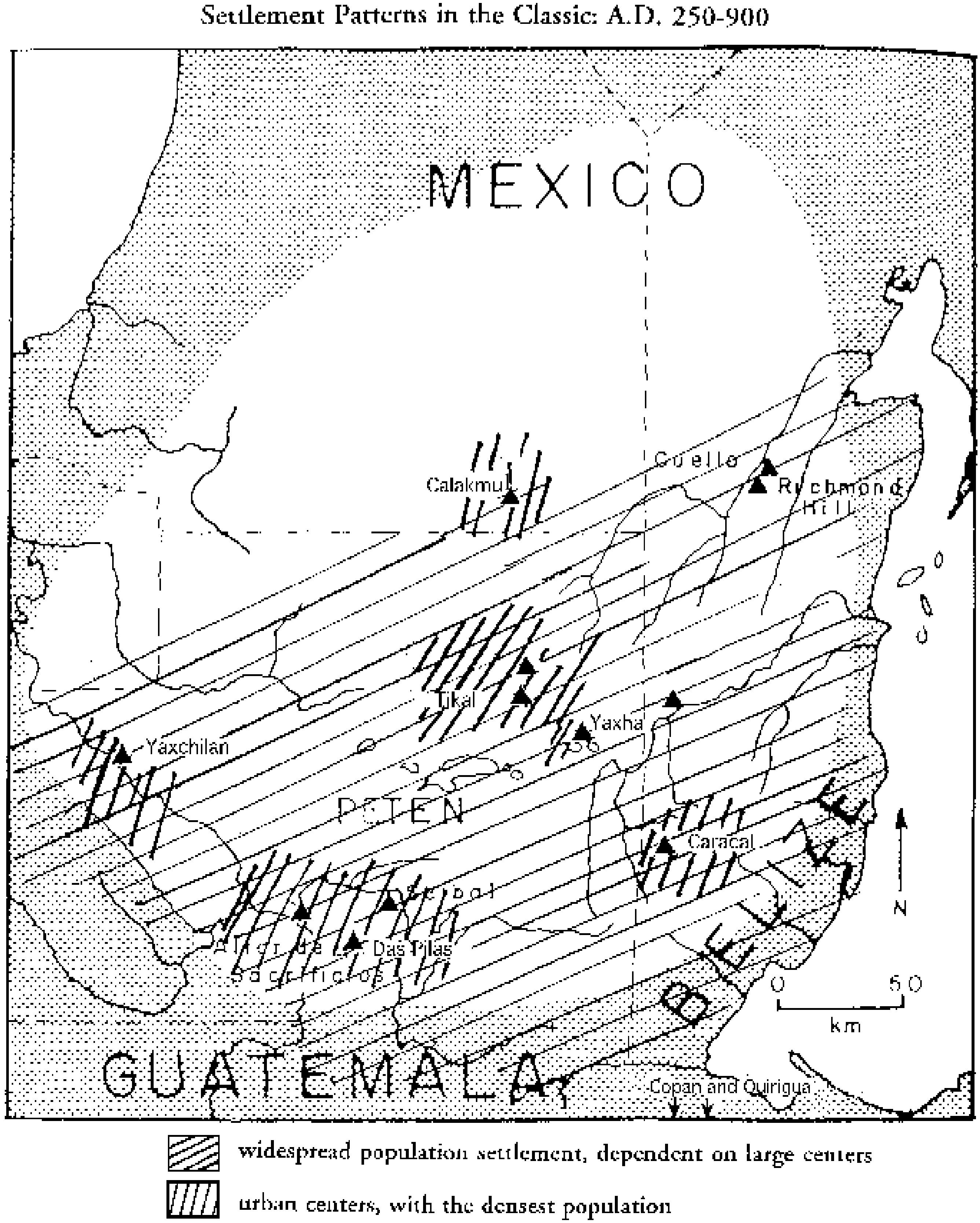

Map 2: Settlement Patterns in the Central Lowlands.

Settlement Patterns in the Early Postclassic: A.D. 900-1150

sparsely distributed, much smaller population

city center (anomalies)

Map 3: Settlement Patterns in the Central Lowlands.

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The Influence of Water Scarcity on Settlement Patterns and Political Economy

Figure 1 is an overview "model," the graphical counterpart to the maps just discussed. A timeline runs from 1000 BC to 1150 AD, which is broken up into four sections, each indicating a major transition. The critical information added to this model, though not present in the maps, is that evidence exists for a short arid period around 500 AD for the Yucatan Peninsula. This may have succeeded in exacerbating an already tenuous hydrological situation for growing populations in the region (due to the onset of an arid period in a karstic landscape with a pronounced dry season). The situation perhaps allowed certain individuals or elites to benefit from the ability to provide a predictable source of water and/or water storage in a time of great scarcity, thus acting as one catalyst to complex state formation.

The evidence for a pronounced arid period is found in recent studies of paleoclimatological data in the Petén lakes region, and the northern Yucatan peninsula. In two separate studies, one at Lake Chichancanab, and the other at Lake Punta Laguna, in the Northern Yucatan, a series of lake cores were analyzed. Based on this data, Curtis et al. conclude that there was a shift to a drier climate around 250 AD, which corresponds roughly with the onset of the "Classic Maya," as well as a major drought between 800 and 1000 AD, which corresponds temporally with the Mayan "collapse" (Curtis et al. 1996; 1995). According to their data, "[t]he oxygen isotopic record from Punta Laguna indicates that the terminal Classic and earliest Postclassic period (800 to 1050 AD) was one of the driest intervals of the last 3500 years" (Curtis et al. 1996: 45). A similar dry period is also recorded in other paleoclimatic data from other regions of Mesoamerica (Curtis et al. 1996). This climate variation may have been a critical factor in many ways, one of which may have been, as stated above, to act as a catalyst for the formation of the Classic Maya states, as well as one of many interacting factors which presumably caused the drastic population decline and abandonment of settlements during the ninth century AD in the central lowlands. Jeremy Sabloff made the following comment on the importance of Curtis, Hodell, and Brenner's research to those interested in the collapse of the ancient Maya:

> To a civilization facing a number of stresses both internal and external, the scarcity of water could have greatly increased the vulnerability of numerous Classic Maya cities, especially in the southern lowlands, where the strains were greatest . . . a drier regime would have exacerbated the perilous situation . . . (Sabloff 1995: 357).

The perilous situation to which Sabloff refers here is the most widely accepted model of the collapse of the Classic Maya. That is, the collapse came about due to interrelated factors which included population growth, environmental degradation, and interpolity conflict. The affects these may have had also varied across the heterogeneous landscape (Sabloff 1995:357).

To turn again to the graphical representations, the entirety of Figure 1 depicts the influence water scarcity and control of water as an indispensable resource may have had on where people settled, how they sustained themselves, and how their political organization developed. To the left of the page in Figure 1.a, there are several smaller, egalitarian populations settled around a river and lake system, exchanging energy and matter (through trade in prestige and subsistence goods) and information (trade in technology and ideology) on a localized scale. As the shift to the Classic Period occurs in Figure 1.b, the populations move into the well-drained uplands. This coincides with the onset of a drier climate around 250 AD. Anabel Ford's research in the Petén lakes region, as well as Belize, indicates that settlements were hierarchically dispersed into these agriculturally desirable lands, with the largest patches of agriculturally-desirable uplands being the location of the largest centers (Tikal being a good example) and the densest, most stratified settlements (1996: 300).

In Figure 1.b the control of water becomes possible because a group of elites invest in the building of water storage systems. They do this by efficiently integrating the topography of the locality with the construction of massive paved areas (near temples and plazas) and building large reservoirs to collect runoff that accumulated during the rainy season (Scarborough 1996). The return to predictability enabled population growth and an increase in centralized power and/or control over the general population. This particular section is expanded in a more detailed, complex version in Figure 2, "Water Scarcity and the Development of 'Classic Maya' Civilization."

In Figure 2, there is a key in the bottom left corner. Symbols used in the model are provided here, as well as a Mayan "guide," whose comments help to assist the reader with the key background information to move through the model from left to right. The model begins in the upper left-hand corner with the geology and ecology of the central lowlands already discussed; there is a "switch" in the region's climate to a short arid period. A group of elites takes advantage of the situation that has presented itself, utilizing their stored capital (represented by the capital nucleation symbol), power and influence to get a large number of people to build temples, paved areas, and reservoirs. This "human-constructed watershed" (Scarborough 1996) enables the elites to control the release of and the use of water. They augment the control over one scarce resource with control of another: that is, the exotic trade goods from Teotihuacan, which contribute to the overall intensification of political and economic power. This growth is elaborated in the area encompassed within the dashed lines. Population increase, subsistence intensification, the elaboration of elite ideology (depicted by the "Water Lily Lords" ideological symbol) and settlement expansion are all crucial to the growth of the Maya civilization in the early Classic. Please refer to the dialogue by the "Mayan guide" for further explanation of this transition.

The role that ideology played in elite control over water is unclear, but speculations necessarily begin with the iconography which is still visible on stelae, glyphs, and temple facades. The frequently depicted water lily iconography and the fact that Maya elites of the Classic period referred to themselves as "*Ah Nab*" or "Waterlily People," is worth noting (Ford 1996: 302). This is a starting place for considering the impact of water control on social structure. Rural farmers who relied on elites for drinking water during the dry season would have been more easily persuaded to go to war or build massive public structures (Ford 1996).

Vernon Scarborough has provided an example of how the control of water may have shaped Mayan polities, based on his work at Tikal, a large urban center, and Kinal, a smaller regional center. At Tikal, there are three reservoir types: *central precinct reservoirs* (of which there were six at the core of the site, with a total capacity of 105,108-243,711m^3), *residential reservoirs* (which are smaller–10m wide–and found near urban house-mounds), and four large *bajo-margin reservoirs* (constructed in naturally-occurring low-lying areas) located approximately at the four cardinal directions from the core of the city, on the outskirts (Scarborough 1996: 305). In contrast, Kinal, a much smaller site than Tikal, had no center-precinct reservoirs, but did have several residential reservoirs, which were fed by runoff as were those at Tikal. The centrally-located water storage facilities at the two sites suggest that the centralized control of water may have allowed populations to become more densely settled, by assuring a predictable water source during the dry months of the year. Elite control over the release of stored water could have intensified their political and ideological influence on ancient Maya society (Scarborough 1996: 313-314; Ford 1996). The differences between the water-containment structures at Kinal and Tikal may indicate that control of water was less centralized or authoritarian at Kinal, due to its smaller size and population (Scarborough 1996). This is summarized in the bottom right corner of Figure 2.

Returning to the first graphic representation (Figure 1), Figure 1.c illustrates the impact that a "hyperdrought" may have had on Maya social and political structure, the economy, and where people were able to live. As the drought hit, the water table dropped and settlements formerly able to store water through the dry season could no longer do so. This may have succeeded in tipping the delicate balance between subsistence strategies,

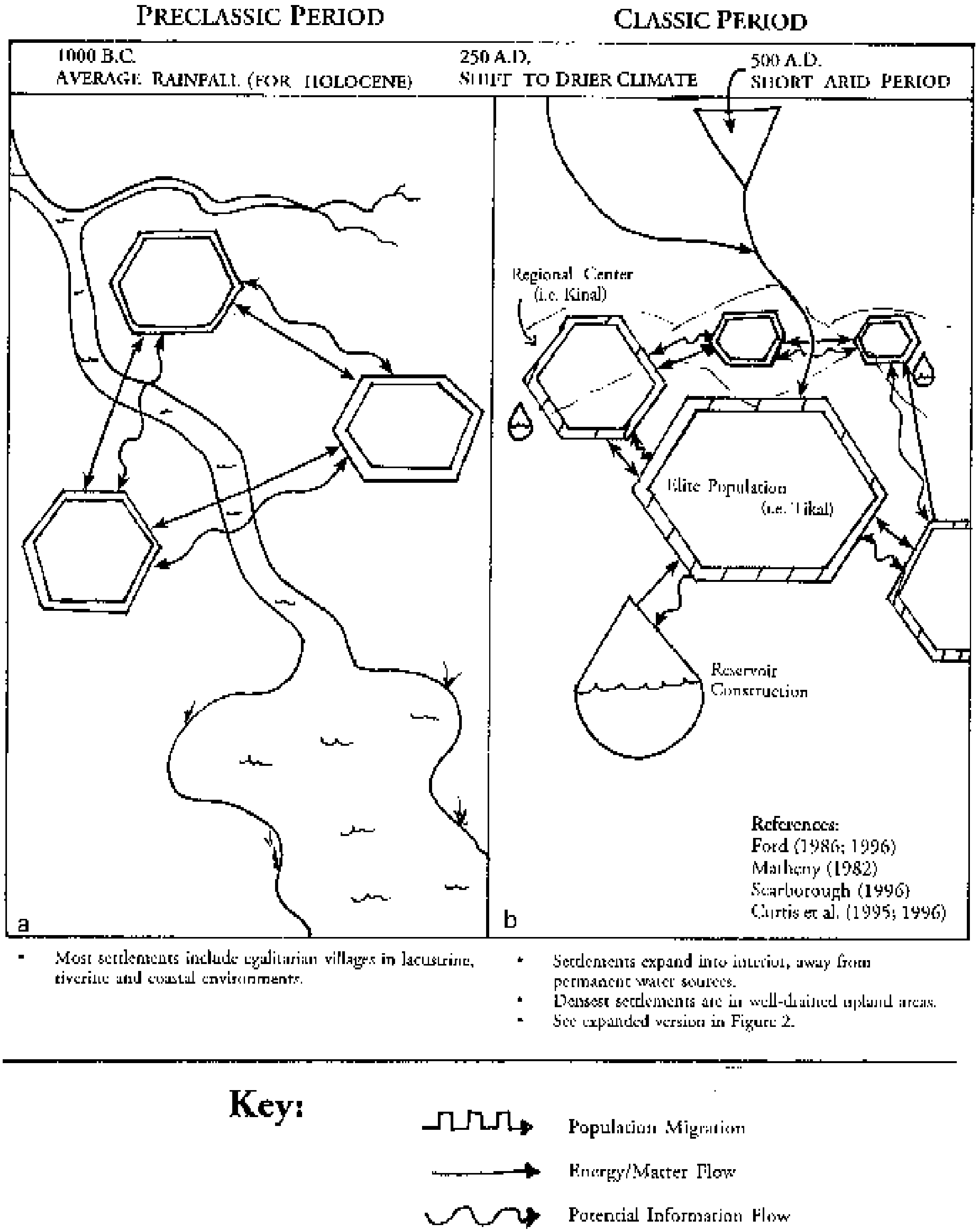
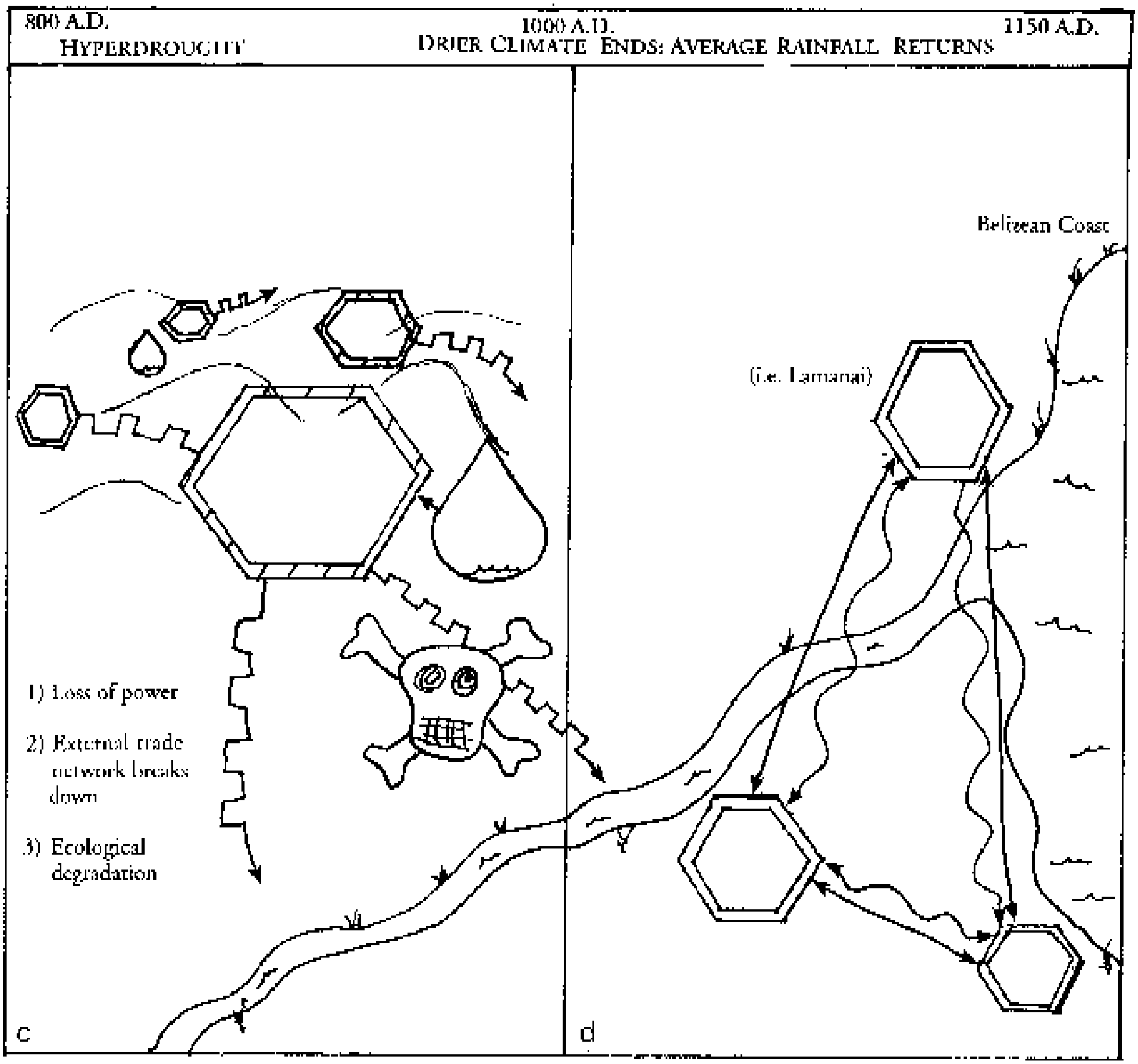


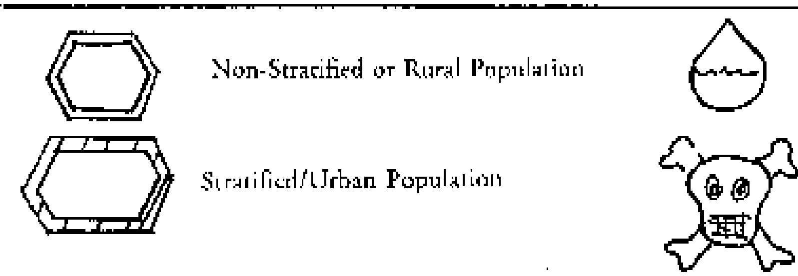
FIGURE 1: THE INFLUENCE OF WATER SCARCITY ON SETTLEMENT PATTERNS AND POLITICAL ECONOMY.

"COLLAPSE" POSTCLASSIC PERIOD



- Due to "Hyperdrought", reservoirs dry up, there is a major population decline and populations migrate back to permanent water sources.
- For a more detailed view of the effect of ecological degradation at Copan, see Figure 3.

- Population is at low density levels
- Settlements again located primarily in lacustrine, riverine, and coastal environments.



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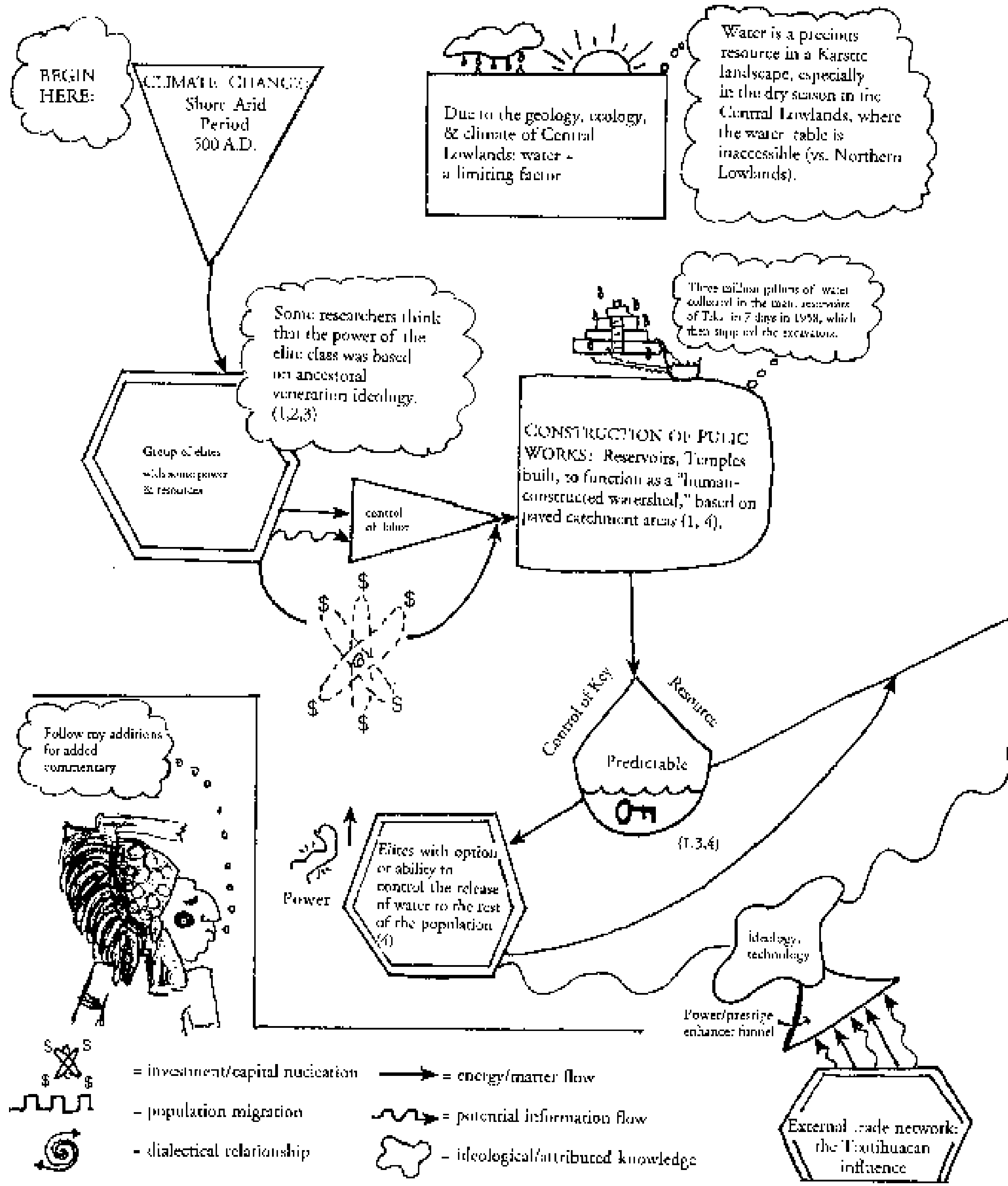
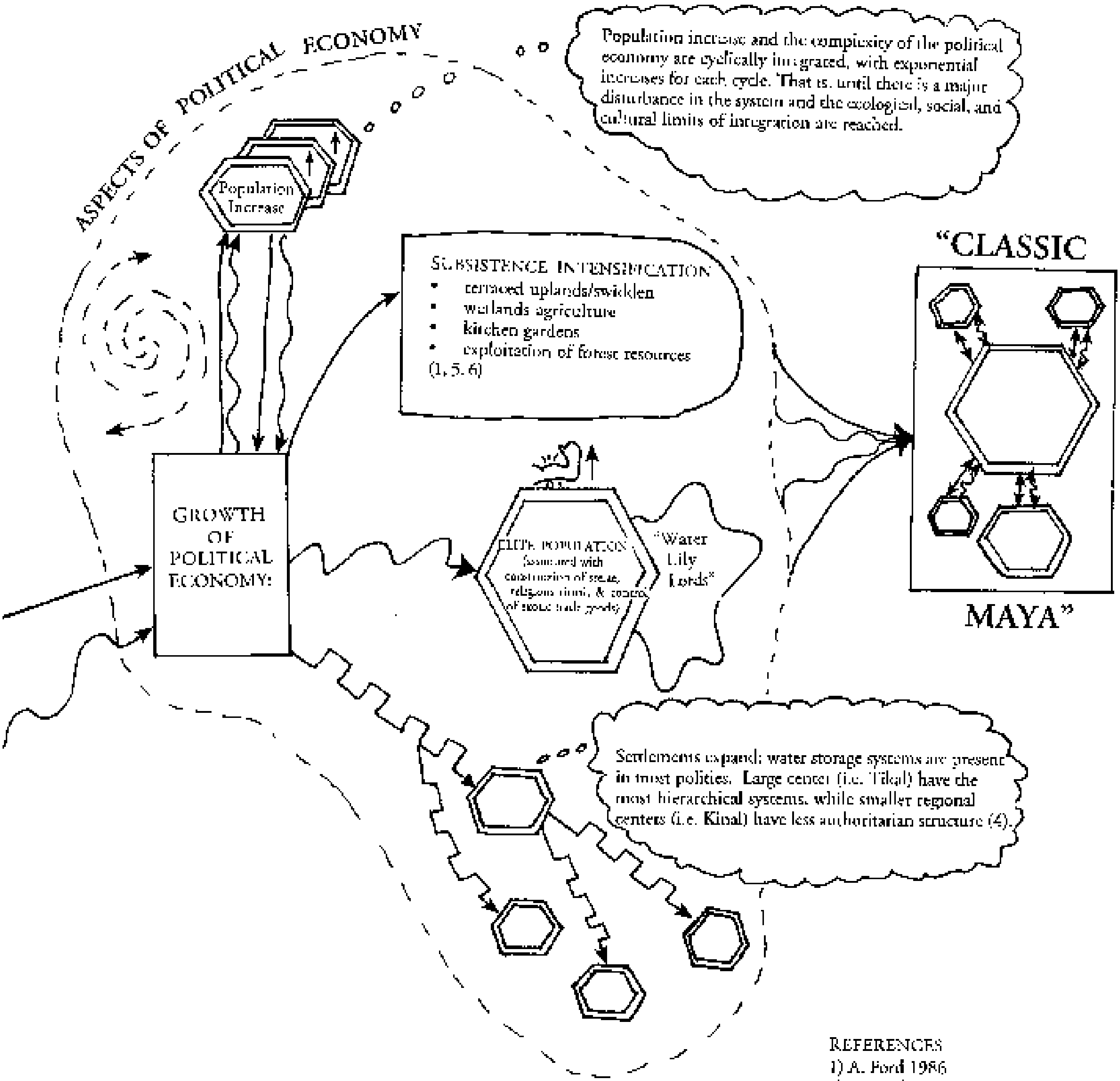


FIGURE 2: WATER SCARCITY AND THE DEVELOPMENT OF 'CLASSIC MAYA' CIVILIZATION.



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1) A. Ford 1986
2) A. Ford 1996
3) R. Adams 1977
4) V. Scarborough 1996
5) B. Voorhies 1996
6) S. Fedick 1996

interpolity warfare, an external trade network, and ideological management of the system (Sabloff 1995). In any case, as was outlined before, the centers were abandoned, and populations migrated to permanent water, such as the Northeast coast of Belize.

At this point, it might be relevant to address one previously raised question about the collapse of the "Classic Maya". That is, why were the polities in the northern part of the Yucatan peninsula able to expand their influence just as the southern polities were abandoned, if water scarcity had such an important role in their collapse? To evaluate the water scarcity argument, it is important to note the differences in landscape between the northern and the southern Yucatan peninsula. Granted, the northern peninsula is much drier than the southern portion, but the critical difference lies in the water table. Adams (1977) points out that the water table at Tikal is 168 m below the surface (inaccessible for human use at the time), while the water table in the northern Yucatan is only 20 m down (accessible). Matheny (1981) and others have also conducted research on the many *cenotes* (sinkholes) and caves from which northern peoples were able to retrieve water year round, gaining access to underground water supplies by using a system of ladders and ceramic vessels.

To turn in greater detail to the influence of human-environment interactions on the "collapse," Figure 3 depicts the specific role that deforestation may have played in the collapse at Copan, a major urban center. Copan is characterized by foothills, where most agricultural activities took place; and upland forest, where the primary reason for deforestation was domestic fuel wood. Cutting trees for domestic fuel wood was the most prominent type of forest-use in the uplands, while materials for habitation and cultivation were the causes of deforestation in the foothills (Abrams and Rue 1988). The deforestation in the uplands and foothills depicted here was followed by a "massive depopulation" of Copan's core, in which out-migration played the central role (Freter 1994:160). This is rather different from explanations for collapses in other areas of the Maya world–perhaps because much previous work was done primarily in urban centers. Freter's work focused on the rural settlement trends of Copan and she found that dispersal may be one explanation for abandonment, not widespread population decline as is often assumed.

Figure 1.d depicts the Postclassic period, during which the drier climate of the previous 900 years ends, and average rainfall returns to the lowlands. The settlements across the landscape returned to permanent water sources, with the settlements of greatest density located in Belize. Population levels were much lower overall by this time, however. As noted, there were some exceptions to the complete abandonment of cities, for instance, Lamanai in Belize. People were still living in the interior regions of the lowlands, but moved closer to the Petén Lake zone, and measurable urban centralization did not occur across the region for many centuries to come.

A Final Note: The Heuristic Value of Graphical Conceptualizations

The usefulness of models and maps, such as those included here, is to present relatively complex sets of ideas or theories in a succinct, clear, and interesting way. Complexity can be expressed more quickly and efficiently if it can be visualized. All models and maps do this to some extent, some better than others, and this is what I want to evaluate here. I have used two types of graphic representations here: a map, or geographical model, and energy/matter/information flow models, to represent the influence of water scarcity on the development of "Classic Maya" civilization in the Central Lowlands. Geographical models are useful for modeling human ecosystems in that they allow the viewer to see the features of the physical landscape and how humans interact with those features across space. By showing a series of these types of maps, through time, in Mayan lowlands, some general patterns become apparent. Scale is very important to consider when using geographical models, given that things such as environmental heterogeneity can appear and disappear depending on the scale depicted. One limitation of "flat" maps, such

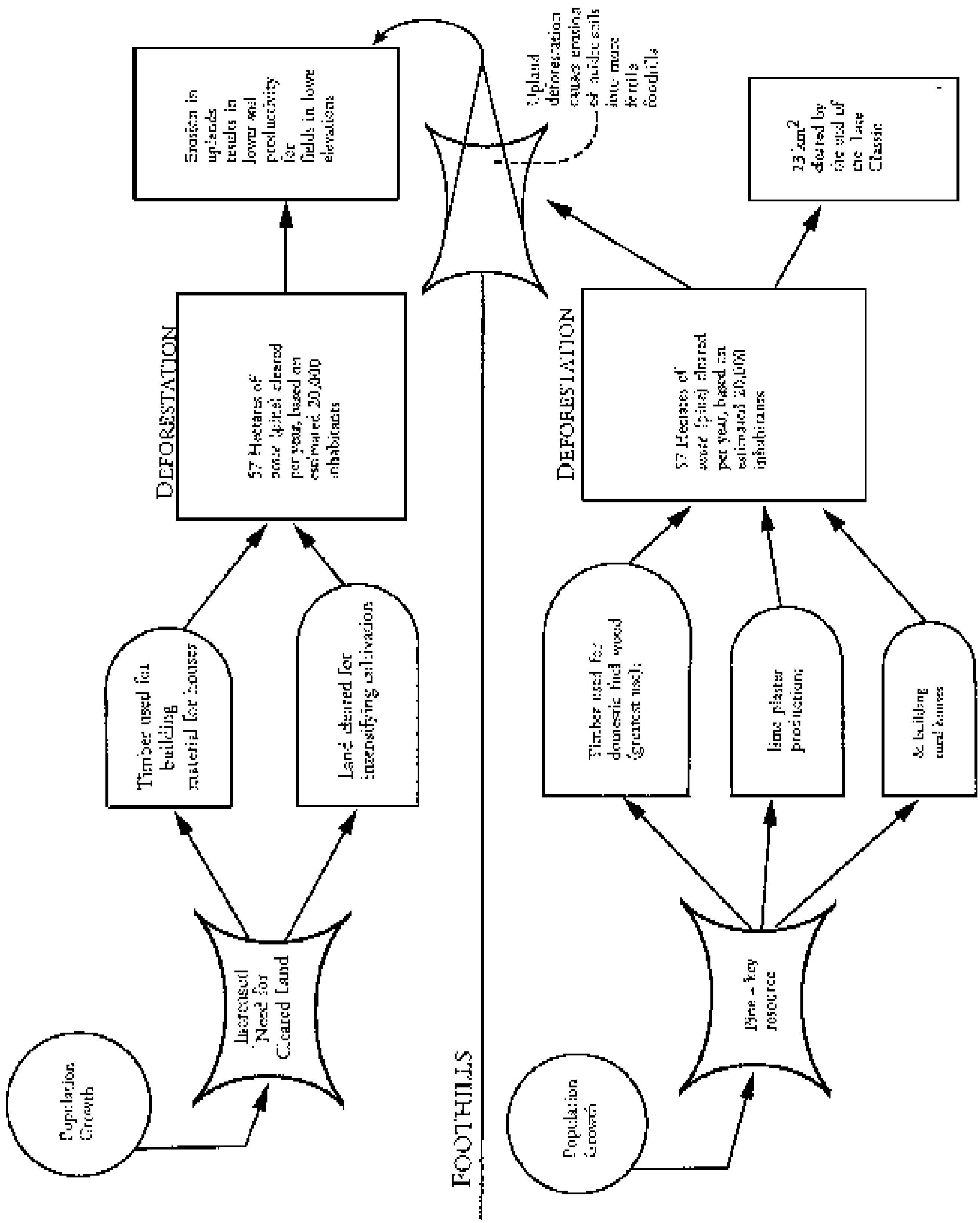

Figure 3: Deforestation in the Late Classic at Copán (after Freter 1994 and Abrams and Rue 1988).

as the ones I have created, is that it is difficult to fully illustrate the heterogeneity of the lowland landscape. For instance, I could not show that settlements were densest in the upland areas in the Classic period. This could have been remedied by using GIS or topographic maps and "zooming in" on certain representative areas or sites.

The second type of graphical representation, or the energy/matter/information flow "models" are most helpful because of their flexibility. Very different kinds of ideas can be depicted simultaneously, and these models are dynamic, as opposed to causal chain models, or hierarchical, pyramid-type models. The goal is not to design a "wiring diagram," but instead to use iconography so that the reader may be more easily guided through the model. The addition of a "guide" and additional dialogue assists in this as well. Once the basic symbols are understood and internalized, it is relatively easy to create models in which the reader can imagine the dynamic processes which are illustrated in the graphics.

An energy/matter/information model is useful in my opinion because it can allow different flows to be shown at the same time, in interaction. It is precisely this interaction between the physical inputs in the system (E and M) and the informational components of the system (Ip) which are at the crux of what makes human ecosystems "human." For example, in depicting the developing political economy of the Classic Maya, it became evident that the energy and matter flows structured the informational aspects, such as the ideology and memory storage technology (in the form of stelae or ritual). Information, or symbolic communication, in turn affects the way its communicators shape the non-human environment (such as building more temples and paved areas because the elites demand it) and thereby, energy and matter flows. The energy/matter/information model is a far-from-perfect methodology, but it provides us a way of exploring what we think is happening in a human ecosystem and of formulating and refining what we believe to be the unique characteristics of human ecosystems. The iconography is effective because it is able to capture a whole series of rich ideas or images in one simple sign. In this sense, creating graphic representations of the complexity inherent in human ecosystems is heuristically valuable as we continue to explore change in human ecosystems, past and present.

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