Chapter 36

The Maya Lowlands: A Case Study for the Future? Conclusions

Michael F. Allen
Arturo Gómez-Pompa
Scott L. Fedick
Juan J. Jiménez-Osornio

INTRODUCTION

Pulling together an overview for such a broad topic as this one is challenging under the best of circumstances. Organizing the conclusions for a topic that has been so extensively researched by many of the world's leading archeologists, agronomists, biodiversity scientists and ecologists, is daunting. However, there are several major advances and new directions in this book that are exciting-both in the context of understanding the Maya and their extraordinary culture and environment, and for creating a case study of how humans might begin to address the crucial challenges of the future of the globe.

There are two potential approaches to analyzing the continuing global environmental challenges and identifying the causal factors behind them. The first approach is to attempt to describe or predict the overall changes in the human and "natural" world over some undefined time period. This approach has been utilized in major works by eminent authors such as Erlich (1968) and Diamond (1997). It is also the general approach taken by social and environmental groups (e.g., Worldwatch Institute, World Wildlife Fund, United Nations, World Bank). These have lead to several assessments of the "world situation", as can be found in many publications (Brown, Flavin, and French 2001).

Within this approach, there are quantitative assessments of human and environmental conditions that can be based on countries or other

organizational entities. For example, Wang et al. (2001) developed a sustainability indicator based on social, economic and environmental parameters. Interestingly, for countries that include the Maya area, Belize, and Mexico rank average or above average with an increasing sustainability index whereas Guatemala, El Salvador, and Nicaragua rank below average with a decreasing sustainability index. The large disparity in values, even within a cultural region, suggests that these approaches have clear limitations when the focal unit is on a political entity.

Although this approaches provided considerable understanding of how we got where we are, few solutions to current environmental dilemmas are apparent. Nor do we understand how responses have been formulated because most human groups, when faced with these challenges, have usually migrated, been subsumed, or died.

A second approach is to develop case studies of individual cultural/geographic systems that have persisted, despite being subjected to the perturbations of the environment resulting from both "natural" and "cultural" impacts. Gómez-Pompa (this book) outlined several challenges, not the least of which was to justify a focus exclusively on one culture-the Maya.

The Maya fit this second approach. They have remained in a region for over three millennia. Their "accomplishments" and "failures" are spectacular and chronicled in both written and archeological records. Finally, they remain a viable and vigorous population retaining many of their original cultural traditions, while simultaneously incorporating new and useful ideas into their technologies, lifeways and belief systems. Because of this, understanding how the Maya survived past perturbations, how they live today, and how they perceive the future makes these studies important to the future of our world. In the last chapter these challenges will be addressed as defined by the participants in the 21st symposium of Plant Biology and the contributors to this book.

MOSAICS

A major contribution of this symposium was to expand the view of the Maya lowlands as a highly variable region in both space and time (see also Fedick 1996b.c). This mosaic of variability emerges at various scales in both environmental and cultural characteristics.

When viewed at the macroscale, the Maya lowlands appears to be a rather homogenous region. As a geological unit, the Maya Block is a single fragment with little topography, until very recently, it was largely marine in the geological time-scale. Thus, there is little space or history for geographic separation in which speciation generally occurs. While a general gradient in environmental characteristics exists from south to north, the entire region

shares common species of most plants and animals. As a culture entity, the Maya also shares a rather astonishing sameness over thousands of years and thousands of square kilometers (Pyburn 1996:240-241).

However, as Pyburn has noted (1996), behind this "veneer" of cultural continuity is a system composed of an interconnected yet highly varied system of local behaviors. As the landscape comes into focus at increasingly detailed scales, the mosaic of diversity is revealed (Fedick 1996a). Local variations in geology, topography and hydrology emerge, which, in turn, influence soil development and the structure of biotic communities. Dunning Beach, Farrell et al. (1998) recently defined 27 distinctive adaptive regions of the Maya lowlands. Each of these units is heterogeneous, but as a repeating pattern of ecosystem types that define a distinctive landscape (see Forman and Godron 1986). It is at this level of disturbance that Maya land use over at last the last three millennium shaped the pattern of biodiversity and ecosystem structure.

The pattern of land use by the Maya, both in the present and in the past, is a clear case of shifting mosaic structure at a range of scales. The persistence of biota in the region may well be attributed to the dynamic structure of Maya land use.

At the local scale of homesteads and villages, the seeds of regional biotic diversity are literally contained and preserved within the homegarden (see Herera et al.1993); a common component of Maya agriculture, both modern and ancient, that has until recently been little-recognized by researchers (see Flores 1993; Goñi 1993; Herrera Castro 1994; Ortega et al. 1993; Stuart 1993). The outfields that surround the village represent an array of cultivation and management technologies (Toledo Maya Cultural Council and Toledo Alcaldes Association 1997). Slash-and-burn cultivation, practiced in combination with selective cutting and replanting, results in the creation of "forest gardens" as an end product of managed succession (Gómez-Pompa, Flores, and Sosa 1987; Gómez-Pompa and Kaus 1990). Within particular landscapes, hillsides might be terraced, and the variety of wetland ecosystems modified or transformed for cultivation (Beach et al., this book; Beach and Dunning 1995; Fedick 1997; Fedick, this book; Fedick et al. 2000; Jiménez-Osorio and Rorive 1999). Dispersed within these managed landscapes, and surrounding larger units of land use, is the wilderness, or wildland forest. The interface of wild forest and various forms of cultivation is essential to deer, peccary, turkeys, and other animals heavily utilized by the Maya. In addition, while the "forest wilds" were feared by the Maya as places of danger (Taube, this book), they also served for protection from one's neighbors and as refuges for many species of large animals persisting today.

At a larger social scale, archeological and historical evidence clearly demonstrates that at no time did any one city or political unit dominate the entire region simultaneously. City-states of varying size and power, ruled by

royal lineages, competed for prestige and control of lands through alliances, arranged marriages, and warfare (Dahlin 2000; Demarest et al. 1997; Martin and Grube 1995, 2000). The success or failure of such campaigns likely corresponded with major shifts in population levels. Thus, while forest resources would be severely depleted in one area, they might recover at another in a shifting pattern dependent on the particular status of various kingdoms (Dunning, Beach, and Rue 1997; Johnson, Breckenridge, and Hansen 2001). This shifting mosaic model is absolutely essential to the preservation of biodiversity and forest resources and is a tenet of conservation biology theory.

BIODIVERSITY

Due to the extraordinarily high human population pressures for such a long time, we would postulate that biodiversity should be very low. Indeed, some argued that the diversity is low for a tropical region compared with expectations. However, the survey information presented in this book strongly suggests that the biodiversity is not really low. It may be structured differently due to the geological context of the region. Diversity of any one location is high. And, as one moves across the landscape, there is continued turnover, but few real breaks in community types. Although endemism is high in the Yucatán Peninsula, those organisms are widely found across the region. Schultz (this book) reported that on an area basis, a small reserve like El Edén has plant species richness per unit area approaching better-known biodiversity hot spots (e.g., the Chamela Reserve in Jalisco) in both endemics and total species per unit area. However, no plant species are endemic to the El Edén Ecological Reserve or to the larger Yalahau region. They are largely the same list as the one for the peninsula as a whole.

Research on many other groups, including algae, fungi, slime molds, protozoa, and the many others reported here, clearly indicate that we have only scratched the surface of the total biodiversity of the Yucatán Peninsula. Symbiosis (such as mycorrhizae and dinitrogen fixation) predominate, and the functioning of the regional ecosystems is dependent on a myriad of unknown organisms and relationships.

This suggests is that biodiversity was not overwhelmed by the large human population density and broad land use. Species, even endemics, are widely spaced across the region. If they decline at one point, they can persist in another. This allows for continual recolonization events. Many types of vegetation resprout after natural disturbance such as hurricanes and fires, or following agricultural practice such as slash-and-burn cultivation, which help make these plant species highly resilient. Bases on the evidence presented here, the persistence of biodiversity is largely due to the mosaic management

strategies practiced by the Maya themselves, coupled with the regional-scale mosaic nature of the rise and fall of the individual city-states.

CLIMATE

Climate also provides a dynamic rather than static background, directly influencing human culture and settlement patterns as well as biodiversity. Climate also changes at local scales in response to human activities. Isotopic evidence from Brenner and colleagues (this book) points to the Classic Period as being unusually dry in the longer climatological history. Further, they provide clear evidence of a severe prolonged drought coinciding with the end of the Classic Period (see also Gill 2000; Hodell, Curtis, and Brenner 1995). It is also important to note (M. Allen and Rincon, this book; see also Sage and Cowling 1999) that the "natural" atmospheric CO_2 level was approximately one-third lower than today (i.e., less than 250 parts per millon [ppm] during the rise and fall of Maya civilization to over 370 ppm today). Thus, water-use efficiency was dramatically lower for C_3 (cool-sea-son) plants making any drought much harsher than would be found today. (this would affect all vegetable and tree species, excepting only C_4 [warmseason] grasses such as maize.)

However, it is still unclear if the spatial pattern of the Terminal Classic collapse is important. Archaeological and epigraphic evidence demonstrate that the major cultural collapse primarily affected the central-southern lowlands. This may be related to the orographic (i.e., mountainous) precipitation of the inland region, which, in part, is derived from the transpiration of upwind vegetation. Alternatively, the precipitation of the northern regions is dependent on moisture derived from ocean evaporation, including hurricanes. If deforestation were widespread, then the precipitation in the inland, higher-elevation sites could have been affected but not necessarily the northern lowlands. (M. Allen and Rincon, this book).

The northern lowlands also appear to have a greater number of hurricanes than the southern inland regions (Boose et al., this book). These can cause extensive damage to croplands and make the forest more susceptible to fires (Whigham and Olmsted, this book). In his original description of Maya life, Landa ([1566]1978) described the terrible effects of hurricane damage on crops, disease and structure of Maya villages (see also Konrad 1985). Humans have little impact on hurricanes, but the presence of La Niña can increase hurricane intensity while El Niño can reduce it. The climate change reported by Brenner and his colleagues (this book) presents evidence for a severe drought in the northern Yucatán Peninsula, but cautions that the data related to drought in the inland central-southern lowlands is

ambiguous. It is not known if the drought period seen in the north is tied to hurricane activity or general precipitation.

COLLAPSE

As agriculture expanded with the increasing population base, the area devoted to forest resources declined while those reserved for urbanization increased-a situation not different from today. The forests became less productive as they shrank, and the resource base within an area controllable by a landed nobility declined. Importantly, there was not a single "collapse" of ancient Maya society. The Classic Period of the Maya was characterized by a large number of city-states vying among each other for hegemony. The Terminal Classic Collapse really consists of the fall of a number of these cities-states and interruption of construction of ceremonial centers. Numerous political and demographic collapses in the Maya lowlands occurred in various areas, and at various times, both before and after the well-known Terminal Classic collapse. The fact that this was not a singular event may be critical for understanding the past as well as for making predictions for the future.

POPULATION DENSITY

Up to the early 1970s, the Maya were still perceived as a collection of dispersed slash-and-burn farmers peacefully co-existing within their tropical forest environment (see Hammond 1978; Turner 1978). A decade ago, there was still some debate as to the human population density and structure in ancient times and whether the population densities were high into the present (Culbert and Rice 1990). Current archeological evidence clearly points to extraordinarily high population densities across the Maya lowlands (see Turner, Kepleis, and Schneider, this book). The cities were large, requiring enormous amounts of land for agriculture, wich, in turn, resulted in extensive land erosion. As sites can be found in almost every region as early as the Preclassic Period, this implies that the entire region was occupied. The major Classic sites, however, were concentrated in the central-southern lowlands at slightly higher elevations. Cities were especially large; the population density was very high-possibly even higher than today, and the various city-states probably covered most of the region with developed lands. Just as important, at the end of the Classic Period, the collapse in the population was largely focused in the Petén and other inland areas with a simultaneous emergence of new cities in the lower elevation, flatter regions of northern Yucatán. There was a second major regional demographic collapse in the sixteenth century with the introduction of new diseases by the Europeans. The population has

continued to rebound through today with expected explosive growth from the present into the near future. These observations support the notion that there are patterns of initiation and collapse that have an environmental and cultural basis.

FOOD

How was food procured during periods of high population densities? A lot has been learned about the food and fiber plants used by the ancient Maya-that is, which ones were domesticated, as well as how they were cultivated (see Fedick 1996c; White 1999). The Maya not only domesticated or adapted those plants that we know today such as chocolate (*Theobroma cacao*) and henequen (*Agave fourcroydes* Lem), as well as the traditional maize, beans, squash, and chilies, but they also used many forest and wetland plants. Just as importantly, forest and wetland animals such as deer, ocellated turkey, curassow, and apple snails were heavily utilized and probably managed (Carr 1996; Emery 1999; Shaw 1999).

The use of these resources constitutes an extremely important advancement and likely also sowed the seeds of Terminal Classic Collapse. The Maya mode of life depended on mosaics of land use. Mosaics of forest gardens and milpas, within a forest matrix, comprised the landscape of each population unit, whether village or city-state. Algal mats and wetland muck may have been a staple mechanism for improving soil fertility, as investigated by a group of collaborating researchers working at the El Edén Ecological Reserve (see chapters in this book by Fedick; Morrison and Cózatl Manzano; Novelo and Tavera, and Palacios-Mayorga et al.). Interestingly, despite many generalizations on the "impoverished" tropical forests, work in the Maya lowlands has consistently shown that soil nutrients are actually quite high in much, if not most, of the region. Growth studies in both agricultural and restoration sites (see E. Allen et al., this book; M. Allen and Rincón, this book) show excellent plant growth if water is available. Even Landa ([1566]1978) commented on the fertility and excellent plant growth in the cracks between the rocks.

Importantly, both ancient writings and symbols and modern practices clearly demonstrate the crucial role of wildland forest as places with resources, but also show these areas as the home of magic beings (e.g., animals such as jaguars) and as scary regions to penetrate (see Taube, this book). These myths and reverence together make for careful use and facilitate the maintenance of wildland mosaics within the regional spatial structure of even developed city-states (Anderson, this book).

The careful use of resources and innovative development of crops was clearly coupled with innovative governmental cooperatives, leading to greater

organization and separation of activity. These innovations allowed populations to expand around villages, then city-states. The resulting division of labor allowed for the incredible scientific and architectural achievements so clearly articulated during the Classic Period. They also created disturbances at ever-larger scales, changing mosaics to large, developed matrices.

PERSISTENCE, RECOVERY AND SUSTAINABILITY

Although the Maya populations collapsed at least twice during this period, they never disappeared. On numerous occasions their populations declined in one area, and recovered in another, either by reproduction or through immigration. The areas from which they declined sometimes recovered, sometimes not.

One reason may lie in the concept of carrying capacity as outlined so eloquently by Turner and his colleagues in this book. They postulate that the population exceeded the carrying capacity leading to a "back-bite" and ultimately population loss. However, as previously described, the environment is not a static backdrop. In ecological theory, the carrying capacity, or *k* value, is only a theoretical limit for the limiting resource. In the case of the Maya, the population collapse may have been due to a loss in food production because of excess land degradation. However, this means that *k* had dropped due to soil loss- not necessarily that some number had been exceeded. Further, because of the drought, production may have been virtually halted as it was limited by the amount of water available. If *k* can decline, it can also recover and grow, and it can also vary spatially.

Thus, the collapse of the Classic Maya may not have been due simply to the excess utilization of resources, but a caused by a combination of a temporally and spatially reduction in the major limiting resource (water?), which regulates *k*. The fact that *k* could recover allowed the Postclassic population recovery to occur. By the time of the Spanish occupation, the Maya population was likely still rebounding from an earlier high.

The population collapse following the Spanish occupation was largely caused by the introduction of exotic disease from Europe. These diseases do not spread except in relatively high population densities. There is little indication that the Maya were overutilizing their resource base at that time.

The Maya knew when they had taxed their resources to a level beyond their institutions. Just as they had ceremonies for creating new kingships, they had an elaborate ceremony to decommission a temple, and kingdom. At Cerros, for example, when the kingship failed, the Maya undertook a "termination ritual" and went back to the fisher and farmer lifestyle (Schele and Freidel 1990). This could be associated with a political collapse, or a loss due to a dramatic environmental change affecting available resources (reduced

k). When this happened, they changed their resource allocations (a higher proportion of the population engaged in food acquisition versus elite activities such as science and architecture), or moved to another region.

Nevertheless, the critical elements of their culture survived. Chontal Maya appears to have persisted as a written language despite the cultural challenges from the Yucatecan Maya and Spanish. Was this persistence supported by small groups of knowledgeable scribe/scientists that were dispersed around the region, and even shifting through time? Perhaps this occurred in a manner similar to the retention of Latin as in modern science and religion? If this written language survived, what pockets of wisdom still remain uncovered by modern anthropologists and biologists? The local extirpation of both human and wildland resources as a function of hurricanes or other natural disasters and re-establishment by regarding the region as a continually fluctuating mosaic bears further careful examination. These elements are complex, but probably hold the keys to their long-term survival as a culture, and to the maintenance of natural biodiversity of a heavily populated region.

SYNTHESIS

If anything is to be learned from the changing Maya world, it is that understanding space and time is absolutely critical to human persistence. There is no absolute *k* value to which we, or any culture, can strive. The *k* value is variable. Humans must allow for fluctuations in both wildland and agricultural use of lands. This must incorporate patchy land use, in both short-term and long-term utilization. This solution resides at the landscape scale of occupation and has been eloquently described by Naveh (1998) as homeorhesis-that is, the shifting landscape patches that cycle in different stages of succession and human use.

Another solution resides in the creation of corridors at a regional scale for sustainability of populations and the migration of plants and animals. The Sian Ka'an an-Calakmul corridor project (World Bank 2000) is one example of such an effort. Another is the effort of the El Edén Ecological Reserve to establish linkages stretching across the wetlands from Yum Balam to Sian Ka'an. It is only in this context that we can understand the Maya world, and develop models for global human survival.

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