This paper was submitted to the National Science Foundation as part of its SBE 2020 planning activity (www.nsf.gov/sbe/sbe_2020/). Its inclusion does not constitute approval of the content by NSF or the US Government. The opinions and views expressed herein are those of the author(s) and do not necessarily reflect those of the NSF or the US Government.

An Integrated Millennial and Centennial History for our Present and Future

Vernon L. Scarborough
University of Cincinnati

The fundamental question for the future of humanity is whether or not we can weather the next half century without dire disaster ecologically and socially.

Simple sustainability or attempting to maintain an ecological world we presently occupy is highly unlikely. To what degree we have induced the radical environmental changes that are now set in motion is perhaps a less meaningful debate. Who is to blame is a political justice issue, but how we ameliorate the posited global transitions in the near term takes on an immediacy we cannot afford to postpone or neglect. Knowing the levels to which humans have induced global warming will aid in evaluating the kind and amount of future energy consumed and the toxic byproducts emitted, but the more fundamental query is how can we—as a species—become truly resilient stewards on this self-contained planet.

Much has been invested by the biophysical scientific community in definitively showing an escalating deleterious ecology worldwide. And though the prospect of slowing this trend is perhaps our best solution environmentally, we need to invest in flexible, creative and reasonable adjustments in our global social fabric if we hope to survive as a civilized form of humanity with the intent of extending well-being to a high percentage of our brethren. Sea level rise for the singularity of Bangladesh will cover a quarter of that country's territory displacing perhaps 35 million people by 2050 (Di Carlo 2009). Whether drought or water overabundance, the incidence of diasporas globally will affect all our shores and their interiors. Our planet's shrinking resources and spiking population will only become more limiting, resulting in crowding and social volatility, unless we give the social sciences greater degrees of responsibility and support. Recent technological breakthroughs have desalinated water supplies and medically extended lifespans, but they have come at a cost and frequently with unintended consequences—and they are unsustainable at a global level. The litany of polluted oceans or contaminated freshwater sources affecting food production and potable access in the context of what is a "right" vs "privilege" requires the intellectual rigor of the social scientist as much as the engineer or the biophysical scientist—the latter sometimes at their culturally insular work bench. Only the former can contextualize the human experience and truly assail the role of culture and society in identifying the kinds of infrastructural adjustments necessary in a highly interdependent world technologically; but a world composed of millions of local communities bound together in ill-defined and poorly understood economic, political, and ideological relationships of varying scales and degrees of influence.

Our search for identifying the necessary changes to our institutional and organizational societal fabric within and between groups is the challenge. What is really possible? Our well supported and endowed "hard" scientific community can measure their product and its immediate return, and they have surely provided deliverables. And now the IPCC can

This paper was submitted to the National Science Foundation as part of its SBE 2020 planning activity (www.nsf.gov/sbe/sbe_2020/). Its inclusion does not constitute approval of the content by NSF or the US Government. The opinions and views expressed herein are those of the author(s) and do not necessarily reflect those of the NSF or the US Government.

provide us with measurable returns on what those technological breakthroughs have cost the earth. Although technologies may well trigger a new set of future energy sources beyond 'peak' and cheap oil, is this a risk worth waiting for given the projected human displacement, suffering, and social violence?

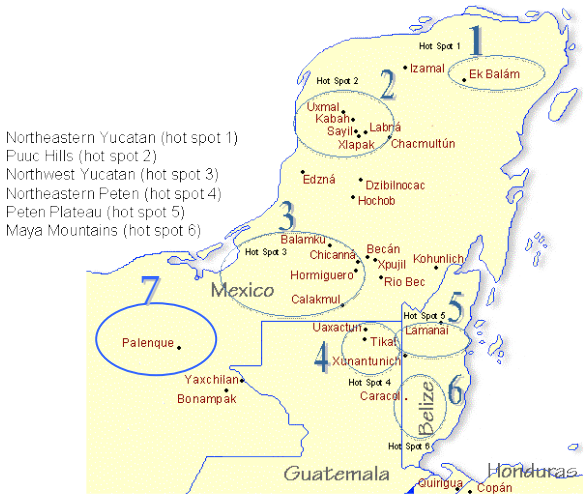
Various individuals – from politicians to philosophers to historians to biophysical scientists – have argued that knowledge of the past is an important key to the future and that, conversely, an ignorance of earlier times and events can result in the unnecessary repetition of historically known failures and problems. Archaeologists often focus narrowly on specific sites and issues, thwarting attempts for broader applications. To remedy this situation, archaeologists have joined with biologists, geographers, meteorologists, modelers and others under the umbrella organization "IHOPE" (Integrated History and Future of People on Earth; http://www.aimes.ucar.edu/ihope). This project calls together a broad range of active researchers to wrestle with existing data sets to aid in explaining how the natural and human worlds couple in the manner that they do. The intent of these efforts is an integrated knowledge assessment of the past within a dynamic global perspective, a design meant to address current world problems and project future solutions (Costanza, Graumlich, and Steffen, eds. 2007).

One sub-group of the IHOPE team is focused on exploring the adaptations of the ancient Maya of Central America. In spite of temporal, technological and environmental differences, many issues that are of interest to archaeologists reconstructing prehistoric Maya lifeways are also of contemporary concern. These issues include, but are not limited to: sustainability and resilience; the role of political and economic factors in collapse and/or the disruption of societal stability; maximum or optimal population levels associated with specific environmental adaptations; the impact of climate change; and the nature of past forms of urbanism and landscape modifications. Our IHOPE-Maya scholarly team hopes not only to develop an integrated history of the ancient Maya, but also to provide rich data sets from a non-modern, non-western culture that will add to our understanding of the dynamics of human – environment interrelationships. The expected end product is the ability to model multiple "answers" to complex globally relevant questions.

It is important to note at the onset that there is substantial variation in the archaeological past that most researchers currently lump together and call "Maya." The ancient Maya were not a single uniform or unified civilization – variation is both regional and temporal. Local variation far exceeds what is normally considered in a modern nation such as the United States. Local governments were founded on diverse tribal and kinship principles to such a degree that each was probably as different as the English are from French based on differing dialects and environmental circumstances. And they were only a few kilometers apart, proximity not unlike several countries today suffering from acute unrest. These ancient, and for that matter modern, differences within the Maya lowlands are important in meeting the IHOPE goals because they offer opportunities to test variable effects of the same global-scale phenomena such as climate change and radical shifts in economic orientations on differing local and regional situations.

This paper was submitted to the National Science Foundation as part of its SBE 2020 planning activity (www.nsf.gov/sbe/sbe_2020/). Its inclusion does not constitute approval of the content by NSF or the US Government. The opinions and views expressed herein are those of the author(s) and do not necessarily reflect those of the NSF or the US Government.

To provide an integrated Maya history, scholars from different parts of the Southern Maya lowlands have joined together to compare and contrast diverse data sets from key areas. Seven diverse areas or "zones" were designated as the basic building blocks for a comparative database. These archaeological regions are discretely distributed across the Maya lowlands, but are not exhaustive of the variability in environments or the different ethnic groups that were once manifest across this region. They were rather selected because they represent long-term and established research areas from which extensive collected datasets already exist (Figure 1).



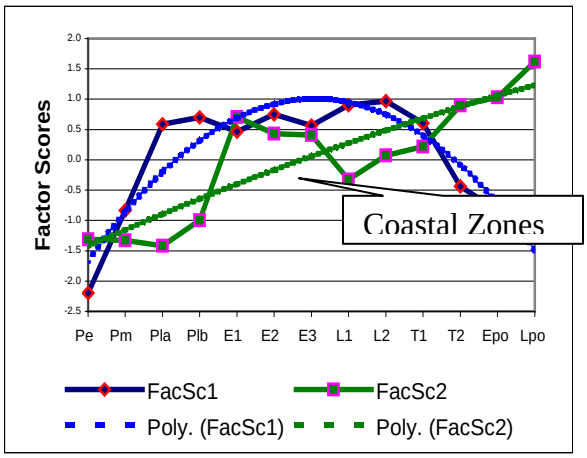
These zones are utilized to compile standardized comparative data sets that best address long-term change and transformation within the quarter-million square kilometers identifying the Maya lowlands. The ancient population for this region is estimated at perhaps ten million people by A.D. 700. The archaeological data provide information about how these societies coped with, cared for, and/or destroyed both their environment and themselves. Given that the "heartland" of the lowland Maya area today—after a great collapse in societal networks a thousand years ago—has only one-tenth of that original population, a comparative examination of this past tropical civilization provides important clues about stability, resiliency, and sustainability that have relevance for modern societies.

For each of these seven geographical zones, the controlled dataset was formulated that focuses on both the biophysical environment and the past cultural landscapes. The biophysical setting is characterized in terms of the general availability of water (climate, seasonality and precipitation patterns, water table access, surface water, and natural sinkholes or related depressions), the richness of resources (biomass availability), and the potential of the terrain for agriculture (soils and topographic concerns). A characterization of this environment is reconstructed directly from the archaeological record—ranging from ancient flora (pollen) and fauna remains to highly visible cultural modifications of the landscape related to water retention (cisterns, wells, and reservoirs), hydraulic management (canals and dams), and enhanced agricultural production (terraces and raised or drained fields).

The ancient cultural landscape is sometimes more difficult to interpret than the past biophysical environment. In the Maya area, however, settlement density (structures/sq km) is quantifiable because of the proclivity of the ancient Maya to raise their architectural constructions above ground level, meaning that they can be mapped and

This paper was submitted to the National Science Foundation as part of its SBE 2020 planning activity (www.nsf.gov/sbe/sbe_2020/). Its inclusion does not constitute approval of the content by NSF or the US Government. The opinions and views expressed herein are those of the author(s) and do not necessarily reflect those of the NSF or the US Government.

recorded largely without excavations. These same constructions can be subdivided into public (ballcourts, palaces, range buildings, or temples) versus non-public (solitary constructions, enclosed residential plaza groups) spaces. While archaeological excavation allows a reconstruction of site layout and development, other data classes are also particularly sensitive to establishing time depth. In particular, ceramic styles are used to anchor archaeological time and track sequenced developments. Ceramics and other artifacts can also be utilized to infer broader interactions within the Mesoamerican world system beyond the level of the polity. Past skeletal remains provide information relevant to diet, health, migration, social divisions and adaptive success within ancient populations. Finally, carved stone monuments and a Maya hieroglyphic record found on buildings and on a variety of portable artifacts serve to provide direct data about past social relationships, institutions, and further refine the time scales. Even a cursory review of the selected zones demonstrates the diversity and variability in and among Maya lowland environments and adaptations.



By way of example, using ceramic vessels as a measure of interaction among zones shows that inter-polity communications increased through the Classic periods (AD 200-800) (Figure 2, blue, dashed line is a polynomial fit to the data). Comparing this with pollen measures of tropical vegetation, however, shows that in the interior cities such as Calakmul and Tikal, inter-polity communications were built at a great cost to the environment. Specifically, useful tropical species of trees diminished in favor of less important species. Toward the end of the Classic -- the Late Classic in Table 1 -- both useful and less important species declined. In other words, the tropical vegetation was sacrificed to construct the waterways, administrative buildings and the like that facilitated the integration of larger political networks. These large political networks – -organized around the city of Tikal and an alliance between the urban aggregates of Calakmul and Caracol -- somewhat resembled the modern concept of empires, though more loosely organized.

Parallel analysis of cities nearer the coasts shows the opposite tendencies (the green line in Figure 2). As social integration between zones increased over time, the forests also flourished. This we think reflects the less environmentally costly organization of coastal cities where avenues of transportation are provided by the sea. Evidence indicates that the near-coastal communities were able to expand their agricultural potential over time by utilizing the forests as orchards. As is evident in Figure 2, the interior communities declined in the ninth century and never recovered. The coastal communities, however, continued on a trajectory of increasing social integration and forest utilization until the arrival of Europeans in the 16th century. Certainly the reported great ninth century drought played a role in decline of interior cities. Clearly, the more efficient structure of

This paper was submitted to the National Science Foundation as part of its SBE 2020 planning activity (www.nsf.gov/sbe/sbe_2020/). Its inclusion does not constitute approval of the content by NSF or the US Government. The opinions and views expressed herein are those of the author(s) and do not necessarily reflect those of the NSF or the US Government.

the coastal communities allowed them to eventually assume the former core roles of the ancient interior cities. In effect, the coastal cities became core cities in the Maya world system and the interior spaces became peripheries and principal sources of raw materials that characterized the commerce of the Yucatan Peninsula with the rest of Mesoamerica.

By standardizing the data sets within each of the seven zones and facilitating communication among researchers working in these areas, a significantly improved understanding of ancient Maya societies is guaranteed. Our approach is novel and challenging, but the identification of types and degrees of resiliency, stability, rigidity (integration, hierarchy, conformity), and pan-regional interaction within the ancient Maya context is overdue. Such considerations will not only elucidate temporal and spatial variation within the Maya lowlands, but it provides a more directly comparable methodology for charting the developmental trajectories of other tropical civilizations. Tropical early states are documented in ancient Cambodia, Java, Sri Lanka, and portion of West Africa; also, recent discoveries in the Xingu region of Brazil indicate sizable past populations of significant social complexity. However, only in the Maya area do we have over a hundred years of rich and well-reported archaeological and complementary natural scientific exploration. Given over half the biodiversity on the planet is harbored in such surrounds, and now in the context of the rapidly changing climatic conditions, it does make some sense to coordinate and invest in well-controlled comparative evaluations. We have no illusions about prediction, but when coupled with the other potential zones on the earth we anticipate meaningful explanation. Our charge is to focus on the ancient Maya and what accessible factors launched that society and its many subregional variants, and in turn, what went so very wrong around AD 800--the Great Maya Collapse. By breaking the ancient Maya area into constituent units, both the cultural and environmental variability become evident; comparing and contrasting these microcosms serve to access and evaluate the variables responsible for different developmental trajectories and permits projections into our planet's collective future.

Costanza, R., L. Graumlich, and W. Steffen, editors
2007 Sustainability or Collapse? Integrated History and Future of People on Earth (IHOPE). Dahlem Workshop Report 96R. The MIT Press, Cambridge, MA.

Di Carlo, Diana D.
2009 (July) The Gathering Storm: The Confluence of Climate Change and Population Growth in 2050. Royal College of Defense Studies and United States Department of Defense. (http://www.mod.uk/NR/rdonlyres/3BA6CAED-4EDD-40F7-91A6-1B1E7EA3E33F/0/SHP2009DiCarloFINAL.pdf)

This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. To view a copy of this license, visit http://creativecommons.org/licenses/by-nc-sa/3.0/ or send a letter to Creative Commons, 171 Second Street, Suite 300, San Francisco, California, 94105, USA.