Unlocking the ancient Maya and their environment: Paleo-evidence and dating resolution

B.L. Turner II
School of Geographical Sciences and Urban Planning and School of Sustainability, Arizona State University, Tempe, Arizona 85287-5302, USA

The Classic Period lowland Maya collapsed at the apex of their material achievements and population size. From about A.D. 800–1000, their societal structure and infrastructure collapsed and their heartlands (henceforth region, which extended north-south from present day central Quintana Roo and Campeche, Mexico, to the Guatemalan highlands, and east-west from the Copan Valley of Honduras to the Usumacinta watershed in Chiapas, Mexico) depopulated on an exceptionally large order, much of the area remaining ephemerally occupied even today. The collapse and depopulation are the subject of long-standing debates about human-environment dynamics among the Maya and during the Holocene in general (e.g., Gill, 2000; Tainter, 1988). It should come as no surprise that the Maya collapse has been extended to themes concerning contemporary climatic change and sustainability (e.g., Diamond, 2005). An emerging consensus eschews simple explanations of this complex phenomenon and focuses on causes emerging from complex but reinforcing coupled human-environment systems interactions (e.g., Lowe, 1985; Turner et al., 2003). Less emphasized in these assessments are the insights to be gained by focusing on what transpired in the region subsequently (e.g., Whitmore and Turner, 1992, 2001). This approach is partially tackled by Mueller et al. (2010, p. 523 in this issue of *Geology*) to reinforce the role of climate change in understanding pre- and post-collapse environmental conditions in the Maya heartland.

The recognition of complexity in the collapse of the Maya and the depopulation of the region initially focused on non-climatic environmental and resource stresses (e.g., Culbert, 1973). Earlier consideration that a change in climate may have played a role (e.g., Huntington, 1917) was resisted, in part owing to the excesses to which environmental determinism had been employed to explain societal characteristics and human history at large. In the mid-1990s, however, paleo-environmental research began to uncover strong evidence of a major spike in climatically driven aridity in the Maya lowlands coinciding with collapse and depopulation (Hodell et al., 1995, 2005; Rosenmeier et al., 2002), results supported by the evidence reported by Mueller et al. Coupled with other evidence of major land-use pressures and water scarcity problems (Gill, 2000; Scarborough and Gallopin, 1991), especially confronting occupation of the karstic upland landscapes (inland of the coastal shelf of the Yucatán Peninsula), a truly complex coupled system orientation has emerged (Beach et al., 2005, 2009). The spike in aridity surely mattered in the Maya collapse and depopulation, but must be cautioned and elaborated by the recognition that (1) the long-evolving Maya florescence took place under conditions of increasing aridity, to which the Maya apparently adjusted quite well; (2) the scale of deforestation in the region likely amplified the level of climate-driven aridity, hinting that the combined forcings on precipitation may have played a role in generating a tipping point for the Maya; and (3) the more arid, far northern part of the peninsula never depopulated, indicating that climate desiccation alone cannot explain the depopulation of the region (Turner et al., 2003). The northern realm remained strongly occupied by the Postclassic Maya who fiercely resisted Spanish conquest.

The collapse-depopulation of the region was followed by a prolonged period of forest recovery, presumed to indicate environmental rebound from the former land pressures and, more recently, from severe climate desiccation. The timing of this recovery, however, was once in modest dispute, largely owing to carbon dating problems in the karstic Maya environment as detailed by Mueller et al. Some researchers pegged the forest recovery to have begun immediately following the collapse. The late Edward Deevey, however, based on paleoecological work in the central Petén lakes (see Mueller et al.), speculated that the recovery did not occur until Colonial times (sixteenth century). This interpretation stood at odds with the written record. The Hernán Cortes expedition of A.D. 1524–1525, from Mexico to Honduras, came close to perishing as it struggled through the forests of the Petén (Cerwin, 1963 52). The fact that there was a modest Maya presence around the central Petén lakes in Colonial times, the discovery of which saved the expedition, possibly explained discrepancies in the two views on forest recovery. Mueller et al. appear to resolve the issue, providing strong evidence that forest recovery in the Maya heartlands dates to the early part of the Postclassic, not the Colonial, period, although open lands remained near Lake Petén Itzá into the Terminal Classic period. Mueller et al.'s projected forest recovery of 80–260 yr after the collapse is consistent with recent work from southern Quintana Roo and Campeche, Mexico, indicating that older-growth forest conditions (species presence but not abundance) may be reached within 50–90 yr after abandonment from slash-and-burn cultivation in which large patches of older-growth forests remain in proximity to disturbed land (Lawrence et al., 2007). The land-cover matrix at the time of the collapse, however, was much more open, with less large forest patches (e.g., Lentz and Hockaday, 2009), suggesting that forest recovery may have taken longer than estimates based on slash-and-burn cultivation alone. Mueller et al. also conclude that species indicative of a return to more humid conditions were involved in forest recovery, adding climate change to land abandonment as explanations for the recovery. This interpretation is consistent with other, recent evidence of changes in climatic conditions across the peninsula at large, but warrants several complementary considerations. First, the huge release in land pressures and increase in forest canopy should have increased regional evapotranspiration, potentially assisting the larger shift to more humid conditions. Second, the recovered forests were surely altered in species abundance by previous Maya activities that included managed forests, orchards and other long-term agricultural activity, and extensive paved-over settlements (Gómez-Pompa et al., 1987; Lambert and Arnason, 1982).

The Maya heartlands witnessed one long-term (millennial) wave of population growth and decline, in which the forest recovered in absence of significant occupation. If the forest recovered, why did the population fail to do so? Did Maya soil degradation contribute to long-term abandonment of the region? The upland slope soils are typically shallow (50–80 cm) but relatively fertile for the tropics in general. Various research indicates major soil losses during the widespread deforestation in Preclassic times (ca. 1500 B.C. to A.D. 250), ultimately leading to major sedimentation of shallow lakes and lagoons, at least along the coastal shelf in Belize, many of which the Maya subsequently cultivated (Beach et al., 2005, 2009; Jacob and Hallmark, 1996). This scale of erosion appears to have been brought under reasonable control by the Classic period through the use of terracing and other management strategies in the uplands (Beach and Dunning, 1999). Mueller et al. do not address the early erosion themes, but their dating of inorganic detrital deposits indicate erosion was ongoing during the Terminal Classic period, at least in the immediate vicinity of the central Petén lakes where Maya populations remained. Other than erosion controls in the face of severe land pressures, the Maya surely practiced methods that reduced the loss of soil nutrients on upland slopes. Recent research reveals that phosphorus (P) is the limiting soil nutrient for cultivation in the region (Lawrence et al., 2007), and the staggering level of deforestation during Classic Maya times significantly reduced the principal source, wind-blown P captured by the forest canopy. Mueller et al. suggest physical soil stabilization ~120–280 yr after the collapse. Forest recovery in general, and canopy capture of P, presumably would have recovered soil nutrients. Despite this recovery, the Maya never returned to their heartlands in any substantial numbers, and their magnificent monumental achievements were consumed by the forest. Significant re-penetration of the region by agriculturalists began only about one-half century ago.

What are we to make of this evidence relative to the human-environment history of the Maya heartlands? The coupled human and environmental systems in pre- and post-collapse times were radically different. Large populations, land and soil stress, and increasingly severe aridity (as well as conflicts among polities; e.g., Webster [2000]) point to a collapse that involved many dimensions. Extremely small populations and low levels of land stress after the collapse reduced the complexity of human-environment relationships while more humid conditions returned. Surely by A.D. 1200–1300, if not before, the environmental conditions of the region were somewhat akin to those that the Maya encountered as they entered the lowlands more than a thousand years previously (save perhaps the conversion of shallow lakes and lagoons to wetlands and the abundance of certain tree species). That the recovered forests and soils of the Maya heartlands prevailed for a millennium with minimal human re-occupation strongly hints that environmental change alone does not determine societal outcomes. At the same time, the case mounts that the Maya collapse and depopulation joins the ranks of cases of other complex human-environment systems that apparently reached tipping points in which climate change played a major role.

Our understanding of the human-environment dynamics of the ancient Maya heartlands has increased significantly. Like all other densely settled civilizations, the Maya undertook large-scale environmental modifications and transformation in order to meet resource demands. The resulting land and water engineering and management efforts have been documented, and the climatic context in which they took place increasingly revealed. Less understood at this time are the resulting regional or landscape-level dynamics. For example, what were the impacts on climate of large-scale deforestation? Was the desiccation itself or its impacts partly endogenous to the human-environment system in the ancient Maya heartlands? Finally, did this system generate legacy effects that inhibited major re-occupation, and how might they be uncovered?

REFERENCES CITED

Beach, T., and Dunning, N., 1999, Soil erosion, slope management, and terracing in the Maya lowlands: Latin American Antiquity, v. 5, p. 51–69.

Beach, T., Dunning, N., Luzzadder-Beach, S., Cook, D.E., and Lohse, J., 2005, Impacts of the ancient Maya on soils and soil erosion in the central Maya Lowlands: Geomorphology and Land Degradation, v. 65, p. 166–178.

Beach, T., Luzzadder-Beach, S., Dunning, N., Jones, J., Lohse, J., Guderjan, T., Bozarth, S., Millspaugh, S., and Bhattacharya, T., 2009, A review of human and natural changes in Maya lowland wetlands over the Holocene: Quaternary Science Reviews, v. 28, p. 1710–1724, doi: 10.1016/j.quascirev.2009.02.004.

Cerwin, H., 1963, Bernal Díaz: Historian of the conquest: Norman, Oklahoma, University of Oklahoma Press, 239 p.

Culbert, T.P., ed., 1973, The Classic Maya collapse: Albuquerque, New Mexico, University of New Mexico Press.

Diamond, J., 2005, Collapse: How societies choose life, and death: New York, Viking, 525 p.

Gill, R.B., 2000, The Great Maya droughts: Water, life, and death: Albuquerque, New Mexico, University of New Mexico Press.

Gómez-Pompa, A., Salvador Flores, J., and Sosa, V., 1987, The "Pet Kot": A man-made tropical forest of the Maya: Interciencia, v. 12, p. 10–15.

Hodell, D.A., Brenner, M., and Curtis, J.H., 2005, Terminal Classic drought in the northern Maya lowlands inferred from multiple sediment cores in Lake Chichancanab (Mexico): Quaternary Science Reviews, v. 24, p. 1413–1427, doi: 10.1016/j.quascirev.2004.10.013.

Hodell, D.A., Curtis, J.H., and Brenner, M., 1995, Possible role of climate in the collapse of Classic Maya civilization: Nature, v. 375, p. 391–394, doi: 10.1038/375391a0.

Huntington, E., 1917, Maya civilization and climate change: Proceedings of the 19th Congress of Americanists, 5-10 October 1914, Washington, D.C., 150–164.

Jacob, J.S., and Hallmark, C.T., 1996, Holocene stratigraphy of Cobweb Swamp, a Maya wetland in northern Belize: Geological Society of America Bulletin, v. 108, p. 883–891, doi: 10.1130/0016-7606(1996)108<0883:HSOCSA>2.3.CO;2.

Lambert, J., and Arnason, T., 1982, Ramón and Maya ruins: An ecological, not economic, relation: Science, v. 216, p. 298–299, doi: 10.1126/science.216.4543.298.

Lawrence, D., D'Odorico, P., Diekmann, L., DeLonge, M., Das, R., and Eaton, J., 2007, Ecological feedbacks following deforestation create the potential for a catastrophic ecosystem shift in tropical dry forest: Proceedings of the National Academy of Sciences of the United States of America, v. 104, p. 20696–20701, doi: 10.1073/pnas.0705005104.

Lentz, D.L., and Hockaday, B., 2009, Tikal timbers and temples: ancient Maya agroforestry and the end of time: Journal of Archaeological Science, v. 16, p. 1343–1353.

Lowe, J.W.G., 1985, The dynamics of apocalypse: a system simulation of the Classic Maya collapse: Albuquerque, New Mexico, University of New Mexico Press.

Mueller, A.D., Islebe, G.A., Anselmetti, F.S., Ariztegui, D., Brenner, M., Hodell, D.A., Hajdas, I., Hamann, Y., Haug, G.H., and Kennett, D.J., 2010, Recovery of forest ecosystem in the tropical lowlands of northern Guatemala after disintegration of Classic Maya polities: Geology, v. 38, p. 523–536, doi: 10.1130/G30797.1.

Rosenmeier, M.F., Hodell, D.A., Brenner, M., Curtis, J.H., and Guilderson, T.P., 2002, A 4000-year lacustrine record of environmental change in the southern Maya lowlands, Petén, Guatemala: Quaternary Research, v. 57, p. 183–190, doi: 10.1006/qres.2001.2305.

Scarborough, V.L., and Gallopin, G.G., 1991, A water storage adaptation in the Maya lowlands: Science, v. 251, p. 658–662, doi: 10.1126/science.251.4994.658.

Tainter, J.A., 1988, The collapse of complex societies: Cambridge, Cambridge University Press.

Turner, B.L., II, Klepeis, P., and Schneider, L., 2003, Three millennia in the southern Yucatán peninsular region: Implications for occupancy, use, and "carrying capacity", *in* Gómez-Pompa, A. et al., eds., The lowland Maya area: Three millennia at the human-wildland interface: New York, Haworth Press, p. 61–387.

Whitmore, T.M., Turner, B.L., II, Johnson, D.L., Kates, R.W., and Gottschang, T.R., 1990, Population and environmental transformation: A Long Term View, *in* Turner, B.L., II, et al. eds., The earth as transformed by human action: Cambridge, Cambridge University Press, p. 25–39.

Whitmore, T.M., and Turner, B.L., II, 1992, Landscapes of cultivation in Mesoamerica on the eve of the conquest: Annals of the Association of American Geographers. Association of American Geographers, v. 82, p. 402–425, doi: 10.1111/j.1467-8306.1992.tb01967.x.

Webster, D., 2000, The not so peaceful civilization: A review of Maya war: Journal of World Prehistory, v. 14, p. 65–119, doi: 10.1023/A:1007813518630.

Printed in USA