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Conserving the American Tropics: Exploring the Cropscape of the Ancient Maya

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Introduction

The environmental legacy of the ancient Maya is a controversial topic. Since at least the nineteenth century, when widely published travelogues began revealing the wondrous monuments of Maya cities to Euro-American audiences,[1] Western popular imagination has been captivated by Maya civilization and especially tales of its demise. Collapse narratives frequently invoke primitive cultivation techniques, fragile tropical forests, and environmentally destructive lifeways as driving the downfall of Maya kingdoms, but these explanations more often hinge on ecological imperialist prejudices than empirical observations.[2] Our research, conducted in partnership with traditional Maya farmers—

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[1] John Lloyd Stephens, *Incidents of Travel in Central America, Chiapas, and Yucatán*, 2 vols (New York: Dover Publications, 1969).

[2] Ralph L. Roys, "Conquest Sites and Subsequent Destruction of Maya Architecture in the Interior of Northern Yucatan," in vol. 11 of *Contributions to American Anthropology and History*, 129–82, (Washington, D.C.: Carnegie Institution of Washington, 1952); and Inés Ortiz Yam, "Los Montes Yucatecos: La Perceptción de un Espacio en las Fuentes Coloniales," in *Texto y Contexto: Perspectivas Intraculturales en el Análisis de la Literatura Maya Yucateca*, edited by Anjet Gusenheimer, John F.

the master forest gardeners—suggests these stories miss the mark. Indigenous agricultural practices and ecological knowledge developed over millennia in the Maya Forest of southeastern Mesoamerica (see figure 1), actually *increased* resilience to climate change while providing all household necessities for ancient populations. A shift in mindsets and willingness to challenge received wisdom are requisite to begin exploring sustainable living solutions from the Maya past that can address our future challenges.

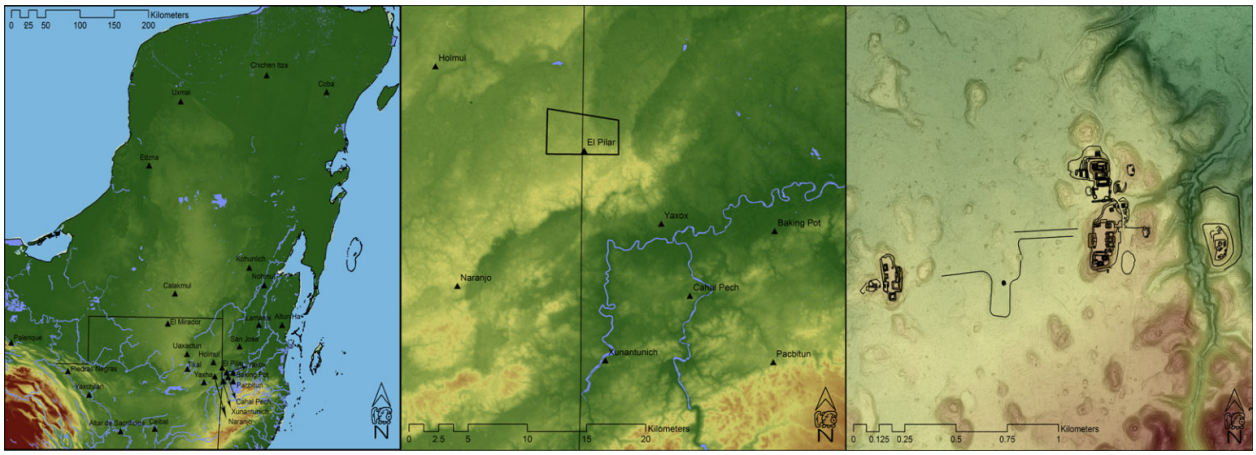

Figure 1A. The Maya Area at Different Scales: Region, Local, and Site (El Pilar). (Source: MesoAmerican Research Center; Thomas Crimmel.) Figure 1B can be accessed at www.technologystories.org/conserving-the-american-tropics/.

Theoretical frameworks for understanding the "Maya Collapse"—which have incorporated data from advanced scientific techniques in recent years—envision Maya societies becoming increasingly vulnerable to climate change, as their environment was degraded and deforested by growing populations and unsustainable agricultural practices.[3] The robust archaeological record and long-enduring Indigenous understandings of forest ecology and food production,[4] however, suggest different

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Chuckiak IV, and Tsubasa Okoshi Harada, 185–203 (Bonn: Bonner Amerikanistische Studien, Universidad de Bonn, 2009), quote from Tomas Lopez Medel, 1552 Ordinance ". . . they should not sow any milpas within the town that they construct houses close to one another, that all shall be clean, without sown land or groves; and if there were any, *they should be burned*" (emphasis ours).

[3] B. L. Turner and Jeremy A. Sabloff, "Classic Maya Collapse in the Central Lowlands," *Proceedings of the National Academy of Sciences* 109, no. 35 (August 2012): 13908-13914.

[4] R. L. Roys, *The Ethno-Botany of the Maya* (New Orleans: Tulane University, 1931); A. Gómez-Pompa, "Tropical Deforestation and Maya Silviculture: An Ecological Paradox," *Tulane Studies in Zoology and Botany* 26, no. 1 (1987): 19–37; A. Ford and R. Nigh, *The Maya Forest Garden: Eight Millennia of Sustainable Cultivation of the Tropical Woodlands*, vol. 6 (Walnut Creek, CA: Left Coast Press, 2015).

interpretations that warrant exploration. The Maya Forest is among the most diverse in the world,[5] and its dominant trees are economically valuable in both local and global markets.[6] These contemporary forest features reflect long-term land-use choices that we must decipher to make sustainable living a reality in the area today.

The topic of tropical forest conservation may seem esoteric to those from temperate latitudes, and the connection to archaeology may not be apparent at first.[7] Tropical forests have long been viewed as marginal environments for human occupation—their soils termed fragile and infertile, their land unworkable for food production without the technology of industrial agriculture—yet they are now at the forefront of a population explosion, with massive growth and development forecast for the coming decades.[8] The Maya Forest, a biodiversity hotspot second only to the Amazon, now faces grave risks from the expansion of industrial plantation agriculture.[9] The top-down imposition of Euro-American agricultural systems,[10] based on pasture and plow, has created the very conditions of deforestation and environmental degradation invoked to explain the Maya collapse (see figure 2). How, then, can archaeology inform debates about sustainable development and human population expansion in the tropical forest?

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[5] R. A. Mittermeirer, N. Myers, and C. G. Mittermeier, *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions* (México: CEMEX, 2000).

[6] D. G. Campbell et al., The Feral Forests of the Eastern Petén, in *Time and Complexity in the Neotropical Lowlands: Studies in Historical Ecology*, edited by W. Balée & C. Erickson, 21–55 (New York: Columbia University Press, 2006).

[7] J. Mercader, ed., *Under the Canopy: The Archaeology of Tropical Rain Forests* (New Brunswick: Rutgers University Press, 2003); P. Roberts, *Tropical Forests in Prehistory, History, and Modernity* (Oxford: Oxford University Press, 2020).

[8] P. Gourou, *The Tropical World: Its Social and Economic Conditions and Its Future Status* (New York: Longman, 1980); Patrick Roberts, *Tropical Forests in Prehistory, History, and Modernity* (Oxford: Oxford University Press, 2020).

[9] The Nature Conservancy and Conservation International: www.nature.org/en-us/about-us/where-we-work/latin-america/mxico/maya-forest/, www.nature.com/articles/35002501.

[10] A. W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Cambridge, MA: Cambridge University Press, 1986).

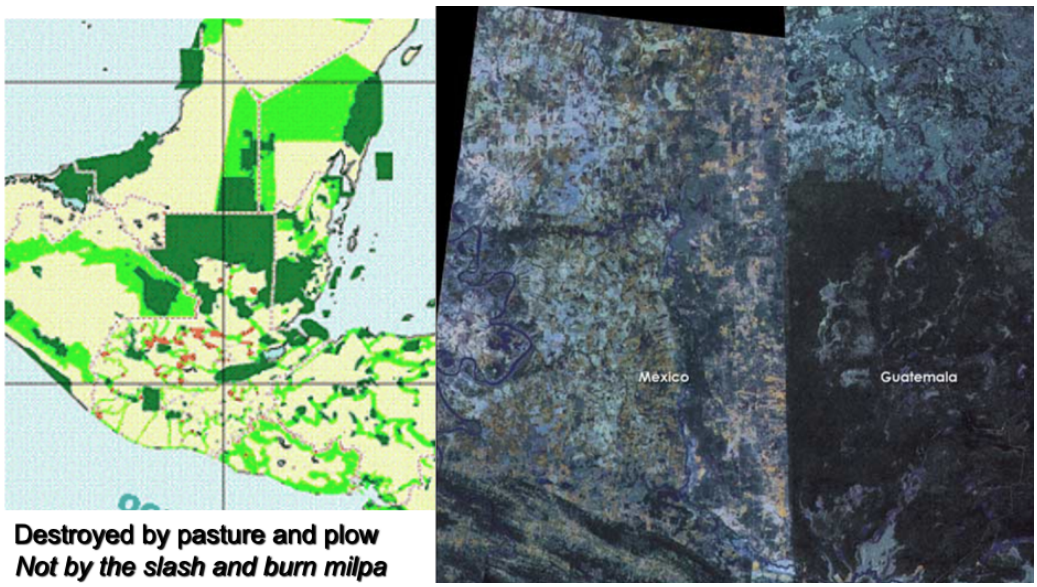


Figure 2: Landsat composite image of the Mexico-Guatemala border showing differences in deforestation. (Source: Assembled by MesoAmerican Research Center; Landsat image from www.nasa.gov/mission_pages/landsat/news/40th-top10-mexico-guatemala.html.)

Mesoamerican histories overwrite the Indigenous past, viewing developments and processes through the lens of Euro-American experiences in tropical settings.[11] The denigration of Indigenous knowledge by colonizing cultures is not a recent development, but regarding the Maya, these narratives are unusually persistent. Maya civilization developed and thrived as a complex agrarian society for millennia in the tropical landscape of the Maya Forest. How could this have happened if Maya cultivation and land management strategies were inherently destructive? The gap between unsustainable contemporary land use—reinforced by historical narratives and views of tropical forests—and the archaeological record of Indigenous sustainability must be reconciled to create resilience against the threats of climate change and hunger facing tropical communities today.

We consider the contemporary Maya Forest as the product of human-environment interactions over millennia—not as a wild or pristine jungle,[12] but as a cropscape shaped by human hands and an integral component of successful land-use

[11] J. Diamond, *Collapse: How Societies Choose to Fail or Succeed* (New York: Penguin Group, 2005).
[12] W. M. Denevan, "The Pristine Myth: The Landscape of the Americas in 1492," *Annals of the Association of American Geographers* 82, no. 3 (1992): 369–85; Denevan, "The 'Pristine Myth' Revisited," *Geographical Review* 101, no. 4 (2011): 576–91.

technologies.[13] By documenting how the ancient Maya settled their landscape, and assessing these settlement patterns in light of traditional food-production and forest-management techniques,[14] our team of archaeologists, ethnologists, geographers, botanists, wildlife biologists, geologists, volcanologists, advocates, and citizen scientists are beginning to reveal how this remarkable civilization was able to thrive in the tropical forest for generations.[15] Recognizing the potential of Maya land-use strategies to create a vibrant, diverse, and economically bountiful cropscape can yield insight into critical concerns facing communities throughout the world today, such as the need to conserve water, reduce erosion, build soil fertility, lower temperatures, maintain biodiversity, and provide people a high quality of life.[16] To understand how the ancient Maya and their descendants developed subsistence technologies that shaped the forest—and how these might be employed for contemporary conservation and sustainable development—we must examine the Maya Forest environment and the history of humans on the landscape.

The Mesoamerican Tropics and the Creation of the Maya Forest Cropscape

[13] S. Atran, "Itza Maya Tropical Agro-Forestry," *Current Anthropology* 34, no. 5 (1993): 633–700; S. Cook, *The Forest of the Lacandon Maya: An Ethnobotanical Guide* (New York: Springer, 2016); J. Mt. Pleasant, "A New Paradigm for Pre-Columbian Agriculture in North America," *Early American Studies,* 13, no. 2 (2015): 374–412. Archaeologists often focus on ancient Maya domestic and ritual activities but pay less attention to the habitat surrounding these remains. We call these areas the cropscape – places where people manage resources for all the needs of daily life.

[14] See examples in A. Ford and K. C. Clarke, "Linking the Past and Present of the Ancient Maya: Lowland Use, Population Distribution, and Density in the Late Classic," in *Handbook of Historical Ecology and Applied Archaeology*, edited by C. Isendahl and D. Stump, 156–83 (Oxford: Oxford University Press, 2019); Ford and Nigh, *The Maya Forest Garden.*

[15] C. E. Topsey, A. Ford, and S. Horn, "Different Ways of Knowing and a Different Way of Being: On a Path to Reawakening Legacy of the Maya Forest," *Heritage* 3, no. 2 (2020): 493–510.

[16] S. L. Fedick, "The Maya Forest: Destroyed or Cultivated by the Ancient Maya," *Proceedings for the National Academy of Sciences* 107, no. 3 (2010): 953–54; C. L. McNeil, D. A. Burney, and L. P. Burney, "Evidence Disputing Deforestation as the Cause for the Collapse of the Ancient Maya Polity of Copan, Honduras," *PNAS* 107 (2010): 1017–22; M. A. Altieri and V. M. Toldeo, "The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants," *Journal of Peasant Studies* 38, no. 3 (2011): 587–612; M. Dove, "Theories of Swidden Agriculture and the Political Economy of Ignorance," *Agroforestry Systems* 1 (1983): 85–99.

The Maya Forest is situated in the southern lowlands of Mesoamerica, spreading across 54,000 km^2 of the modern-day countries Belize, Guatemala, and Mexico in the Yucatan Peninsula.[17] Large rivers flank this area to the east and west but do not traverse its extent; lakes are concentrated near its geographic center but are otherwise uncommon. A combination of permeable limestone bedrock, which absorbs surface water, and a karstic topography of ridges and low-lying troughs creates a complicated landscape mosaic, comprising well-drained uplands and perennial wetlands with transitional areas between. Well-drained soils of the rocky ridges and hills, supporting the greatest diversity of broadleaf forest vegetation and particularly prized by ancient and modern people,[18] cover about 30 percent of this region, while poorly drained wetland soils overlay around 40 percent of the land (see figure 3). Variation in the physical environment, along with the restricted nature of available surface water, produces a range of habitats for plants and animals and provides a foundation for the biodiversity seen in the area today.

[17] The Nature Conservancy, www.nature.org/en-us/get-involved/how-to-help/places-we-protect/maya-forest/#:~:text=Reducing%20human%20and%20ecological%20vulnerability.&text=After%20the%20Amazon%2C%20Mesoamerica's%20Maya,and%20through%20Mexico's%20Yucatan%20Peninsula.
[18] S. L. Fedick and A. Ford, “The Prehistoric Agricultural Landscape of the Central Maya Lowlands: An Examination of Local Variability in a Regional Context,” *World Archaeology* 22 (1990): 18–33.

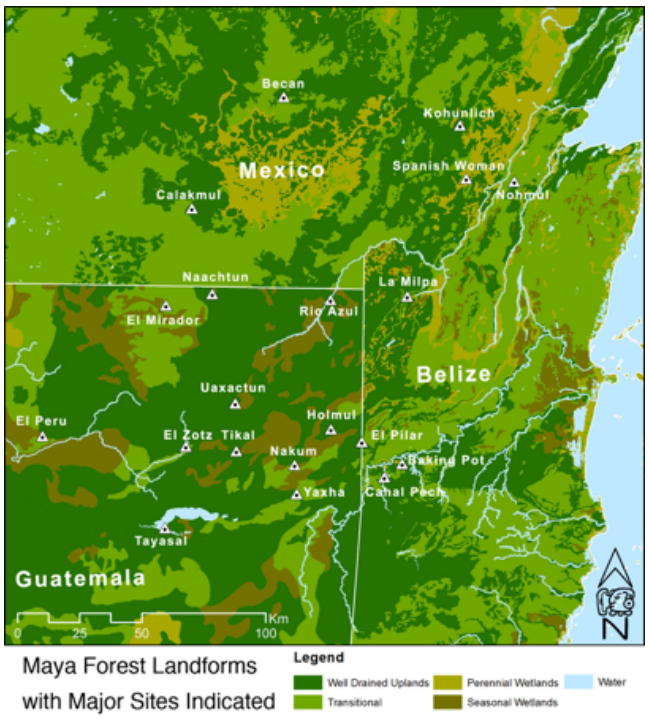


Figure 3. Landforms of the Maya Lowlands with major sites indicated (including Tikal and El Pilar). (Source: MesoAmerican Research Center.)

Maya settlements emerged in the tropical forests of the Yucatan Peninsula more than 3,000 years ago and, over the ensuing centuries, developed into one of the world's great pre-industrial civilizations.[19] The expansion of Maya populations—along with increasing organizational complexity in their communities—was underwritten by adaptations to the tropical forest environment that sustained growth and development for millennia.[20] Indeed, part of the enduring public fascination with Maya civilization seems to derive from the circumstances of its development. How could a literate society, with notable achievements in mathematics, astronomy, architecture, and fine arts possibly have arisen in the "inhospitable" Mesoamerican jungles? This view reveals a fundamental, cultural bias in Euro-American understandings of both the tropical forest

[19] S. R. Hutson and T. Ardren, eds., *The Maya World* (London: Routledge, 2020).
[20] T. Ardren and S. Miller, "Household Garden Plant Agency in the Creation of Classic Maya Social Identities," *Journal of Anthropological Archaeology* 60 (2020): 101212; S. L. Fedick, "Maya Cornucopia Indigenous Food Plants of the Maya Lowlands," in *The Real Business of Ancient Maya Economies*, edited by David A. Freidel and Marilyn A. Masson (Gainesville: University Press of Florida, 2020); A. Ford, "The Maya Forest: A Domesticated Landscape," In *The Maya World*, edited by S. R. Hutson and T. Ardren (London: Routledge, 2020).

and its occupants, and it obscures another great technological achievement: the creation of the Maya Forest cropscape.

The story of how humans adapted to life in the Yucatan Peninsula, and ultimately created a verdant and resilient environment in the Maya Forest, pre-dates by thousands of years the pyramids, temples, and hieroglyphs associated with Maya civilization. In fact, this story begins even before tropical forests became the dominant ecosystems in the region. Recent archaeological evidence from submerged caves near Mexico's Caribbean coast and caverns in the mountains of southern Belize indicate people had entered the area perhaps 15,000 years ago, when global climate regimes were cool and dry at the end of the Pleistocene Epoch, popularly known as the Ice Age. These migrants arrived from Asia, and their technology—based on manipulating stone and fire—allowed them to spread across the American continents in some 2,000 years (see figure 4).

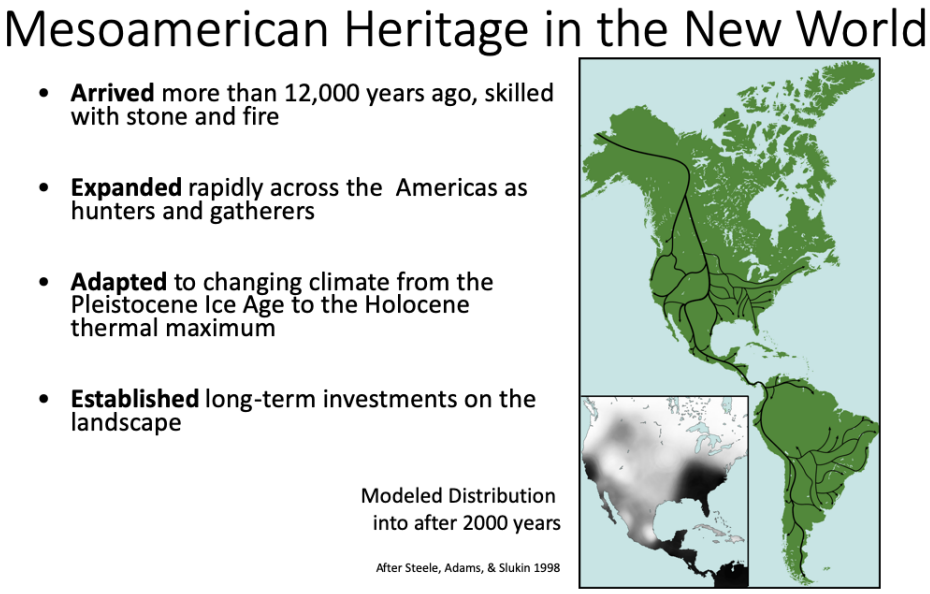


Figure 4.

By 8,000 years ago, global trends toward warmer and wetter climates created ecological shifts across Mesoamerica, especially in the lowland region that later fostered Maya civilization. These shifts changed the environment to a complex, biodiverse tropical forest ecosystem well-suited to support human communities. Opportunities

presented by such dramatic environmental changes were accompanied by challenges for the early inhabitants of the Maya Lowlands, who had embraced a mobile way of life well-adapted to Pleistocene conditions. Pioneering communities unlocked the potential of their new landscape, developing food-production and resource-management strategies that involved both domesticated crops and forest species. These strategies left an enduring impact on the Maya Forest that is conspicuous to this day.

The history of the earliest food production in the Maya Forest is still being written.[21] Early tropical forest dwellers were mobile horticulturalists who left few traces of their presence and no remains of permanent settlements. Evidence indicates that people in the Maya Lowlands cultivated maize and other crops, but the processes of integrating domesticated plant use with forest products remain unknown. Despite it being but one of many plants that provided sustenance for the Maya and their ancestors, maize—the Mesoamerican grain—captured the attention of Spanish conquistadors and is a global staple today.[22]

People learned through trial and error to use available technology in concert with abundant natural resources to produce the food and other materials necessary to live in the tropical forest. Experiments manipulating the ecology of plants and animals, based on observations of natural forest succession, began a process of accumulating knowledge for effectively using the environment to benefit human communities. An outcome of these early human-environment interactions was the development of the Indigenous production system known as the *Milpa Cycle*, which continues to be

[21] E. S. Deevey et al., "Mayan Urbanism: Impact on a Tropical Karst Environment," *Science* 206, no. 4416 (1979): 298–306; H. H. Vaughan, E. S. Deevey Jr. and S. E. Garrett-Jones, "Pollen Stratigraphy of Two Cores from the Petén Lake District, With an Appendix on Two Deep-Water Cores," in vol. 77 of *Prehistoric Lowland Maya Environment and Subsistence Economy*, edited by M. Pohl, 73–89 (Cambridge, MA: Harvard University Press, 1985); B. W. Leyden, "Pollen Evidence for Climatic Variability and Cultural Disturbance in the Maya Lowlands," *Ancient Mesoamerica* 13, no. 1 (2002): 85–101; A. A. Vela-Pelaez et al., "Holocene precipitation changes in the Maya forest, Yucatán Peninsula, Mexico," *Palaeogeography, Palaeoclimatology, Palaeoecology* 505 (2018): 42–52.

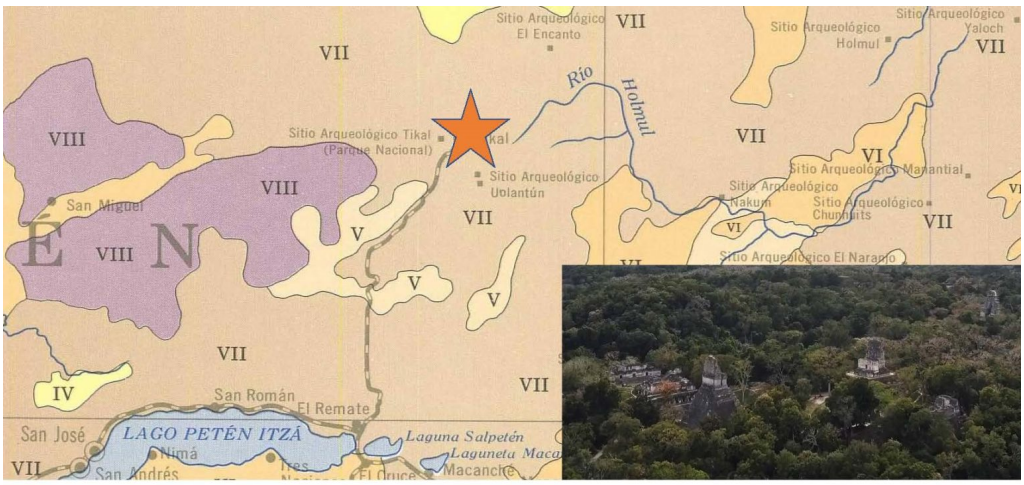
[22] Maize was domesticated near the Balsas River Valley of Central Mexico almost 9,000 years ago. M. Blake, *Maize for the Gods* (Oakland: University of California Press, 2015); See also A. Warman, *Corn and Capitalism: How a Botanical Bastard Grew to Global Dominance* (Chapel Hill: University of North Carolina Press, 2003).

practiced and refined by forest gardeners in the Maya area today (figure 5).[23] The language of the Maya Forest and the knowledge of how to manage food production and resources in a tropical forest setting were integral to supporting millions of Maya people at the apogee of their civilization. The Milpa Cycle may prove key in developing sustainable plans for the tropics today.

The Forest Cropscape: The Domesticated Landscape of the Milpa Forest Garden

Debates about the viability of the tropical forest to sustain ancient Maya civilization are not new, but our perspective here is original; the relationship between soils and Maya land-use technology serves as an example to illustrate our frame of reference. Rocky soils are considered undesirable in European cultivation systems centered on the plow—a tool not used in the pre-Conquest Americas—and it was inconceivable to non-Indigenous observers that the 'primitive' Maya cultivation system could support large populations and complex societies without destroying the shallow tropical soils (see figure 6). This view discounts the knowledge, skill, and labor that form the foundations of Indigenous food production and fails to appreciate the productive potential of soils—dubbed "uncultivable" by non-Indigenous assessors—when managed with traditional methods.[24] Consequently, archaeologists and others have presumed that overpopulation, leading to excessive agricultural demands, precipitated societal collapse and the abandonment of cities.

[23] Ford and Nigh, *The Maya Forest Garden*; figure 5 available at www.technologystories.org/conserving-the-american-tropics/#_ftnref5.
[24] Instituto Geografico Nacional de Guatemala, Capacidad Productiva de la Tierra, *Mapa de Cubertura y Uso de la Tierra* (Guatemala, Republica de Guatemala, 1982); J. M. Pleasant, "The Paradox of Plows and Productivity: An Agronomic Comparison of Cereal Grain Production under Iroquois Hoe Culture and European Plow Culture in the Seventeenth and Eighteenth Centuries," *Agricultural History* 85, no. 4 (2011): 460–92.



Land Use Capacity Based on US Department of Agriculture: Soil classes V, VI VII are considered not cultivable because of shallow, broken, and steep terrain subject to erosion. Most suitable for perennial forests and wildlife (ING 1982).

Figure 6. Where were the Maya cultivating? The U.S. Department of Agriculture classification shows all soils around the major ancient Maya center Tikal as Not Cultivable. (Source: Assembled by MesoAmerican Research Center, Instituto Geografico Nacional de Guatemala 1982.)

This scenario is hard to square with post-Conquest Spanish writings, which tell of hierarchical Maya societies possessing knowledge of writing, astronomy, and effective agriculture practices. Evidence suggests ancient Maya populations grew by drawing upon a vast array of ecological knowledge to enrich soil, foster biological diversity, and ultimately produce a consistent supply of agricultural and home-economic resources while maintaining the long-term viability of the forested landscape. Our research explores Indigenous strategies, preserved in the archaeological record and documented by ethnography, to illustrate the value of simple but sophisticated technologies from the past to inform innovative solutions for the future.

Introducing the Milpa Cycle: From Field to Forest and Back Again

A popular perception holds that slash-and-burn fields—components of the Milpa Cycle in Mesoamerica and the Maya area—are responsible for destroying forests.[25] By focusing on domesticated crops and the fields they are grown in, *ecological imperialists* only see shifting agriculture and discount the majority of the landscape as

[25] "Deforestation and forest degradation in . . . Belize are caused by the milpa system, also known as the shifting cultivation, which is practiced by Belizean and illegal Guatemalan farmers," Belize National Agroforestry Policy Draft, November 2020.

"abandoned." In fact, traditional Maya land use has a deep history, but these practices have been deliberately dissociated from the living Maya by adherence to imperialistic views. These views deny the obvious connection between the contemporary Maya and their ancestors (see figure 7).[26]

Contrary to this perspective of an abandoned landscape, studies show that the forest today was shaped by practices developed by the Maya millennia ago.[27] The ancient Maya maintained their environment while using it to provide food, shelter, medicine, and other necessities of daily life. The Milpa Cycle—a complex and sustainable sequence that alternates between cultivated fields and forest gardens—builds a useful cropscape that can sustain human life and maintain the biodiversity of the forest.[28] Contemporary Maya forest gardeners draw on the knowledge of their predecessors to preserve the forest as a garden.[29]

The Maya Forest reflects countless generations of managed crop cultivation and directed succession of perennial forests. As a result of this careful curation of the forest as a cropscape, the Maya Forest is today among the most biodiverse in the world, filled with plants valued for the economic uses and the habitats they provide.[30] This wealth untold is both a cultural and economic treasure, representing millennia of short- and long-term choices of planting annual crops and perennial trees to sustain the needs of Indigenous Maya communities (see figure 8).

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[26] I am Mayan, especially the first part: https://youtu.be/00M40NizTFk ; www.nature.org/en-us/about-us/where-we-work/latin-america/mexico/maya-forest/mexico-maya-forest-local-communities/; Figure 7 available at: www.odysseyearth.com/videos/sustainable-farming-the-maya-milpa-cycle/.
[27] Campbell et al., "The Feral Forests of the Eastern Petén."
[28] M. Everton, *The Modern Maya: Incidents of Travel and Friendship in Yucatán*, 1st ed. (Austin: University of Texas Press, 2012).
[29] A. R. Corzo Márquez and N. B. Schwartz, "Traditional Home Gardens of Petén, Guatemala: Resource Management, Food Security, and Conservation," *Journal of Ethnobiology* 28, no. 2 (2008): 305–17; G. C. Wilken, *Good Farmers: Traditional Agricultural Resource Management in México and Central America* (Berkeley: University of California Press, 1987); Wilken, *Sustainable Agriculture is the Solution, But What is the Problem?* (Washington, D.C., 1991).
[30] A. Ford, "Valuing the Maya Forest as a Garden," in *Exploring Frameworks of Tropical Forest Conservation*, edited by N. Sanz (Mexico City: UNESCO, 2017).

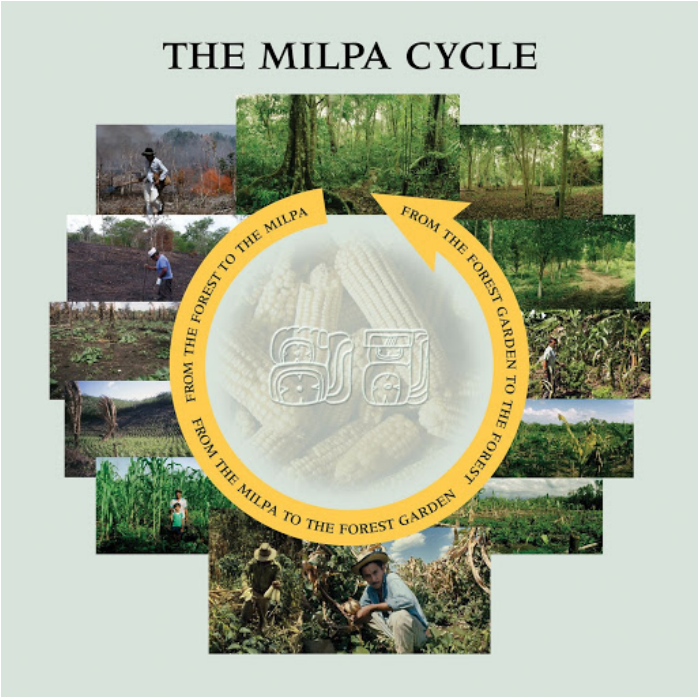

Figure 8. The Milpa Cycle creates field gaps to build the forest as a garden. (Source: MesoAmerican Research Center.)

The ancient Maya cultivated their landscape in ways that prioritized usefulness and complemented natural forest cycles. Collaborations with contemporary Maya farmers reveal a sophisticated knowledge base that contributes to the continued maintenance of the forest as a garden.[31] The average twenty-year Milpa Cycle is tethered to the infield home gardens that are the hub of the outfields. The system is characterized by a rotation, starting with open fields of traditional agricultural crops, progressing through a sequence of products obtained from secondary growth, and completing the circuit with a closed canopy forest over the original cleared area that is ready to repeat the cycle again (see figure 9).[32]

The choices of farmers in selecting plants account for the dominance of economically useful species across the extent of the Maya Forest (see table 1), as generations of Maya agriculturalists applied their knowledge to meeting community needs. Forest gardening strategies have also developed to be responsive to climate change, as the predominantly forested landscape and poly-cultural fields constantly

[31] Ford and Nigh, *The Maya Forest Garden*.
[32] Figure 9 photo sequence available at www.technologystories.org/conserving-the-american-tropics/.

maintain land cover in ways that enhance biodiversity, conserve water, and moderate temperatures. These common land-use practices also help retain organic matter, which contributes to soil fertility and reduces erosion. The outcome is a managed cropscape that can support the diverse daily, monthly, seasonal, and annual economic necessities of people living in the forest.

Table 1: Dominant Plants of the Maya Forest: Their Pollinator and Uses

Common Name	Scientific Name
Bay Leaf	*Sabal morrisian**
Breadnut	*Brosimum alicastrum**
Cabbage Bark	*Lonchocarpus castilloi*
Chicle	*Manilkara zapota**
Cohune	*Attalea cohune **
Drunken Baymen	*Zuelania guidonia*
Fiddlewood	*Vitex gaumeri*
Give-and-Take	*Cryosophila stauracantha*
Guaya	*Talisia oliviformis**
Gumbolimbo	*Bursera simarouba**
Hogplum	*Spondias radlkoferi*
John Crow Redwood	*Simira salvadorensis**
Mahogany	*Swietenia macrophylla*
Mamee Ciriola	*Pouteria campechiana*
Mayflower	*Tabebuia rosea*
Monkey Apple	*Licania platypus*
Mylady	*Aspidosperma cruentum*
Wild Mamey	*Alseis yucatanensis*
Wormwood	*Piscidia piscipula*
Zapotillo	*Pouteria reticulata*

*dominant in contemporary gardens

The Milpa in Detail

Milpas are regularly equated with planted fields, but in truth, those fields are but one part of a cycle that invests in long-term perennial growth by clearing land in the short term. The home infield is the most intensively attended part of the system (see figure 10), and its products are complemented by necessities from the surrounding cropscape.

The integration of Milpa Cycle elements is so complete that master forest gardeners say there will be no forest without the fields, and no fields without the forest. By recent estimates, the Maya use some 500 plants from their fields and forests as food,[33] and they favor around 200 different trees for various and sundry uses.[34]

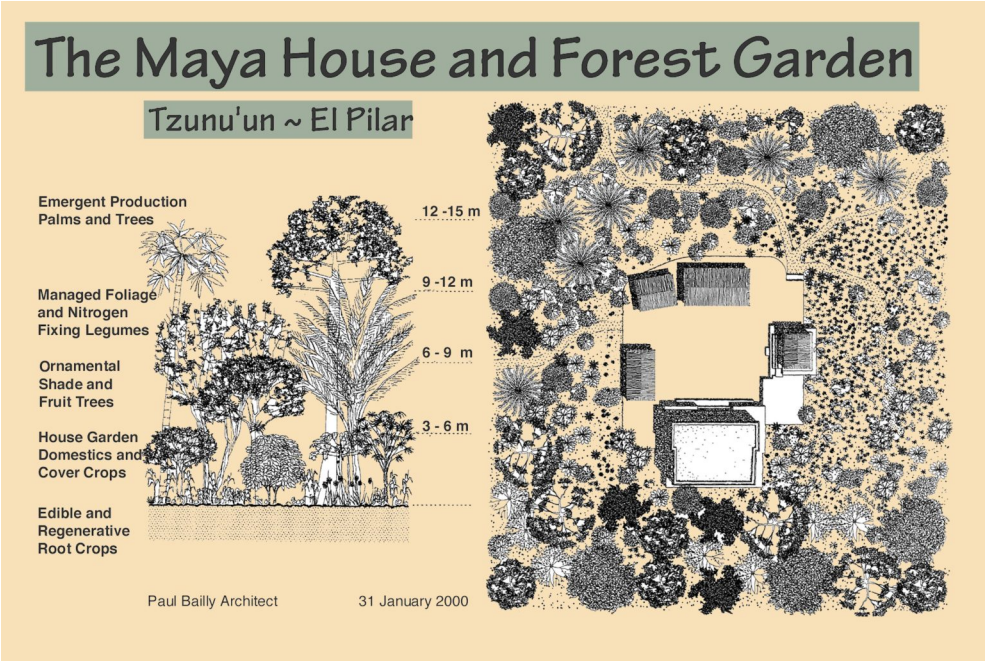

Figure 10. Profile and Plan Schematic of a Maya House and Forest Garden Infield. (Source: MesoAmerican Research Center.)

Open fields provide gaps that are intermingled with and surrounded by areas of perennial succession and closed-canopy forest.[35] Farmers selectively cut trees with resprouting in mind, favoring and preserving those that usefully hasten the transition to succession perennials.[36] Slashed fields are then burned to clear an area for sun-loving, annual food crops, which are fertilized by nutrients left in the soil from ash. Maize, beans, and squash, the “three sisters” of New World fame, lead the variety of crops selected for each milpa field. It is not unusual to find more than thirty different crops in one field, however, which are chosen from a basketful of more than 100

[33] Fedick, *Maya Cornucopia*.
[34] Ford and Nigh, *The Maya Forest Garden*, appendix B.
[35] See the milpa field surrounded by forests in 1.6 and 2.1 of MFPIC_GIF.gif.
[36] Note the trees and stumps in 1.4 of MFPIC_GIF.gif.

possibilities.[37] This poly-cultural field is sustained for about four years of a minimum twenty-year cycle, all the while fostering selected perennial trees that emerge with the natural cycle of forest succession.

Over the next sixteen or more years of the Milpa Cycle, Maya farmers today promote a variety of useful perennials, starting with fast-growing trees, such as papaya, and other economically useful succession saplings.[38] These provide shade for a diversity of slow-growing fruit and hardwood trees that emerge over the remaining eight years and form the new shade canopy. Many of these trees—palms for oils and construction; avocado, ramon, allspice, mamey, nance, and cacao for fruits; and mahogany, cedar, and manchiche for lumber, to name but a few—will mature to build a functional forest garden, providing for the needs of people as well as habitats for wildlife.[39] After the cycle is completed, new farmers follow in their fathers' footsteps—nurturing favored trees, burning fields, inviting new sprouts to aid the transition of clearings to shady forests—and the process begins anew (see figure 11).[40]

The Western concept of agriculture views intensification as expanding fields at the expense of the forest, following a zero-sum mentality of culture versus nature (see figure 12A). While it features so prominently in the focus on shifting agriculture, the open fields of the Milpa Cycle will only compose, on average, one-fifth of the total cropscape (see figure 12B).[41] The majority of the cropscape will emphasize the perennial component found in phases of forest succession, which provide for the numerous needs of community members (see figure 13). Across generations, the open fields of annual crops are transformed into useful forest gardens, creating a nurturing, productive, and biologically diverse landscape. The milpa-forest garden system is primarily practiced in well-drained places on the landscape, leaving the majority of wet and steep areas as managed forests. Maya forest gardeners demonstrate a finesse with nature, cultivating biological capital from their surroundings as a product of their culture.

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[37] Ford and Nigh, *The Maya Forest Garden*, appendix A.
[38] This is phase 2 of building perennials in the MFPIC_GIF.gif.
[39] This is focused on phase 3 of mature perennials as well as phase 4 of managed forests MFPIC_GIF.gif.
[40] See figure 11 at www.technologystories.org/conserving-the-american-tropics/.
[41] See figures 12A and 12B at www.technologystories.org/conserving-the-american-tropics/.

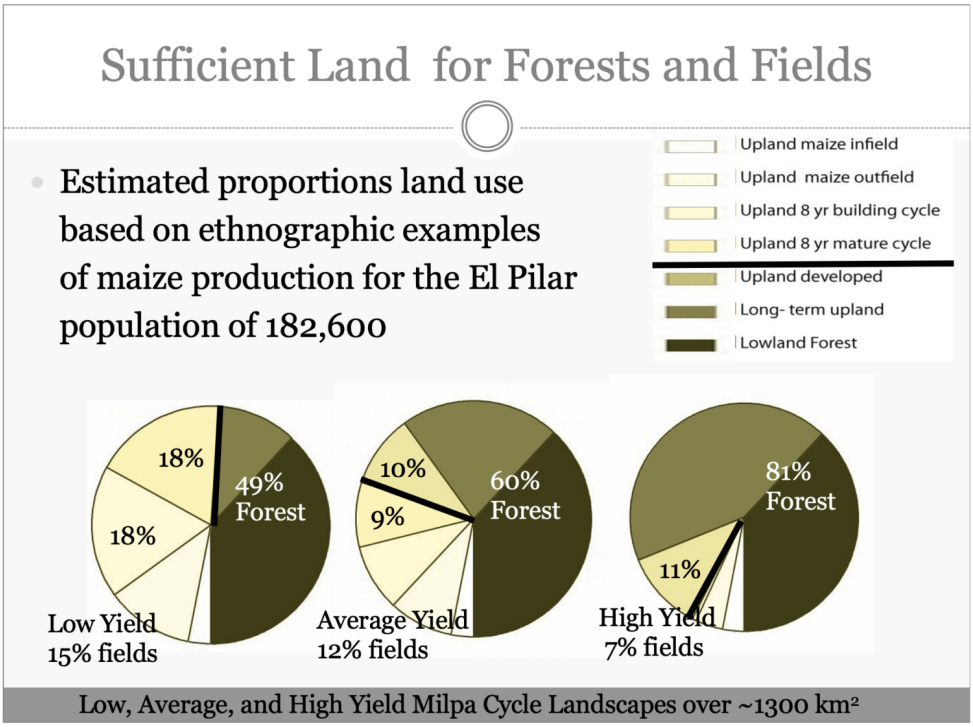

Figure 13. Forest-Fields proportions for the El Pilar area based on example yields. (Source: MesoAmerican Research Center.)

Forest Gardens I Action for Climate Change & Food Sovereignty

The Maya were an agricultural society that relied on the basic technologies of stone tools and fire. They moved through the landscape on foot (see figure 14), observing their environment while walking and learning crucial lessons in the footsteps of their elders.[42] Maya farming practices—based on family knowledge, skill, and labor—generated complex relationships between communities and the environment they inhabited, and the growth and development of these communities through time provides ample proof that those practices were sustainable.[43] Yet the perspective of Maya civilization as doomed to fail by virtue of its emergence in a fragile environment continues to be promulgated, untested, as fact. The current focus on the so-called "Maya collapse" discounts millennia of successful adaptations and undermines an

[42] W. G. Lovell, "A Tumpline Economy: Production and Distribution Systems in Sixteenth-Century Eastern Guatemala," *Hispanic American Historical Review* 67, no. 3 (1987): 512–13; R. Hassig, *Trade, Tribute, and Transportation: The Sixteenth-century Political Economy of the Valley of Mexico* (Norman: University of Oklahoma Press, 1985).
[43] F. Bray, *The Rice Economies: Technology and Development in Asian Societies* (New York: Blackwell, 1986); Bray, "Agriculture for Developing Nations," *Scientific American* 271, no. 1 (1994): 30–37.

investigation of sustainability in the tropics today. The attitude of ecological imperialists persists in pejorative views of the tropics and a general indifference toward exploring what the Maya example can offer to discussions of sustainability in tropical environments.[44]

Figure 14. Mesoamerica and the Maya relied on human power to move and to transport goods, a Tumpline economy. (Source: Florentine Codex https://www.mexicolore.co.uk/aztecs/artefacts/carrying-frame.)

The Maya milpa-forest garden cycle provides a stimulus for exploring solutions to global issues of food sovereignty and climate change, which are critical challenges in the world today.[45] The Maya Forest cropscape comprises diverse trees that create shade to lower temperature, conserve water, and reduce erosion while producing organic matter to build soil fertility. Food produced by annuals and perennials met the subsistence needs of millions at the height of Maya civilization and could do so again. It is valuable to consider master forest gardeners as citizen scientists whose traditional ecological knowledge promotes sustainability through biodiversity, and whose traditional practices demonstrate an alternative strategy in maintaining a productive environment.

[44] Gourou, *The Tropical World.*
[45] UN Sustainable Development Goals www.undp.org/content/undp/en/home/sustainable-development-goals.html.

Ancient Maya monumental centers of Belize, Guatemala, and Mexico have today been "restored" to serve as popular destinations for foreign tourists. These attractions, while promoting the accomplishments of an advanced Indigenous civilization, have been divorced from the living Maya. Grandiose structures are presented as removed from their natural context. Exposing these monumental temples and palaces to the elements accelerates natural processes of architectural degradation (see figure 15). We advocate for a new way to engage with the Maya at the ancient center El Pilar, on the border of modern Belize and Guatemala, that honors past forest gardeners and challenges visitors to view the forest as a garden. Visitors to El Pilar experience the city in its forest setting in an approach we call "Archaeology Under the Canopy" (see figures 16 and 17),[46] which highlights the monuments amidst the bounty of natural resources available to provide food, condiments, fiber, oils, ornamentals, fuel, gum, medicine, poisons, furnishings, supplies, construction materials, household utensils, and habitat for animals.[47] Tourists can experience the environment represented in the language of the Maya Forest and once-common knowledge of the landscape.

Figure 15. Clearing Monuments for Tourism, Where is the Mask? Northern Acropolis in 2012 and 1972, Tikal, Guatemala. (Source: MesoAmerican Research Center; Credit: Bianca Graves.)

[46] Figure 16 is available at www.technologystories.org/conserving-the-american-tropics/.
[47] Ford, "Valuing the Maya Forest as a Garden."

Figure 17. Archaeology Under the Canopy. Plaza Jobo, El Pilar Archaeological Reserve for Maya Flora and Fauna, Belize-Guatemala.

Long-term strategies for land management are essential in the contemporary tropics, which have endured extreme changes from deforestation (see figure 18) and are projected to host the highest levels of future population growth.[48] Tropical forests have regularly been dismissed as fragile landscapes, and received wisdom suggests these environments are inadequate and unable to sustain large populations without substantial alteration. Yet this is the very strategy that has put the tropics at risk today. By contrast, long-surviving Indigenous food-production and land-use practices, involving sophisticated understandings of forest ecology, remind us that tropical forests are indeed hospitable environments. The Maya are one people among many who deserve recognition for creating sustainable land-use practices, and those practices should inform successful development programs in the tropics as we confront present and future challenges. The real threat to the Maya Forest is the loss of traditional Maya farming practices, for once the carriers of this knowledge are lost, it may never again be regained.

[48] Figure 18 is available at www.technologystories.org/conserving-the-american-tropics/.

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