Mayan Mysteries

Global Hydrology Resource Center

by Michon Scott

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Centuries before Europeans arrived, an advanced civilization flourished in Mesoamerica, a region extending from southern Mexico through Central America. The Maya mastered astronomy, developed an elaborate written language, built towering monuments, and left behind exquisite artifacts.

Title graphic image: The Rain God Chac appeared in one of the few Mayan texts to escape burning by the Spanish. (Image adapted from the Madrid Codex appearing on the NOAA Paleoclimatology Mirror Site, photo by David A. Hodell.)

According to NASA archaeologist Tom Sever, the Mayan civilization in Mesoamerica was one of the densest populations in human history. Around 800 A.D., after two millennia of steady growth, the Mayan population reached an all-time high. Population density ranged from 500 to 700 people per square mile in the rural areas, and from 1,800 to 2,600 people per square mile near the center of the Mayan Empire (in what is now northern Guatemala). In comparison, Los Angeles County averaged 2,345 people per square mile in 2000. Yet by studying remains of Mayan settlements, Sever found that by 950 A.D., the population had crashed. "Perhaps as many as 90 to 95 percent of the Maya died," he said.

Before their sudden decline, the Maya built impressive monuments, including the pyramids of Tikal, Guatemala. (Photograph Copyright © Tom Sever.)

For Sever, figuring out how the Maya flourished—but ultimately failed—in Mesoamerica is about more than simply solving a 1,200-year-old mystery. Since the 1980s, he has tried to understand the history of the Maya and their natural environment, a story that may hold important lessons for people living there today. Using satellite data and climate models, Sever and his colleagues hope to help governments and citizens throughout Mesoamerica ensure that the region can

continue to support the people who live there. By learning from the Maya, modern humans may avoid sharing their fate.

Mayan Deforestation

Before its collapse, the Mayan empire stretched out from its center in northern Guatemala's Petén region across the lowlands of the Yucatán Peninsula. Pollen samples collected from columns of soil that archeologists have excavated across the region provide evidence of widespread deforestation approximately 1,200 years ago, when weed pollen almost completely replaced tree pollen. The clearing of rainforest led to heightened erosion and evaporation; the evidence of the erosion appears in thick layers of sediment washed into lakes.

"Another piece of evidence," explained Sever, "is the thickness of the floor stones in the Mayan ruins. They would have needed about 20 trees [to build a fire large and hot enough] to make a plaster floor stone that is about one square meter. In the earliest ruins, these stones were a foot or more thick, but they progressively got thinner. The most recently built ones were only a few inches thick." Sever's colleague, atmospheric scientist Bob Oglesby of Marshall Space Flight Center, calls the Mayan deforestation episode "the granddaddy of all deforestation events." Studies of settlement remains show that this deforestation coincided with a dramatic drop in the Mayan population.

"After the Mayan collapse, this area was abandoned and the forest recovered. But as people have returned over the last three decades, the deforestation has returned," Sever explained. Today, the regenerated forests of the Petén are the largest remaining tropical forests in Central America. While present-day deforestation in the Petén region hasn't yet occurred on a Mayan scale, today's technology could easily enable modern residents to surpass the Maya in cutting trees. According to the Food and Agriculture Organization of the United Nations, deforestation in Guatemala averaged 1.7 percent annually between 1990 and 2000.

Besides a cautionary tale about what can happen to civilizations when they clear-cut surrounding forests, the long-gone Mayan civilization also offers clues to a more sustainable use of the landscape. Before their catastrophic decline, the Maya thrived in Central America for two millennia. "We want to know how the Maya used this landscape because we don't know how to use it successfully today," said Sever. Although the Maya's secrets for success are harder to discern than their reasons for failure, Sever has at least one idea.

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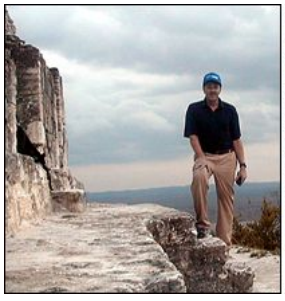


Archaeologist Tom Sever (left) and remote sensing specialist Dan Irwin (right) have pooled their skills to understand the Maya. (Photographs Copyright © Tom Sever.)

Populations in densely forested regions often rely on slash-and-burn agriculture. At first glance, this might seem like the approach the Maya used, but Sever doesn't think so. "In slash-and-burn agriculture, people clear the land to plant corn, for instance," he said. "They get 100 percent productivity the first year, 60 percent the

next year, and something less than that afterwards. So in three to five years, the land is basically useless, and they have to move on." In a sparsely populated region, slash-and-burn agriculture might work, but Mesoamerica around 800 A.D. was one of the most densely populated areas in the pre-industrial world. "Slash and burn wouldn't have enabled a population to grow to that size," he said.

Sever believes the Maya took a different approach to farming: effective water management. "The biggest threat we face doing fieldwork in this region is dying of thirst," Sever explained. Even the rainforest experiences an annual dry season; the trees hang on by tapping groundwater. "The Maya couldn't use groundwater because it was 500 feet below them, and they had no technology to reach it, so they depended on rainwater."

In the Petén region Sever studies, rainwater accumulates in swamplands, known as *bajos*, that cover about 40 percent of the landscape. Today, that rainwater evaporates before anyone can use it effectively, but excavations and satellite images have revealed networks of canals among the *bajos*, apparently dug during the time of the Maya. Sever suspects that the Maya used the canals to redirect and reuse the rainwater. This labor-intensive agriculture, which probably kept farmers working diligently all day, would have barely outpaced demand. If the Maya farmed the *bajos*, however, they took advantage of an additional 40 percent of the landscape, which would have made a significant contribution to food production.

Modern Mesoamericans consider the *bajos* worthless and ignore them. "We're trying to understand how to control water and enable this landscape to support current populations, to reduce some of the stress on the economy and environment," Sever said.

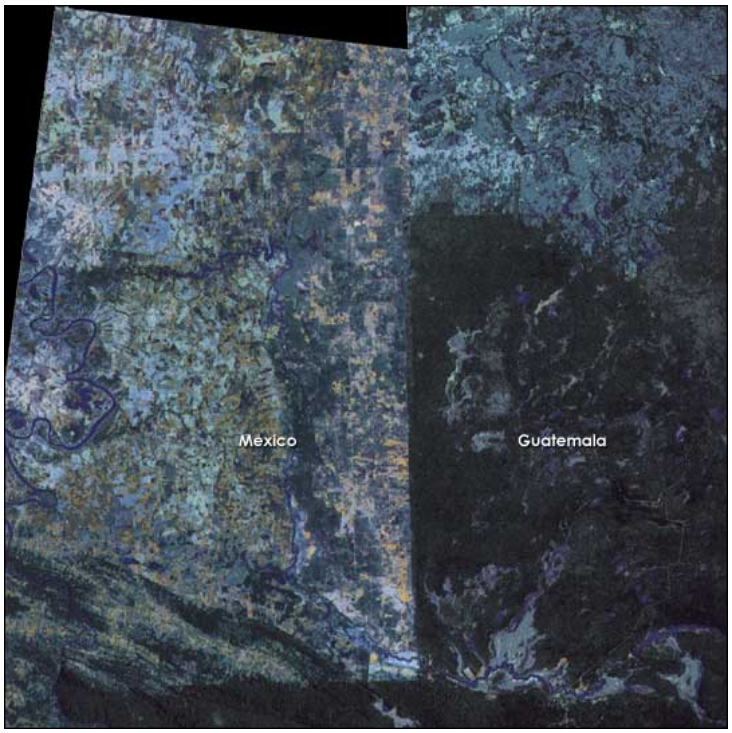
Climate Change

In the end, Oglesby speculated, the increased productivity the Maya gained by farming the *bajos* might have made them too successful. "Population pressure might then have led to their having to clear more and more land, both for settlement and for agriculture," he said. Oglesby has used three-dimensional regional climate models to help visualize the Mayan demise, and what he has found so far is intriguing.

"If we completely deforest the area and replace it with grassland, we find that it gets considerably warmer—as much as 5 to 6 degrees Celsius," Oglesby said. Sunlight that normally evaporates water from the rainforest canopy would instead heat the ground. Although his model paints a more extreme picture than what actually happened (the region was heavily, but probably not completely deforested), Oglesby suspects that deforestation contributed to a drought. Lake sediment cores indicate that the Mayan deforestation appears to have coincided with natural climate variability that was already producing a drought. "Combined with the land-use changes, the drought was a double whammy," he said. By 950 A.D., the Mayan lowland cities were largely deserted.

Learning from the Mayan Legacy

Today, population density in Central America is only a fraction of what it was during the Mayan peak. In Belize, for example, population density may be as low as 26 people per square mile (10 people per square kilometer). Yet human pressure on the environment is still significant.



The razor-sharp border between Mexico and Guatemala, as seen in this 1988 Landsat image, shows the impact of high rural population on the rainforest. Guatemala's sparsely populated Petén district stands in stark contrast to the stripped and tilled landscape of Mexico. This image prompted the leaders of Mexico and Guatemala to set aside long-standing tensions and focus on preserving the rainforest. (Image courtesy of NASA.)

The effectiveness of modern tree-cutting technology became clear to Sever in the late 1980s. NASA and the National Geographic Society hired him to study the potential impact of a hydroelectric dam on the Usumacinta River in Guatemala. Sever, who had pioneered the use of remote-sensing data in finding archaeological sites, turned to satellite imagery once again. Using Landsat data, he produced an image showing part of the border between Guatemala and Mexico. Most political borders are invisible in satellite images, but this border was obvious. The rainforest —still intact in Guatemala—stopped abruptly at the Mexican border, where the landscape had been stripped.

Sever's images stunned Guatemala's president. "There had been tensions along the Mexico-Guatemala border for about 150 years," said Sever. After seeing the satellite image, however, both nations' presidents "decided that the environment must unite them." In a ceremony on a river bridge between the countries, Guatemalan President Vinicio Cerezo and Mexican President Carlos Salinas shook hands and pledged to protect the dwindling rainforest. It marked the beginning of a larger effort to protect the environment in Mesoamerica.

Mesoamerican Biological Corridor

Dan Irwin, one of Sever's colleagues, is a remote-sensing specialist who uses satellite data to study the environmental health of Mesoamerica. Regarding the image Sever showed to the Guatemalan president, Irwin remarked, "It may be the single most important image for conservation purposes that I know of on the planet, because it prompted Guatemala and Mexico to work together. More importantly, that one image was directly responsible for the Guatemalan Congress declaring the Maya Biosphere Reserve in northern Guatemala, which is the largest protected area in all of Central America."

The Maya Biosphere Reserve is part of the larger Mesoamerican Biological Corridor. Originally known as *Paseo Pantera* (Path of the Panther), the corridor is a network of protected areas extending from southern

Mexico to Colombia, through Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. The corridor preserves Mayan ruins, along with habitat and migration routes for wildlife. "Mesoamerica has less than half a percent of the Earth's landmass, but it has over 7 percent of the world's biodiversity," said Irwin.

Animals that depend on the rainforest for habitat in the Mesoamerican Biological Corridor include (left to right) hummingbirds, howler monkeys, quetzals, jaguars, and macaws. (Howler monkey image courtesy of the *U.S. National Park Service*, quetzal image courtesy of *Cloud Forest Alive*, other images from Photos.com.)

Irwin began working with Sever in the early 1990s as an employee of Conservation International. "I planned to be in Central America for two months and came back five years later," Irwin said. He distinctly remembers the moment he decided to stay and continue his work there, which occurred one evening when he showed some of Sever's satellite images to a rural Guatemalan community.

Unlike their president, the villagers initially had trouble understanding the images. "They had never worked with maps or any type of spatial data," Irwin said. "Part of the process was showing them, 'This is a road near you' and 'This is a lake.' All of a sudden, the light bulbs turned on and they became very interested."

Once the villagers understood what they were seeing, they shared the Guatemalan Congress's concern for the rainforest. "This society was an agricultural community, and the people had assumed that you could keep on developing more fields and bringing more people up, and the forest would last forever," he said. "But I showed them that the Mexican border really wasn't that far away, and that Mexico's side had been completely deforested. It was an amazing moment that I'll never forget. With that, I made the decision to continue on and do this type of work."

Choosing a Sustainable Future

Remote sensing observations provided by NASA's data centers have been critical for monitoring the health of the Mesoamerican Biological Corridor. Through routine satellite observations, researchers can monitor important ecosystem vital signs, such as rainfall, vegetation productivity, cloudiness, and forest gains or losses over the entire area. Oglesby and his colleagues will be archiving the results from their modeling experiments on the climate impacts of the Mayan deforestation at the Global Hydrology Resource Center at NASA's Marshall Space Flight Center.

While they hope Central American forests can be spared the kind of clear-cutting seen in Mexico, the researchers don't want to stop all development in the region. "The purpose isn't to discourage any development, but to encourage improved development," Irwin said.

Remote-sensing data and modeling technology have already enabled natural resource managers in Mesoamerica to predict and avoid environmental damage. Irwin recalled a proposal to build a road through the middle of a reserve to connect two archaeological sites. Using data on how deforestation spreads outward from roads, the scientists developed a model that examined the road's distance from water, the surrounding soil type, and other factors. "We made an animation of what the place would look like in one year, two years, four years, etc. That particular study was a

factor in the decision to build the road around the reserve instead," Irwin said.

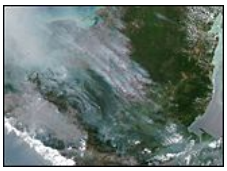
Irwin is also encouraged by improved agricultural practices, such as shaded coffee. In a traditional coffee plantation, farmers typically cut down all the trees, a process that's harmful to wild birds, including local species like macaws and quetzals, and migrating songbirds. By planting shade-tolerant coffee around existing trees, farmers can strike a balance. "You can find all kinds of birds on shaded coffee plantations. It's a type of agriculture that goes along with the theme of the corridor," he said.

Using Satellite Data to Study the Corridor

Sever and Irwin are now providing Mesoamerican scientists, policymakers, and land managers with direct access to satellite data and models. "The Guatemalan Minister of the Environment wants to replace his old topographic map with a plasma TV showing the latest data," Irwin said.

To improve general access to remote-sensing data, NASA has partnered with the U.S. Agency for International Development, the World Bank, the Central American Commission for Environment and Development, and several U.S. universities to develop the SIAM-SERVIR Website. The site offers a satellite data archive and distribution system for professional researchers, maps for more casual users, visualizations, and a decision support system that provides information to researchers and policymakers.

The Website, initially developed at NASA's Marshall Space Flight Center, will ultimately be hosted in Panama, with nodes throughout Central America. "We're proud of the decentralized control," said Irwin. "Users can post data and make them available to anyone." Another source of pride for Irwin is the rapid spread of remote-sensing expertise. "I'm the first to admit that there are people in Central America I've trained who know more than I do now when it comes to some of the imagery," he said. "I have to read the book to keep up with them."



The SIAM-SERVIR Website monitors wildfires, such as these fires burning across the Yucatán Peninsula. Click here for more information.

Remote sensing and climate modeling have given today's Mesoamericans a chance to understand their environment in a unique way—one that would probably have been as surprising to the Maya as it was to the Guatemalan farmers seeing the satellite photos of their surroundings for the first time. Archeological studies have likewise given modern Mesoamericans clues to Mayan success and eventual failure.

The Mesoamerican Biological Corridor may give the region's tropical forest ecosystems a chance to thrive despite increased population pressure. The environment around Petén recovered only after the Maya deserted, but scientists involved in the corridor hope to strike a balance between human needs and environmental health. "We're trying to protect the forest to avoid what happened at the time of the Mayan collapse," Sever explained. "This project shows how various organizations, researchers, and new technology can come together to make something productive, something that's beneficial for everyone."

Reliable information on the state of Mesoamerican environment and how it reacts to natural and human-produced change is fundamental to helping Mesoamerica's modern residents recreate the Maya's successes without repeating their mistakes.

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For more information:
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