Science Societies

Inherited landscapes: Ancient Maya land use and soil transformation

Soils at Mexico's Budsilhá site reveal how ancient inhabitants farmed and used the land

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Scientists study a soil profile in a modern channel in the area of Canan in Mexico. The team did similar work at the ancient Maya site of Budsilhá. Photo by Jaime Díaz.

The ancient Maya site of Budsilhá in southern Mexico offers valuable insights into the past, revealing how the region's inhabitants transformed the landscape for agriculture. In a recent article published in *the Soil Science Society of America Journal*, researchers studied the soil at the site to understand Maya land use, uncovering evidence of erosion, deforestation, and other human activities that significantly impacted the environment. The findings show how the Maya adapted their farming practices to a hilly, swampy landscape and how soil degradation, including erosion of upland soils, might have contributed to the decline of the civilization. The researchers continue to explore the effects of ancient human activity on soil health, providing potential lessons for current and future agricultural practices.

The ancient Maya site of Budsilhá in southern Mexico, while not a major city, was once home to a palace and noble court that was vital to the politics and economy of the era. The hilly landscape had sweeping terraces with dwellings constructed on the uplands and crops growing in the lowlands, crops that were essential to the health and economy of the region. As is the case with nearly every society on earth, its foundations lay in the soil on which buildings and homes were built and in which crops

were grown.

And that soil has a story to tell.

For many years, unique interdisciplinary research partnerships have brought together archeologists, anthropologists, soil scientists, and ethnobotanists to work at ancient Maya sites to better understand how their inhabitants developed the land and defined their culture. By overlaying the results of archeological excavation with studies of the soil, they are able to piece together the land use of the ancient Maya.

In a new article in the *Soil Science Society of America Journal*, scientists at the Universidad Nacional Autónoma de México in Mexico City, Brandeis University, and Brown University studied soil development and ancient Maya land use at the Budsilhá site. Budsilhá is in a tropical karst landscape characterized by an abundance of limestone bedrock, which produces a characteristic jagged relief of hills, sinkholes, and caves as it weathers.

“We studied the soils around Busiljá Valley and their relationship to the Maya occupation of the area,” explains Pamela García-Ramírez, a graduate student at the Universidad Nacional Autónoma de México who served as lead author on the paper. “We focused on understanding the land use and what the relationships were between soil development and cultural activities. Our goal was to understand what was happening in the countryside in these ancient Maya communities.”

The archaeological site of Budsilhá is located in a landscape of dramatic relief—especially compared with Maya sites farther north on the Yucatán Peninsula—meaning it is defined by narrow valleys, jagged hills, and the tributary streams feeding into the Usumacinta River. The soil scientists describe how they reconstructed the environmental setting and soil mantle over which cultural

development took place.

Their major findings provide evidence that the highlands had thin, poor soils—largely classified as Rendolls—and were filled with constructed dwellings while the swampy lowlands—classified as Aquepts—were managed in a way that allowed for productive agriculture in their deeper and more developed soils. The results also point to detrimental erosion that occurred in the highlands and some surprises in the lowlands, such as the unexpected presence of gypsum in the soil. Taken together, the findings showed a soil mantle and landscape heavily impacted, often negatively, by ancient Maya civilization.

The swampy lowlands near Budsilhá are in a tropical landscape surrounded by hills. The researchers think that the ancient Maya cultivated fields of crops in areas like this one. Photo courtesy of Sergey Sedov.

An ancient landscape modified for agriculture

The Budsilhá site is located in southern Mexico in the state of Chiapas near the border with Guatemala. The hilly and mountainous region is hot and humid, receiving 3,413 mm (more than 130 inches) of rainfall each year. A relatively large community with

inhabitants spread out around the countryside, it was not a major metropolis and was likely interwoven culturally and economically with larger cities and kingdoms nearby, such as the powerful metropolis Piedras Negras. The research team believes it was inhabited from at least 400–900 CE.

Charles Golden, an archeologist at Brandeis University, has worked in this region since the late 1990s and at Budsilhá since 2012. He describes an ancient time in capital cities with kings and queens living opulent lives and raising temples to the gods, punctuated by periods of violence between warring kingdoms. But much less is known about the smaller towns and villages, which likely housed the courts of noble lords and played a critical role in producing food for a rapidly expanding population. The details of how this food system was maintained are largely unknown.

“In some ways Budsilhá is an island in a swamp,” Golden says. “The archeological site is on a rise in a seasonally inundated wetland. As a relatively large village, we know it had a palace and played an important role in this ancient world. Through remote sensing techniques like Light Detection and Ranging (LiDAR), as well as artifacts found through excavation, we’ve been able to understand some of what the area looked like and was used for.”

The soil profile in the wetlands is dark with a relatively high water table. The researchers found gypsum in this soil. Photo courtesy of Sergey Sedov.

Remote sensing shows a landscape clearly modified for agriculture. The hills were terraced to allow for the constructions of dwellings, which required the excavation and moving of large amounts of soil. Some of these homes would have been accompanied by small home gardens while the majority of agriculture occurred farther downhill.

In the lowlands, there is evidence of channels being built to manage the annual inundation of the landscape in the wet season as well as transport water in the dry season. Golden says these were likely made by excavating the trenches and piling the soil up on the open fields.

The ancient Maya commonly practiced slash-and-burn agriculture where an area of forest is burned and planted on, and over time as it becomes less fertile, is allowed to regrow. Unlike modern monoculture, ancient residents likely cultivated a mosaic of crops, including staples like corn, beans, squash, and root crops like manioc (also known as cassava) and arrowroot. They also cultivated a complex canopy and

understory of trees and plants, such as cacao and vanilla, that would serve as luxury market crops.

“What we are seeing is a landscape that is drastically transformed by water and people together,” Golden says. “There is a lot more human intervention in these landscapes and the soils than we had previously thought. Through the centuries there was a lot of intensive landscape modification going on. And the partnership with Pamela and others has brought in their expertise to understand how that human intervention has changed the development of soils over the centuries.”

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Most consequentially, the colonizing of this land required deforestation. Sergey Sedov, a professor of soil science at the Universidad Nacional Autónoma de México who was part of this research, has partnered with archeologists on ancient Maya sites for decades. He says that deforestation coupled with the heavy rainfall in this area leads to near immediate soil erosion.

The group's findings in the soil have led them to understand how the soils at sites like Budsilhá are not as natural as they may seem but have definite anthropogenic components. The results from studies of the soil profile confirm the archeologists' understanding of ancient Maya land use and how the society changed the landscape.

The soil science team, along with collaborator Saul Ascencio, sampled soils on the slopes of the archaeological site of Budsilhá. Photo by Pamela García-Ramírez.

"We found evidence of the preexisting red soils in the hills that has been eroded," Sedov explains. "Further, we found evidence that these soils were deposited in the lowlands, so [we] can trace this eroded soil material. This was difficult because the saturated environment of the lowlands transformed the redeposited soil material and erased many properties of the original soil. While not easy to recognize, we found strong evidence of some features, such as the composition of clay minerals, that tell us that these depressions contain soil eroded from the highlands."

One of the biggest surprises the researchers found was the presence of gypsum in the lowland soils, which is uncommon in humid tropical areas. Rather large crystals were found in the upper and medium soil horizons. In an area with so much precipitation, gypsum and other soluble salts would normally be washed from the soil, Sedov says.

"Yet at this site it was not only present, but we could tell the crystals were formed here in this soil recently and did not come from elsewhere," he says. "They were quite fresh.

This is still a bit of a mystery to us, a very enigmatic feature of this soil. It told us once again that the soil development in this karstic environment is very different from normal soil development in humid tropics."

One of the researchers' most surprising finds was gypsum crystals in the wetland soil, particularly in the upper and middle soil horizons. Gypsum is uncommon in humid tropical areas, so the scientists hope to further study this finding. Photo courtesy of Sergey Sedov.

Did soil degradation contribute to the Maya's decline?

How did the Maya feed their growing population in this environment and respond to their negative impacts on the landscape? The researchers point to their past work, which details a form of ancient precision agriculture that manages small areas of soil individually. In addition to altering the landscape by building channels to move water, the Maya also worked with what they had by, for example, planting crops with shallow roots in soils that were not deep enough to support anything else, and planting others, often tree crops, in deeper soils. While labor intensive, it was productive and fed their society.

> “What we detected in our research is that the soil mantle is dynamic,” Sedov says. “There have been large changes that occurred over the last millennia to this soil and these changes were partly related to the impact of Maya civilization. There was different soil when the Maya arrived there and different soil today because of the effects of their practices, particularly degradation and erosion of upland soils.”

The Maya’s degradation of soils, not just at Budsilhá but throughout the wider region, is also considered to be an important factor in the decline of the ancient Maya kingdoms, although one that rarely receives adequate acknowledgement, Sedov says. Many details remain hazy of how and why an advanced and evolved society rich in art, language, architecture, and science experienced such a dramatic population decline and political collapse between 750 and 900 CE. Many postulate it may have been partially linked to a breakdown in the food system and supply, which was already stretched thin. But inextricably linked to that food system is the soil crops are grown in.

“Many theories behind the Maya collapse do not consider soil, instead giving preference to catastrophic climatic change or the so called ‘Maya drought,’ yet what we detect in our work in these areas is the degradation of the soil mantle,” Sedov says. “And so we have asked the question, how was the soil resource used and changed at that time? In addition, does soil matter for agricultural resilience in the case of drought? We think that shallow, eroded soils with little water storage made the agrosystem more vulnerable to any drought that occurred.”

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The future of an inherited landscape

Yet the soil's story is not over. Golden notes how people are returning to the land and beginning to farm and ranch. He calls the area an inherited landscape, deeply connected to its past, partially through the soil. Working with these local experts and farmers is one of the most rewarding parts of this work, Golden says. They openly welcome the researchers and also engage in sharing their expertise and knowledge of the land.

"You often hear 'if we don't understand the past, we're doomed to repeat it,' but I think it's better to think of it as 'the past is not the past' because the past creates the landscape we live on today," Golden says. "If we want to understand what it means to live sustainably and be resilient to climate change, we have to understand how the people of the past succeeded or not and how they confronted these situations and their reactions to that transformed landscape. If we see this as just the natural environment, we are missing a big piece of what is going on."

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Soil degradation is still ongoing in this area of Mexico today. While today’s local farmers in the area have an intimate understanding of their soils, there are still ongoing practices, particularly deforestation, that degrade the soil. The researchers say the Mexican government and others are working to advance programs that support practices that maintain soil health.

“Soil is a very important resource that is often ignored, and not only is it important for agriculture, but it is the base for vegetation and fauna and everything that comes with that at any given area,” says lead author García-Ramírez. “It is a resource that is easy to degrade and ‘difficult’ to generate. The anthropogenic activities are always mostly destructive, so understanding the relationship between soils and these activities is

important. It helps to understand soil degradation and pedogenesis, and in the context of archaeological research, it could explain the limitations that some societies are subject to. Further, it can help us understand how we can solve problems we continue to face."

Studying the Budsilhá site with an interdisciplinary research team comes with unique challenges, some expected and others not. In a race against rainfall, the researchers trekked through mud and muck in the lowlands with temperatures exceeding 37 °C (100 °F). They were also often joined, sometimes chased, by cows that move across the landscape from ranches, bringing moments of levity. Also, given that gypsum is not common in tropical soils, Sedov was overjoyed about that particular discovery.

The team looks forward to continuing its research at the ancient site. García-Ramírez says the work is just beginning, and the team hopes to make a detailed soil map that accounts for human impact on the area to better understand the agricultural properties of the soils in the terraces and channels. The curious finding of gypsum also has García-Ramírez and Sedov eager to further analyze the lowland soils.

The pedological and archaeological teams survey the terraces of the Rancho Nuevo site, another ancient Maya site in southern Mexico. Photo by Pamela García-Ramírez.

Sedov adds that he is interested in trying to understand what has occurred in many of these soils since they were abandoned over a millennium ago. As the story of the soil continues to be told, he muses on what it can tell us about the time of the ancient Maya to present day.

“In many cases until recently this land went back to being covered with forest, so what happened with these artificial soils, these human-made substrates, and their natural ecosystems in the intervening 1,000 years?” he asks. “Are they rehabilitated in some way or not? They may look like their natural state at first glance, but can the soil return to its natural state after this ancient human impact, or is it forever changed?”

Dig deeper

Check out the research highlighted in this article:

García-Ramírez, P., Guillén, K., Sedov, S., Golden, C., Morell-Hart, S., Scherer, A., Pi, T., Solleiro-Rebolledo, E., Dine, H., & Rivera, Y. (2024). Soil development and ancient Maya land use in the tropical karst landscape: Case of Busiljá, Chiapas, México. *Soil Science Society of America Journal*, *88*, 1561–1582. https://doi.org/10.1002/saj2.20723
