INSTITUTE OF MAYA STUDIES
NEWSLETTER

An Affiliate of The Miami Museum of Science

Jan. 19, 2005
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VOLUME 34, ISSUE 1
January 2005
ISSN: 1524-9387

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Measuring a Maya Metropolis:

The use of remote sensing for settlement pattern research at the Classic Maya site of Chunchucmil, Yucatán, Mexico

By **David R. Hixson**,
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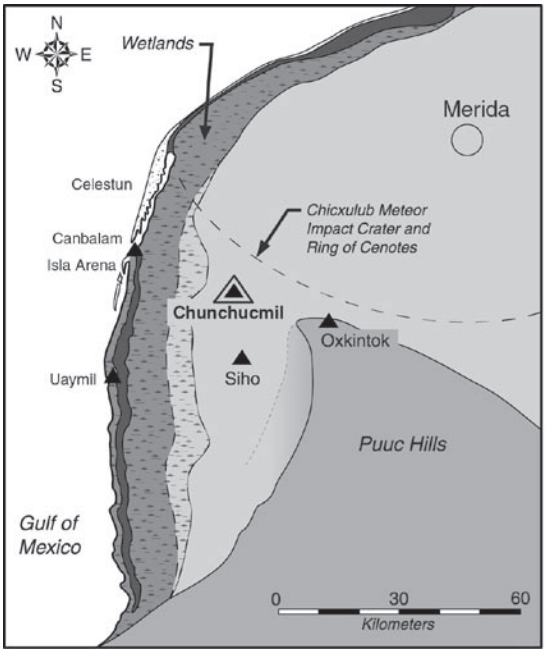
The ancient Maya of Mexico and Central America, long known for their grand achievements in art and architecture, remain shrouded in a veil of mystery surrounding exactly how they were able to sustain such large populations. While there has been localized evidence of intensive agricultural techniques (such as terracing and canalized fields) in some areas of the Maya lowlands, such practices do not appear to have been widespread (Fedick 1996; Harrison and Turner 1978; Pope and Dahlin 1989).

Researchers investigating this topic have recently turned to remote sensing techniques in order to address such issues on a regional scale. The majority of large Classic period sites, however, lie deep within the jungles of Mexico and Central America, buried beneath a canopy of dense vegetation. Efforts to pierce this canopy with remote sensing techniques have yielded mixed, though occasionally positive, results (Adams 1982; Corbley 1999; Folan, Marcus and Miller 1995; Pope and Dahlin 1989; Scarborough 1983; Sever 1998).

One large Classic period center, however, stands apart in its ecological location and surface manifestations. The Classic Maya site of Chunchucmil is located in the dry scrub-forest near the coastal savannas and seasonal wetlands of northwest Yucatán within an ecological zone described as "semi-arid" or "semi-desert" (Beach 1998; Dahlin *et al.* 2000; Vlcek *et al.* 1978; Wilson 1980). Lacking the towering canopies of tropical forest that cover much of the southern Maya lowlands, the Chunchucmil region therefore provides a potentially ideal location to test the capabilities of remote sensing for Maya archaeology.



Chunchucmil is located near the Gulf of Mexico in the northwestern quadrant of the Yucatán Peninsula.

Surface soils blanketing the area rarely exceed 0.30–1.0 meters in depth, barely enough to cover the most modest archaeological features. In fact, it is estimated that as much as 50% of the terrain surrounding Chunchucmil is composed of exposed

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Jim Reed, Editor

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Measuring a Metropolis:

By **David R. Hixson** *continued from page 1*

limestone bedrock (Beach 1998). Agriculture in this region is highly susceptible to drought conditions and wildfires, as annual rainfall totals are among the lowest of all the Maya area (Beach 1998; Wilson 1980).

Additionally, viable agricultural land is at a premium, due to the vast expanses of seasonally inundated savanna land that borders Chunchucmil to its west. These seasonal wetlands are flooded both from above (through localized rainfall) and from below (through sub-surface artesian springs fed by the Yucatán aquifer after especially heavy rains in the interior of the peninsula).

Provisions for the population

Some areas immediately west of Chunchucmil are under as much as half a meter of water during prime growing seasons and are therefore unsuitable for slash-and-burn agriculture. Yet, the paradox remains that Chunchucmil's population is currently estimated as having been one of the highest of all Classic period Maya cities (Dahlin 2000; Dahlin and Ardren 2002). How did this large city provide food for its inhabitants in a region that currently boasts one of the lowest yield potentials in southeastern Mesoamerica?

This question was first raised in 1978 (Vlcek *et al.* 1978) and is now one of the many questions being addressed by the Pakbeh Regional Economy Project, directed by Dr. Bruce Dahlin (Howard University) and Dr. Scott Hutson (UC-Santa Cruz), along with graduate students Aline Magnoni (Tulane), David Hixson (Tulane) and Dan Mazeau (SUNY-Buffalo).

This multidisciplinary project has drawn together specialists in archaeology, anthropology, geology, paleobotany and paleoclimatology. One of our research goals is the completion of a regional settlement pattern analysis based upon pedestrian surveys a well as remotely sensed data from archaeological survey information acquired from aerial and space-borne remote sensors. We hope the results will provide new insights into the diverse economic and subsistence strategies practiced by the ancient Maya.

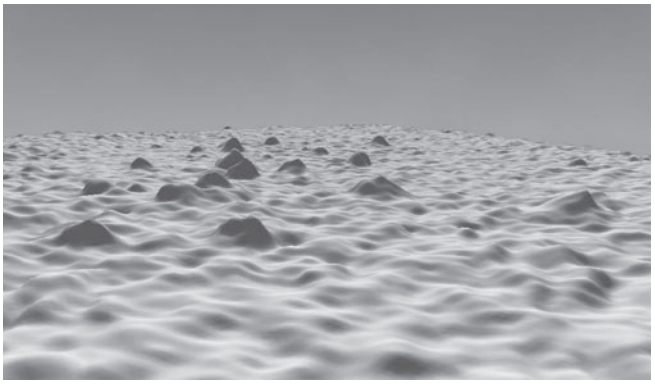
The remote sensing data currently in use by the project include satellite photos (largely from the Landsat 7 ETM+ sensor), aerial photographs, and newly acquired radar imagery. A similar array of data sources provided the necessary tools for archaeologists to uncover the exact location of the "lost" city of Wakná in Guatemala (Corbley 1999). There, archaeologists were searching for a towering pyramid in the middle of the rainforest of the Petén. In contrast, the geography and ecology of the Chunchucmil region allows us to locate archaeological sites and structures of even the most humble dimensions.

We began with the "known" (the site center on our architectural map) and proceeded to the "unknown" (the western wetlands between the site center and the Gulf of Mexico). First, by overlaying our map of Chunchucmil with the remotely sensed data, we were able to examine how ancient structures are reflected (quite literally) in the imagery. It was immediately clear that even the low-resolution Landsat data (each pixel in a Landsat scene is roughly 25 m in width) was able to detect areas with dense residential architecture.

We then looked for similar reflectance values (the "signature" indicating architecture) in areas outside of our current map, and overlaid a set of aerial photographs taken when the area had been clear-cut for growing henequen in the 1970s. Again, the satellite imagery clearly detected areas of habitation visible in the aerial photographs.

Widening our perspective

We then wanted to examine areas on the outskirts of Chunchucmil that were outside of both our map and our high resolution aerial photos, but within the field of view of the Landsat satellite. We left our laptops in the lab and used handheld GPS units to navigate to various points of interest. At every point where architecture was implied in the Landsat imagery, we found relatively dense mounded limestone architecture.



This is the first published AIRSAR image of downtown Chunchucmil, and it shows that the sensor can detect even modest pyramidal architecture beneath a thin forest canopy.

There is, however, a catch. We found that the Landsat satellite must be able to "see" the ground surface (without too much leafy vegetation or cloud cover), yet conditions are best when the soil is saturated. This is a difficult combination in the Maya area. When the rains come, vegetation sprouts and blankets the landscape, reducing the contrast between the broken limestone mounds and flat saturated soils. During the dry season, leaf-off conditions allow for better penetration to the ground surface, but the spectral contrast between limestone mounds and rocky dry ground is minimized. We are therefore fortunate to have obtained an early rainy season image with minimal vegetation and no cloud cover.

Preliminary results

The preliminary results are astounding. The ancient city of Chunchucmil may have once covered an area larger than 64 km^2. Its shape was likely amoebic, with vacant pockets within its vague boundaries. Based upon the portions that we've mapped, it was a sprawling city, with winding paths leading in and out of the site center between boundary walls of residential groups. On the outskirts, the boundary walls are placed further apart, while at the very edge of the city and beyond, the countryside residents rarely felt the need to erect walls around their homes.

Through remote sensing and ground observations, we have demonstrated what has been surmised for decades. Chunchucmil was big. But how does this help us solve the mystery of how such a large city survived in this region? *cont. on page 4*

Measuring a Metropolis:

By **David R. Hixson** *continued from page 3*

The answer may rest in our ongoing research into the seasonal wetlands west of Chunchucmil.

When we began our work, only two sites were known to exist in the seasonally inundated zone. At that point, these two sites were viewed as possible rest-stops when crossing an unpopulated swampy landscape on the way to the coast. We placed an arbitrary grid over the satellite image of the wetlands, and surveyed randomly selected locations across the landscape, so that we could document the surface characteristics of a variety of micro-ecological zones.

Inevitably, we encountered more archaeological sites. We found, when comparing their reflectance values to those of the site center of Chunchucmil, that we could detect a number of probable locations for secondary sites in the western wetlands using the satellite imagery. With GPS units again in-hand, we navigated to these locations and found evidence of habitation in every case.

Therefore, while the Pakbeh Regional Economy Project continues to examine various ways in which the sprawling city of Chunchucmil may have sustained itself in the semi-arid northern plains, including trade with the coast and specialized agricultural techniques (infield gardens), we are drawn to the possibility that the western wetlands may have been a valuable resource in the regional economy. According to our remotely sensed data, dense settlement from the city extends up to the very limit of seasonal inundation and then compact communities are found perched upon the slightest of rises further into the wetlands, while ancient field houses are found in the most isolated locations in the midst of the seasonal swamp.

Wetlands use elsewhere

The larger implications of this archaeological and remote sensing survey are similar to recent findings in other parts of the Maya world. The ancient Maya were innovators, adapting their subsistence strategies to unique environments across the lowlands. For example, the ecology of Chunchucmil's western wetlands is most similar to the Yalahau fracture zone of Quintana Roo,

Survey crew stands upon the remains of an ancient platform at a site within the seasonal wetlands discovered using satellite imagery.

where Dr. Scott Fedick (Fedick *et al.* 2000) has found rock alignments that may have functioned as water and erosion management features, to create agricultural land out of the seasonally inundated *bajos*. We have found nearly identical rock alignments in the seasonal wetlands west of Chunchucmil, although we have not yet demonstrated that they could have served the same function.

In addition to the data from Chunchucmil and the Yalahau fracture zone, recent archaeological and remote sensing projects at sites like Yaxha, and other areas of the Petén, have shown that Preclassic and Classic period communities of the southern lowlands may have been similarly established in seasonal wetlands (Gidwitz 2002).

Conclusions

A growing picture is forming that the ancient Maya did not likely view the seasonal *bajos* of the northern or southern lowlands as formidable obstacles to settlement, as we do today, but instead as rich, replenishing resource zones for an increasingly dense population. Studies such as these will increasingly illuminate the diversity of adaptations the ancient Maya employed to sustain their populations and polities, and must eventually address what role these adaptations played in their collapse.[1]

[1] The results discussed in this report are preliminary, and will continue to be tested in upcoming field seasons. Our newest acquisition is a synthetic aperture radar image by NASA-JPL's AIRSAR platform. This platform provides a high-resolution digital elevation model (topographic map) of the ground surface. We have only begun to work with this data, but as you can see in the image on page 3, the results promise to be impressive.

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