Climate linkages between fire, population, and agriculture in the Maya lowlands

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Understanding past societal responses to climate change requires proxy indicators of human population, climate and land-use change. We apply a range of proxies to a lake sediment core from Laguna Itzan, a cenote adjacent to the ancient Maya population centre of Itzan, in order to examine the response of the lowland Maya to climatic and environmental change, which remains poorly understood. By combining molecular proxies for population (faecal stanols) and biomass burning (polycyclic aromatic hydrocarbons or PAHs) with isotopic analyses of plant wax n-alkanes as proxies for vegetation change ($\delta^{13}C$) and palaeohydrology (δ^2H), we show the complex interplay of environmental and societal changes over 3300 years.

Leaf wax hydrogen isotope records show that drought between ca. 750 and 900 CE, thought to have been responsible for societal collapse or transformation across the Maya lowlands, is not expressed in the catchment of Itzan. This likely reflects spatial variability in the magnitude and timing of climate change. Population decline at Itzan may have been a result of instability caused by drought from other areas as a result of military incursions or through climate migration/an influx of climate refugees, pressures between neighbouring polities, or disruptions to trade networks or regional food production systems.

Leaf wax carbon isotope ratios indicate brief intervals of intensive maize agriculture, generally associated with wet periods, but this expansion of maize agriculture is not long lasting, and often returns to baseline levels of C_4 plant abundance. In addition to the earlier presence of humans at this site than currently indicated in the Itzan archaeological record based on the abundance of faecal stanols, we infer cultivation of maize around 4000 year BP, and potentially earlier. Further, analysis of the distribution of polycyclic aromatic hydrocarbons suggests that fire in the catchment transitioned over the past 3500 years from intense fires associated with slash and burn, or swidden, agriculture to a less intense fire regime following initial land clearance.

Our data indicate that human population dynamics and patterns of land clearance for agriculture varied substantially throughout the sediment core record, and that palaeoclimatic change may have driven these patterns.