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A late Holocene paleoenvironmental reconstruction from Agua Caliente, southern Belize, linked to regional climate variability and cultural change at the Maya polity of Uxbenká

Megan K. Walsh [a,*], Keith M. Prufer [b], Brendan J. Culleton [c], Douglas J. Kennett [c]

[a] Dept. of Geography, Central Washington University, Ellensburg, WA 98926, USA
[b] Dept. of Anthropology, New Mexico State University, Albuquerque, NM 87131, USA
[c] Dept. of Anthropology, Pennsylvania State University, University Park, PA 16802, USA

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ABSTRACT

We report high-resolution macroscopic charcoal, pollen and sedimentological data for Agua Caliente, a freshwater lagoon located in southern Belize, and infer a late Holocene record of human land-use/climate interactions for the nearby prehistoric Maya center of Uxbenká. Land-use activities spanning the initial clearance of forests for agriculture through the drought-linked Maya collapse and continuing into the historic recolonization of the region are all reflected in the record. Human land alteration in association with swidden agriculture is evident early in the record during the Middle Preclassic starting ca. 2600 cal yr BP. Fire slowly tapered off during the Late and Terminal Classic, consistent with the gradual political demise and depopulation of the Uxbenká polity sometime between ca. 1150 and 950 cal yr BP, during a period of multiple droughts evident in a nearby speleothem record. Fire activity was at its lowest during the Maya Postclassic ca. 950–430 cal yr BP, but rose consistent with increasing recolonization of the region between ca. 430 cal yr BP and present. These data suggest that this environmental record provides both a proxy for 2800 years of cultural change, including colonization, growth, decline, and reorganization of regional populations, and an independent confirmation of recent paleoclimate reconstructions from the same region.

Introduction

Understanding the relationship between past climate variability, landscape change, and human land-use patterns has become an increasingly important goal of paleoecological research (Dearing et al., 2006). This is especially true in the Maya region of Mesoamerica where many researchers have argued that drought-induced reductions in agricultural productivity played a major role in the disintegration of Maya political systems at the end of the Classic Period (Hodell et al., 1995; Haug et al., 2003; Webster et al., 2007; Kennett et al., 2012). Paleoecological records from regions with large populations prior to Euro-American settlement, specifically those based on palynology, are not always useful for reconstructing past climatic variability. In many instances human influences on vegetation tend to blur or even overrule the effects of climate and make it difficult to interpret pollen records (Horn and Sanford, 1992; Hodell et al., 1995; Rosenmeier et al., 2002; Santos, 2004; Anselmetti et al., 2007). On the other hand, pollen analysis has proven useful in helping to decipher the link between past climatic variability and the way in which humans respond to changing environmental conditions (Brenner et al., 2002; Kennett et al., 2010; McNeil et al., 2010; Mueller et al., 2010). Often pollen records are most useful for illustrating the timing and direction of human landscape alteration as a result of rising/falling population numbers and changes in agricultural strategies (Rue, 1987; Goman and Byrne, 1998; Pope et al., 2001; Leyden, 2002; Neff et al., 2006; Park et al., 2010).

Perhaps even more helpful for understanding past human–environment interactions are records of fire activity, especially those from regions where natural ignitions are limited. Throughout much of the tropics humans are the primary source of fire and likely have been for many thousands of years (Billings and Schmidtke, 2002; Anchukaitis and Horn, 2005). This is especially true in tropical lowland broadleaf forests where lightning strikes are rare, evidenced by the fact that most species of trees are not adapted to fire and have likely evolved in the absence of it (Budowski, 1966; Meerman and Sabido, 2001). Historically, human ignitions are primarily the result of swidden (slash-and-burn) agriculture, which is used throughout these forests today as well as many other parts of Mesoamerica to clear tracts of land in order to plant crops such as maize, rice, beans, and cassava (Montagnini and Mendelsohn, 1997; Harvey et al., 2005). As a result, charcoal records from areas where swidden agriculture has traditionally been employed may prove more reliable than pollen records in terms of identifying the timing and nature of expanding agricultural systems, particularly when climate drying can be ruled out with independent records.

* Corresponding author at: Department of Geography, Central Washington University, 400 E. University Way, Ellensburg, WA 98926, USA. Fax: +1 509 963 1047.
E-mail address: walshme@cwu.edu (M.K. Walsh).

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Studies from Central and Mesoamerica that use both pollen and charcoal as an indicator of past anthropogenic activity are limited (Nevle and Bird, 2008), and only a few come from within the Maya region, including the Petén of Guatemala (Vaughan et al., 1985; Dunning et al., 1998; Johnston et al., 2001; Hillesheim et al., 2005; Correa-Metrio et al., 2012; Wahl et al., 2013), the southern Maya area of Guatemala and El Salvador (Tsukada and Deevey, 1967), Pacific coastal Guatemala and Mexico (Neff et al., 2006; Kennett et al., 2010), western El Salvador (Dull, 2007), the Yucatan peninsula of Mexico (Leyden et al., 1994; Leyden, 2002), and the Copan Valley of Honduras (Rue et al., 2002). Only two such studies have been carried out in Belize (Pohl et al., 1996; Rushton et al., 2013), although several pollen records exist from the northern and central portion of the country (Hansen, 1990; Jones, 1994; Wooller et al., 2007; Monacci et al., 2009, 2011). However, out of all of these studies only Wahl et al. (2013) examined macroscopic charcoal (as opposed to pollen-slide charcoal), which provides a continuous reconstruction of local fire activity (Whitlock and Larsen, 2001). The lack of previous paleoecological work in southern Belize is largely due to the limited number of suitable study sites (e.g., lakes); however, several freshwater lagoons do exist and were targeted for this study.

The goal of this study was to reconstruct a late Holocene record of environmental change from southern Belize using multiple incremental proxies within lacustrine sediments recovered from the Agua Caliente lagoon (Toledo District). Our specific objectives were to: 1) reconstruct the fire and vegetation history of the Agua Caliente watershed using macroscopic charcoal, pollen, and sedimentological analyses, and 2) to compare these results with local climatic and archeological records in order to determine linkages between climate variability, environmental change, and human land-use in the region. For the local climate record, we used a recently published 2000-year long speleothem record from Yok Balum Cave (Kennett et al., 2012), which is located approximately 11 km WNW of our study site. The archeological record comes from Uxbenká, which is the ancient Maya settlement geographically closest to our study site and the primary Classic Maya center in the Agua Caliente watershed (Prufer et al., 2011; Culleton, 2012). Ideally, we hope that this reconstruction can contribute to our collective understanding of human-caused landscape alteration within the vicinity of the ancient Maya center of Uxbenká.

Study area

Background

The Toledo District of southern Belize extends from the eastern branch of the Monkey River in the north to the Sarstoon River in the south, which forms the border with Guatemala, and west to Guatemala along 88°12.500′W longitude (Fig. 1). Within the district the geography varies widely. In the west, the Maya Mountains dominate and extend more than 1000 m above sea level (asl). Composed primarily of Cretaceous limestones (Keller et al., 2003), the Maya Mountains are dominated by lush submontane broadleaf forest (Meerman and Sabido, 2001). The eastern foothills of the Maya Mountains drop to approximately 500 m asl and are underlain primarily by Cretaceous limestones and the Toledo Beds, a series of interbedded Tertiary marine sediments (Keller et al., 2003). The area's vegetation is characterized by lowland broadleaf forest and shrubland (Meerman and Sabido, 2001), although much of it has been altered by agricultural practices, both ancient and modern (Culleton, 2012). A relatively flat coastal plain extends from the base of the Maya Mountain foothills east to the Atlantic Ocean. This plain is underlain by Pleistocene fluvial sediments originating from the Maya Mountains and surrounding foothills (Bateson and Hall, 1977). Lowland broadleaf forest and shrubland also dominate this region, except in a few areas where lowland pine forest and savanna exist (Meerman and Sabido, 2001). This region has recently been severely altered by more intensive forms of maize and rice

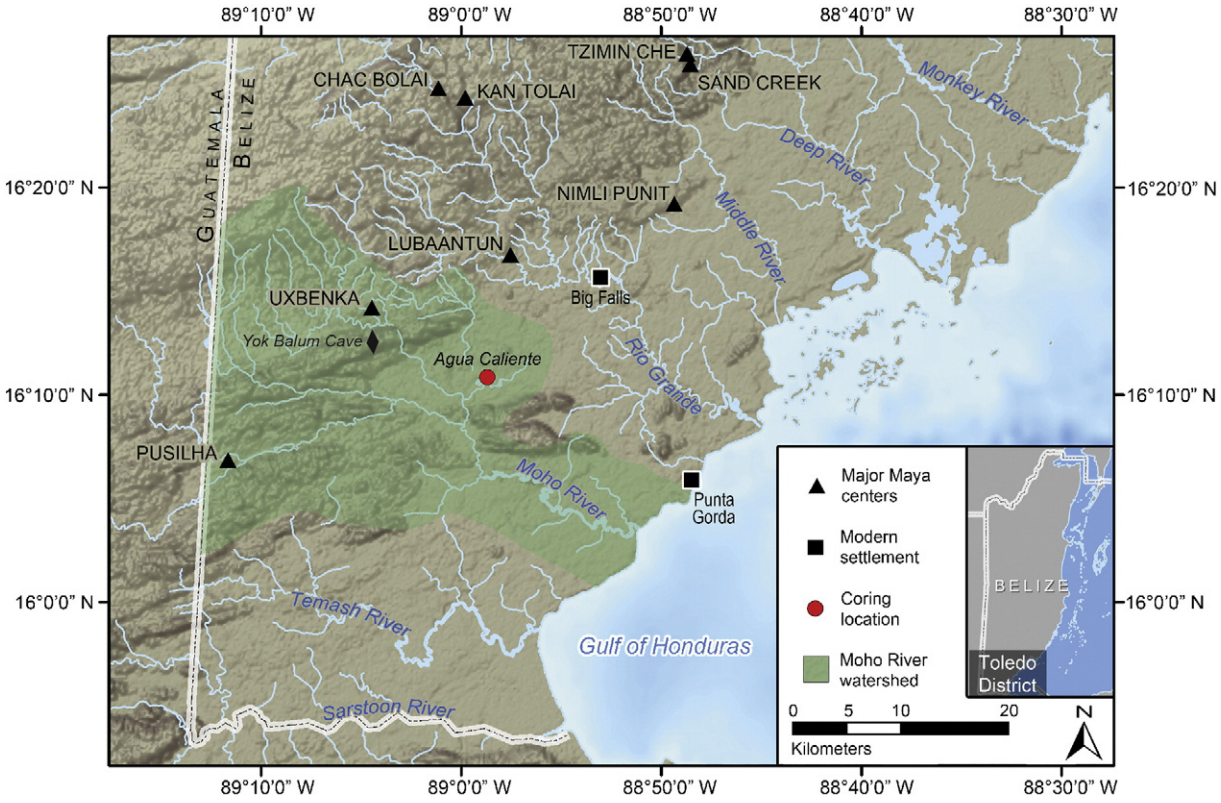

Figure 1. Map of Toledo District (southern Belize) and adjacent areas showing the coring location (16°10.698′N, 88°58.048′W; elevation ~13 m asl), Yok Balum cave location, Moho River watershed, and major Maya centers.
Figure credit: T. Harper.