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Alluvial plain dynamics and human occupation in SW Amazonia during the Holocene: A paleosol-based reconstruction

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ABSTRACT

The present study reconstructs Holocene fluvial dynamics in the southern Amazonian foreland basin through the analysis of 36 stratigraphic profiles taken along a 300 km long transect across the Llanos de Moxos (LM), in the Bolivian Amazon. Based on 50 radiocarbon ages from paleosols intercalated with fluvial sediments, the most important changes in floodplain dynamics on a millennial scale are reconstructed and the links between pre-Columbian cultural processes and environmental change in the region explored. Results show that the frequency of river avulsions and crevasses, as inferred from the number and age of the cored paleosols, is stable from 8k cal. yrs BP to 4k cal. yrs BP and increases significantly from 4k to 2k cal. yrs BP, following the strengthening of el Niño/la Niña cycle and an increase in average precipitation. Fluvial activity then decreases and reaches its minimum after 2k cal BP. A comparison between the stratigraphic record and the archaeological record shows a match between periods of landscape stability in SW Amazonia (low river activity) and periods of pre-Columbian human occupation. The first Amazonians lived in the LM until 4k yrs. BP, when an abrupt increase in the frequency of river avulsions and crevasses forced the abandonment of the region. After two thousand years of archaeological hiatus, which matches the period of highest river activity in the region, agriculturists reoccupied the Bolivian Amazon.

1. Introduction

The Llanos de Moxos (LM), an extensive savannah that covers most of the Bolivian Amazon, covers an important part of the South American wetlands and provides valuable ecological services (Junk, 2013; Melack and Hess, 2011). It is a fragile hydrological system, increasingly threatened by global warming and human activity (Junk, 2013; Müller et al., 2011; Pacheco, 2006). The landscape of the LM is constantly being reshaped by the region's very active rivers, with important implications for local livelihoods and biodiversity (Lombardo, 2016, 2017). The LM is home to a rich biodiversity, including several endemic species (Langstroth, 2011), and it is the area in Amazonia with the highest cultural and genetic diversity among its modern indigenous populations (Bert et al., 2004; Crevels and van der Voort, 2008). The LM is also known for its archaeological heritage, amongst the most important in Amazonia (Erickson and Walker, 2009; Lombardo et al., 2013a; Lombardo and Prümers, 2010; Prümers and Jaimes Betancourt, 2014). Despite the LM's ecological and cultural significance, very little is known about how the landscape here has evolved during the Holocene. Reconstructing the evolution of the landscape is key in order to understand the links between pre-Columbian cultural processes and environmental change in the region; the origin of its modern landscape and biodiversity; and the potential changes they could undergo due to global warming and other anthropogenic pressures. The extent to which changes in the natural environment have influenced pre-Columbian cultural trajectories, and vice versa, is a controversial and much debated topic amongst Amazonian archaeologists and paleoecologists (Bush and Silman, 2007; Erickson, 2008; Lombardo et al., 2015; Meggers, 1971, 2007; Sponsel, 1986). While some scholars have downplayed the importance of the environment in shaping pre-Columbian cultural trajectories in the LM (Erickson, 2008), others have argued that climate change had a direct impact on the archaeological record because of the changes it induced on vegetation (Carson et al., 2014; Iriarte et al., 2017) or the disruption brought about by

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changes in the ENSO cycle (Lombardo et al., 2011a; Meggers, 2007; Rodrigues et al., 2016). It has also been argued that, in Amazonia, river activity has had an important impact on the evolution of the landscape (Kalliola et al., 1992; Lombardo, 2016; Salo et al., 1986) and local livelihoods (Lathrap, 1968; Pärssinen et al., 1996). Rivers have a paramount role in controlling many fundamental aspects of Amazonian ecology (Ayres and Clutton-Brock, 1992; Ferreira and Stohlgren, 1999; Remsen and Parker, 1983). Rivers are also of great importance for local populations, providing aquatic resources, fertile land for agriculture and waterways for transportation (Junk, 1984; Marengo, 2008; McGrath et al., 1993). Archeological research has shown that, in Amazonia, rivers greatly influenced pre-historic settlement patterns too (Denevan, 1996; McMichael et al., 2014; Neves, 2008).

However, with a few exceptions (Lathrap, 1968; Lombardo et al., 2012; Neves, 2008; Pärssinen et al., 1996), the relationship between changes in river dynamics and pre-Columbian settlement patters in Amazonia has been largely overlooked in the literature.

Given the LM's highly active rivers (Aalto et al., 2002, 2003; Gautier et al., 2010; Hanagarth, 1993; Lombardo, 2014, 2016, 2017; Plotzki et al., 2015; Schwendel et al., 2015) and the importance of the region's archaeological record (Erickson, 2000; Jaimes Betancourt, 2013; Lombardo and Prümers, 2010; Lombardo et al., 2013b; Prümers and Jaimes Betancourt, 2014; Rodrigues et al., 2015, 2016; Walker, 2004), the LM offers an excellent study area to investigate the relationships between river dynamics, landscape evolution and human histories.

Recent archaeological research shows that the eastern LM were inhabited since the early Holocene until about 4k cal yrs BP (Lombardo et al., 2013b). Beside hunting and gathering, these first inhabitants cultivated maize (Brugger et al., 2016) and even domesticated rice (Hilbert et al., 2017). Abundant archaeological evidence suggests that complex societies repopulated this area, known as the Monumental Mounds Region (MMR) (Lombardo et al., 2013a), in 2k cal yrs BP until the arrival of the Spaniards (Carson et al., 2014; Erickson, 2000; Lombardo and Prümers, 2010; Prümers and Jaimes Betancourt, 2014; Whitney et al., 2014). Between these two periods of occupation, there is an archaeological hiatus of about 2000 years. It has been suggested that this hiatus was related to a period of increased fluvial activity during which Río Grande deposited a sedimentary lobe that covered early and mid-Holocene archaeological sites (Lombardo et al., 2013b) and created the conditions for the later development of the Monumental Mounds culture (Lombardo et al., 2013a, 2015, 2012). However, it is as yet unclear whether the increased activity of Río Grande was an isolated phenomenon, due to intrabasinal processes, with localized effects; or if it was part of a larger scale change in river behavior that affected the whole of the Bolivian Amazon, and, if so, what triggered this large-scale change.

In this study we aim to identify which parts of the early Holocene landscape were covered with mid or late Holocene alluvia. We discuss the implications of our findings in terms of 1) the evolution of the landscape in the Bolivian Amazon and the possible triggers of change in river activity (to what extent crevasse splays and river

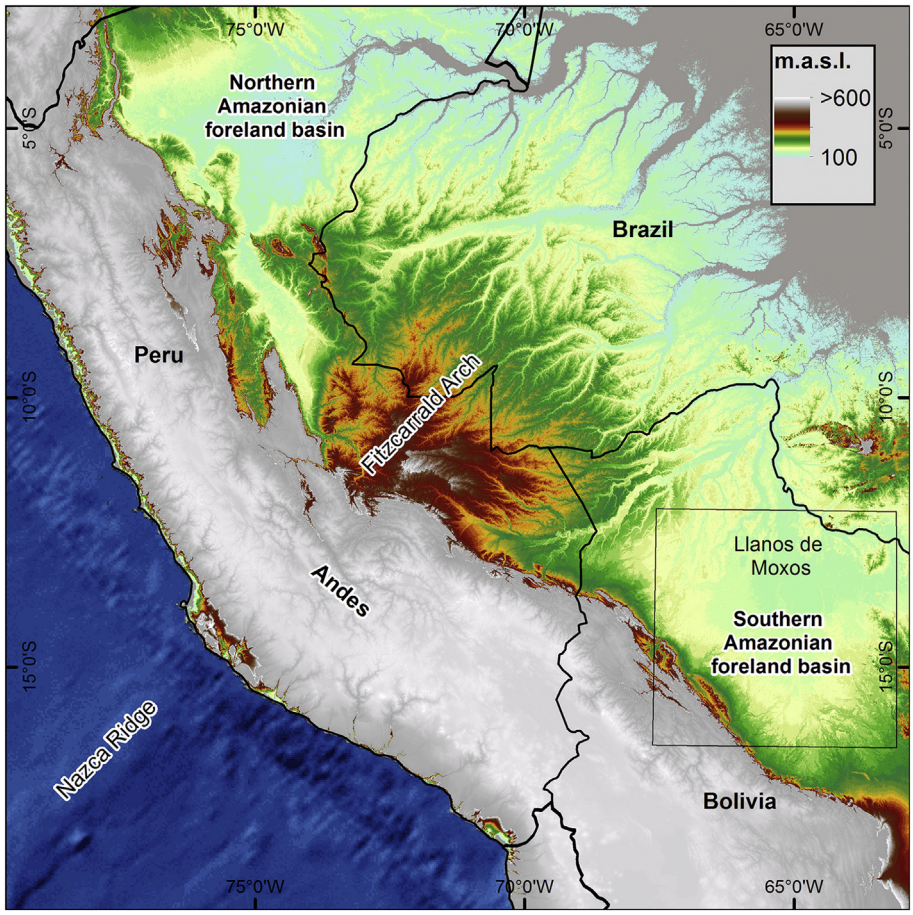

Fig. 1. Topographic map of western South America with some important geological features. The south-eastern part of the Fitzcarrald Arch constitutes the LM's north-western border, which, together with the Brazilian Shield, to the north-east of the LM, forms a continuous barrier which impedes the drainage of the LM (see Lombardo, 2014). The box identifies the study area, shown in Fig. 2A.