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Pollen-based differentiation of Amazonian rainforest communities and implications for lowland palaeoecology in tropical South America

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ABSTRACT

An ongoing controversy in Amazonian palaeoecology is the manner in which Amazonian rainforest communities have responded to environmental change over the last glacial–interglacial cycle. Much of this controversy results from an inability to identify the floristic heterogeneity exhibited by rainforest communities within fossil pollen records. We apply multivariate (Principal Components Analysis) and classification (Unweighted Pair Group with Arithmetic Mean Agglomerative Classification) techniques to floral-biometric, modern pollen trap and lake sediment pollen data situated within different rainforest communities in the tropical lowlands of Amazonian Bolivia. Modern pollen rain analyses from artificial pollen traps show that evergreen *terra firme* (well-drained), evergreen *terra firme* liana, evergreen seasonally inundated, and evergreen riparian rainforests may be readily differentiated, floristically and palynologically. Analogue matching techniques, based on Euclidean distance measures, are employed to compare these pollen signatures with surface sediment pollen assemblages from five lakes: Laguna Bella Vista, Laguna Chaplin, and Laguna Huachi situated within the Madeira-Tapajós moist forest ecoregion, and Laguna Isirere and Laguna Loma Suarez, which are situated within forest patches in the Beni savanna ecoregion. The same numerical techniques are used to compare rainforest pollen trap signatures with the fossil pollen record of Laguna Chaplin.
Pollen assemblages of pollen traps situated within riparian forest communities are most similar to surface sediment samples from Lagunas Bella Vista and Chaplin. Pollen derived from *terra firme* forests also comprises a significant proportion of these assemblages. Together, these pollen spectra successfully identify riparian and *terra firme* rainforest communities surrounding the two lakes today. Close similarity between *terra firme* liana pollen trap assemblages and surface samples obtained from Laguna Huachi, a lake surrounded by relatively undisturbed liana forest, suggests liana forest pollen rain may also be identified within lake sediment records. Pollen spectra obtained from surface sediment samples from lakes situated within gallery forests of the Beni savanna ecoregion are significantly different to those obtained from the Madeira-Tapajós ecoregion, reflecting their different floristic compositions. By applying our findings to the previously published Laguna Chaplin Quaternary pollen record, we show that differentiation between riparian and *terra firme* rainforest pollen assemblages can lead to more robust and detailed palaeovegetation reconstructions than has hitherto been possible.

1. Introduction

Amazonian rainforests are complex ecosystems that are heterogeneous across the Amazon Basin in terms of their structure and floristic composition as well as their carbon storage capacity (Tian et al., 1998; ter Steege et al., 2006). They are among the most biodiverse ecosystems on earth (Morley, 2000; Groombridge and Jenkins, 2003) and are globally important in terms of carbon and hydrological cycling. Diversity between rainforest habitats (beta-diversity) is very high resulting in a rich mosaic of communities that reflect underlying physical controls such as edaphic conditions, successional stage, and hydroperiod (Nebel et al., 2001a). *Terra firme* (non-flooded) evergreen rainforests are the most species-rich (Duivenvoorden, 1996; Salvias Database, 2007) and comprise moist evergreen forests as well as liana forests. Seasonally inundated forests are periodically flooded by blackwater (igapó forests) or whitewater (várzea forests) rivers that drain the Precambrian Shield and the Andes, respectively (Sioli, 1968; Prance, 1979, 1989). Seasonally inundated and riparian forest communities are notably less species-

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rich, and smaller in stature, than *terra firme* forests (e.g. Duivenvoorden, 1996; Nebel et al., 2001a) as a result of frequent disturbance caused by hydrological changes of meandering rivers and because many constituent species are unable to tolerate flooded conditions.

The floristic heterogeneity exhibited by Neotropical lowland rainforests across the Amazon Basin has not been well-recognised within fossil pollen assemblages (Van der Hammen and Absy, 1994; Colinvaux et al., 1996; Haberle and Maslin, 1999; Mayle et al., 2000;

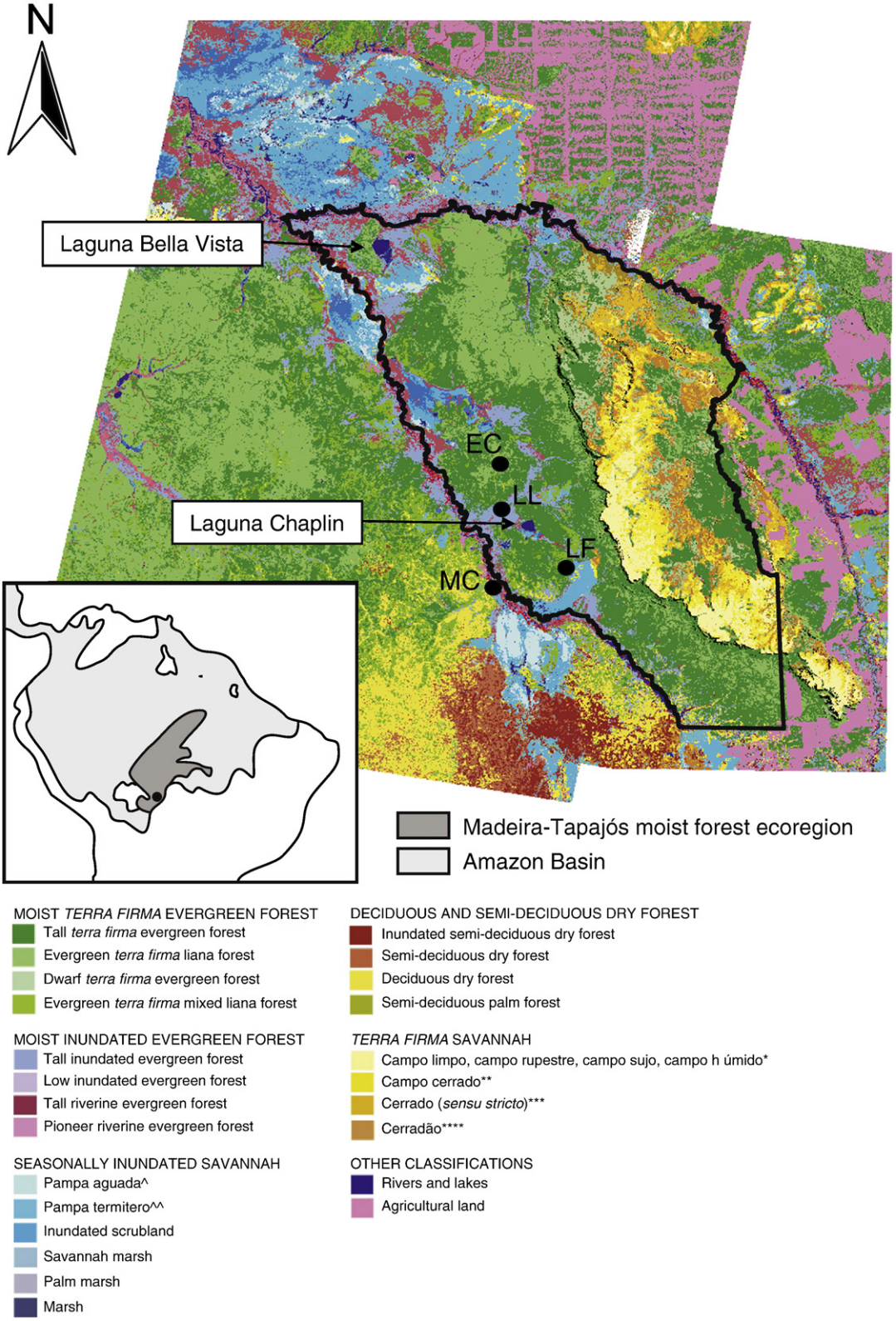

Fig. 1. Location map (inset) and distribution of plant communities within Noel Kempff Mercado National Park (NKMNP), northeast Bolivia. Study sites are marked by the letters LF (Los Fierros), LL (Las Londras), EC (El Chore) and MC (Monte Cristo). Modified from Killeen and Schulenberg (1998).