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Alluvial terrace preservation in the Wet Tropics, northeast Queensland, Australia

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ABSTRACT

Alluvial terraces provide a record of aggradation and incision and are studied to understand river response to changes in climate, tectonic activity, sea level, and factors internal to the river system. Terraces form in all climatic regions and in a range of geomorphic settings; however, relatively few studies have been undertaken in tectonically stable settings in the tropics. The preservation of alluvial terraces in a valley is driven by lateral channel adjustments, vertical incision, aggradation, and channel stability, processes that can be further understood through examining catchment force–resistance frameworks. This study maps and classifies terraces using soil type, surface elevation, sedimentology, and optically stimulated luminescence dating across five tropical catchments in northeast Queensland, Australia. This allowed for the identification of two terraces across the study catchments (T1, T2). The T1 terrace was abandoned ~13.9 ka with its subsequent removal occurring until ~7.4 ka. Abandonment of the T2 terrace occurred ~4.9 ka with removal occurring until ~1.2 ka. Differences in the spatial preservation of these terraces were described using an index of terrace preservation (*TPI*). Assessments of terrace remnant configuration highlighted three main types of terraces: paired, unpaired, and disconnected, indicating the importance of different processes driving preservation. Regional-scale variability in *TPI* was not strongly correlated with catchment-scale surrogate variables for drivers of terrace erosion and resistance. However, catchment-specific relationships between *TPI* and erosion–resistance variables were evident and are used here to explain the dominant processes driving preservation in these tropical settings. This study provides an important insight into terrace preservation in the tectonically stable, humid tropics and provides a framework for future research linking the timing of fluvial response to palaeoclimate change.

1. Introduction

Alluvial terraces are topographic landforms that result from floodplain abandonment when a river incises, therefore providing records of river aggradation and incision (Leopold et al., 1964). Terraces have formed in all global regions and are commonly studied to understand how rivers have responded to the combined effects of changes in external controls including climate, tectonics, and sea level (Merritts et al., 1994; Macklin et al., 2002; Bridgland and Westaway, 2008) and in internal controls, such as catchment morphology (Coulthard et al., 2005) and reach-specific conditions (Houben, 2003).

Terraces are generally identified in the landscape using a range of techniques including soil properties (see reviews in Birkeland, 1990; Huggett, 1998), topographic data (Pazzaglia and Gardner, 1993; Jones et al., 2007), aerial and satellite imagery (Litchfield and Berryman, 2005), with correlations further aided by sedimentology and dating (Stokes et al., 2012). The use of soil characteristics to classify terraces has made an important contribution to understanding the broad temporal patterns of terrace abandonment (Bull, 1990). Following channel incision, time-dependant weathering processes lead to the development of pedogenic constituents such as clay and iron minerals, and thus soil characteristics are useful for broadly differentiating the ages of terraces (Walker, 1962; Harden and Taylor, 1983; Tsai et al., 2007). In this way, the degree of soil development can help overcome issues associated with terraces in areas of subdued topographic relief where differences in surface elevations can be unclear (Warner, 1972; Cohen and Nanson, 2008).

The identification of terraces has predominantly been for the purposes of studying valley aggradation phases (i.e., terrace production), with much less attention directed toward the erosional processes that influence terrace preservation (Lewin and Macklin, 2003). Terrace preservation, which is represented by the remaining terrace as a proportion of the valley floor, reflects changes in the processes of channel incision, lateral removal, channel aggradation, and channel planform stability (Colman, 1983; Lewin and Macklin, 2003). These factors are, in turn, influenced by catchment characteristics such as contributing area (e.g., Lewin and Gibbard, 2010), valley width (e.g., Richardson et al.,

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2013), stream power (e.g., Fryirs and Brierley, 2010), and bedrock resistance (e.g., Reneau, 2000).

The factors that influence terrace preservation can be represented using the concept of force and resistance (Bull, 1979). Using this concept, fluvial response (i.e., terrace removal) can be considered to reflect the balance between driving factors that promote their erosion (e.g., stream power) or resistance (e.g., boundary material resistance). While Bull (1979) suggested the use of the specific variables of stream power to represent force and critical power to represent the resistance, a broader, catchment-scale focus may encompass other factors such as catchment area, drainage density, slope, lithology, stream power, valley width, or alluvial material properties that are relevant to processes operating over timescales of terrace evolution.

The main aim of this paper is a spatial classification of terraces across five catchments in the Wet Tropics region of northeast Australia for the purposes of examining terrace preservation and catchment factors associated with their removal. In this paper we undertake desktop mapping of terraces based on terrain, elevation, and soil type and validation using ground truthing and independent chronostratographic data. We assess catchment terrace preservation using metrics for spatial preservation and remnant configuration. We also investigate the relationship between terrace preservation and a range of catchment variables selected to represent drivers of terrace erosion and resistance (i.e., the force–resistance framework). Collectively, these analyses are used to present a conceptual model to explain the dominant terrace types and the processes driving their preservation in the Wet Tropics. This study provides

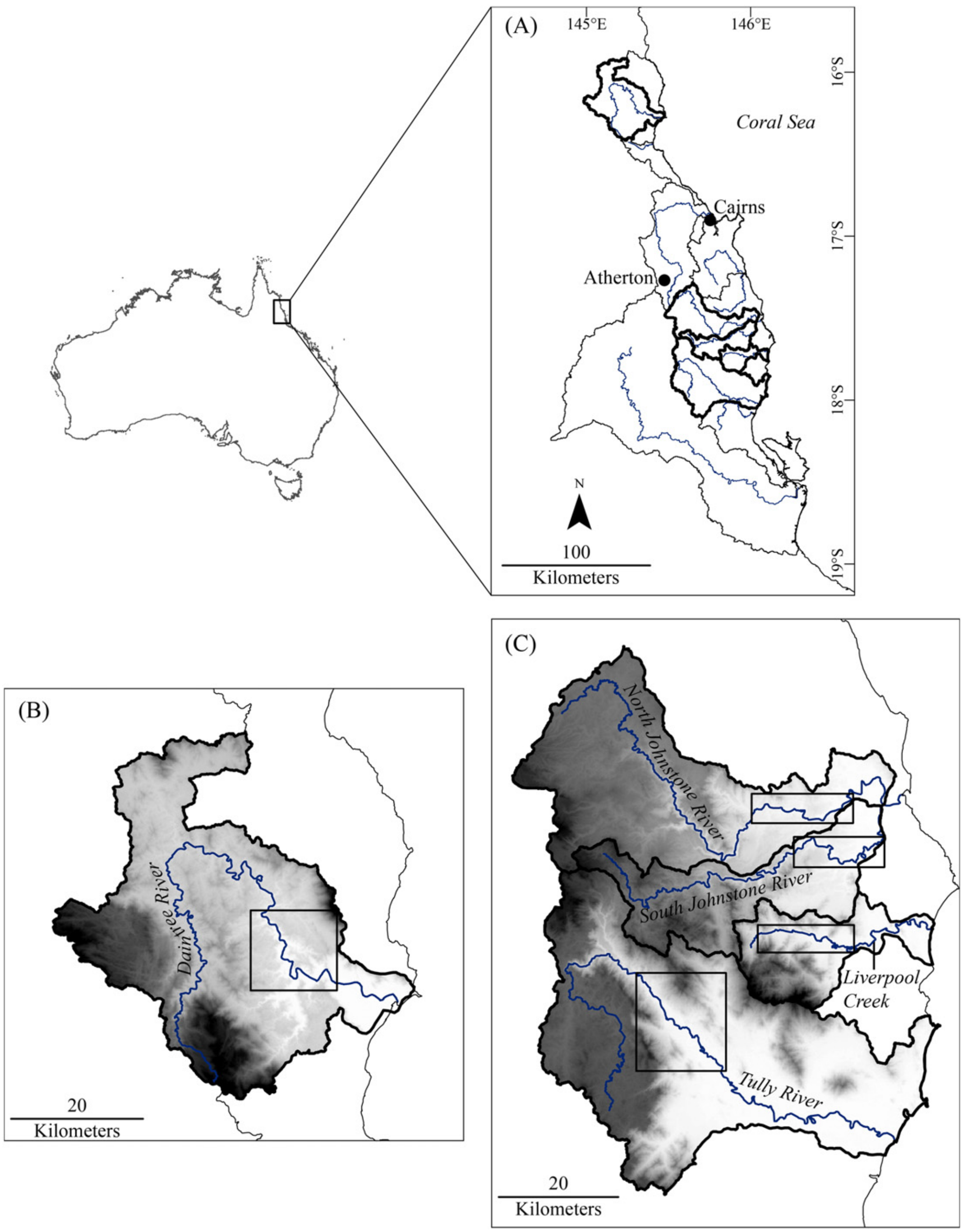

Fig. 1. Location map of (A) Wet Tropics region in northeast Australia and selected study catchments of (B) the Daintree River and (C) the North Johnstone River, South Johnstone River, Liverpool Creek, and Tully River. The inset boxes highlight the focus study reaches in each catchment.