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Holocene river dynamics in Northland, New Zealand: The influence of valley floor confinement on floodplain development

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ABSTRACT

Valley floor mapping, sedimentology, and ^{14}C-dating have been used to reconstruct the fluvial history at eight floodplain sites spread throughout Northland, a region removed from the main areas of tectonic and volcanic activity in New Zealand. We present a probability-based record of Holocene river behaviour for Northland using ^{14}C-dated Holocene fluvial deposits and compare this with independent palaeoclimate proxy records from the North Island. Holocene floodplain evolution and fluvial behaviour have been conditioned by the degree of valley-floor confinement. In the most and least confined valley settings, Holocene floodplain evolution has involved the development of a single floodplain surface. At partly confined sites, the river terrace and floodplain geomorphology are more complex. Region-wide progressive floodplain alluviation through the mid to late Holocene and a period of increased river activity between 3500 and 2800 cal. YBP in response to climatically driven increases in sediment supply was followed by a period of valley floor incision and terrace formation beginning after 1900 cal. YBP. In partly confined valley settings, this was followed by the aggradation of a lower Holocene floodplain surface, with rapid rates of vertical accretion in response to post-settlement catchment disturbance. The results of this study indicate that valley floor confinement has played a major role in controlling Northland Holocene river floodplain development, producing a continuum of floodplain and river terrace landforms in response to climatically and anthropogenically driven variations in sediment flux.

1. Introduction

With increased hydroclimate variability predicted for the future (IPCC, 2007), developing a better understanding of long-term valley floor evolution and river behaviour will be vital for determining the impacts of future environmental change on river systems. Studies examining alluvial sequences have been successful in identifying the sensitivity of fluvial systems to environmental perturbation, and those taking a basinwide (Macklin et al., 1992, 2000) or regional (Cohen and Nanson, 2007; Jones et al., 2010) approach have been able to elucidate the primary controls on Holocene-scale fluvial landform development. The key geomorphic drivers of river behaviour include external factors such as land use, climate, and tectonics as well as intrinsic threshold controls operating within the boundary conditions imposed by geology (Cohen and Nanson, 2008; Brierley, 2010). Much of the late twentieth century research from the Northern Hemisphere examining river response to Holocene environmental change has focused on the role of climate and anthropogenic impacts in driving change (Starkel, 1983; Knox, 1993; Macklin and Lewin, 1993; Rumsby and Macklin, 1996).

More recent research has emphasised the role of short-term climate change as a major control of Holocene river behaviour, with sedimentary records demonstrating that phases of river activity and increased flooding have occurred in response to centennial-scale climatic fluctuations (Macklin et al., 2006; Starkel et al., 2006; Thorndycraft and Benito, 2006; Hoffmann et al., 2008) and have been linked to hydroclimatic changes associated with shifts in atmospheric circulation patterns (Knox, 2000; Harden et al., 2010; Macklin et al., 2010; Richardson et al., 2013). However these records also show that more recent episodes of alluviation are related to anthropogenic impacts associated with historical agricultural expansion and catchment land-use changes (Starkel et al., 2006; Hoffmann et al., 2008; Macklin et al., 2010; Foulds et al., 2013; Richardson et al., 2013).

In New Zealand, emphasis has been strong on climate as the dominant forcing mechanism of change in Holocene river systems (e.g., Grant, 1985; Vella et al., 1988; Marden and Neall, 1990; Berryman et al., 2000). Evidence preserved in alluvial terrace sequences from North Island catchments suggests that the predominant response to climate amelioration during the Holocene was degradational, with sensitivity exhibited in association with more subtle climate shifts (Clement and Fuller, 2007). However, New Zealand's active tectonic setting means that tectonics (e.g., Berryman et al., 2000, 2010; Litchfield

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and Berryman, 2005, 2006) and volcanic activity (e.g., Manville, 2002; Manville et al., 2005) are also major controls influencing river and floodplain dynamics (Clement and Fuller, 2007).

The operation of autogenic fluvial processes in the channel and hillslope domain can result in nonuniform landscape responses to external perturbation (Cohen and Nanson, 2007). The nature of landscape response and alluvial unit preservation reflects the influence that variables such as valley floor width, accommodation space, and sediment flux have on Holocene floodplain development and contemporary landscape-forming processes (Lewin and Macklin, 2003; Brierley, 2010). Antecedent landscape controls in fluvial landscapes are important in determining the path of Holocene river development (Fryirs, 2002; Coulthard et al., 2005; Phillips and Slattery, 2008). Valley confinement (created by antecedent topography or inherited geology) is identified as a major determinant of floodplain morphology (Brierley and Fryirs, 2005) through its control on floodplain and reworking processes (Nanson and Croke, 1992). Brierley and Fryirs (2005) described valley confinement as the degree to which the channel impinges on the valley margin. River types vary across a continuum ranging from confined valley setting rivers with no floodplain, through partly confined river valley settings comprising discontinuous floodplain, to fully laterally unconfined alluvial systems (Brierley and Fryirs, 2005). The style of floodplain development in partly confined systems commonly involves floodplain reworking processes that lead to the polycyclic formation of terraces and floodplains, with similar morphology but with different alluvial chronologies and stratigraphy (e.g., Cohen and Nanson, 2008; Stinchcomb et al., 2012). To date, in New Zealand, no fluvial research has been performed that has examined the role that valley floor confinement has on floodplain evolution and Holocene river behaviour.

Analysis of Holocene fluvial radiocarbon records from New Zealand (Richardson et al., 2013) has highlighted the geographical gaps in New Zealand Holocene fluvial research. The majority of New Zealand studies have been catchment specific with limited chronological control, and some regions remain completely unexamined in terms of their Holocene fluvial history. The river systems of Northland (Fig. 1), the most northern region of New Zealand, are among the least researched catchments, and very little is known about their behaviour during the Holocene. Northland's distance from the main zone of plate convergence between the Australian and Pacific Plates and the Taupo Volcanic Zone (Fig. 1) allows us to focus on the impact that environmental change and valley floor configuration has had on sediment flux and sediment storage within the alluvial landscape, largely without the

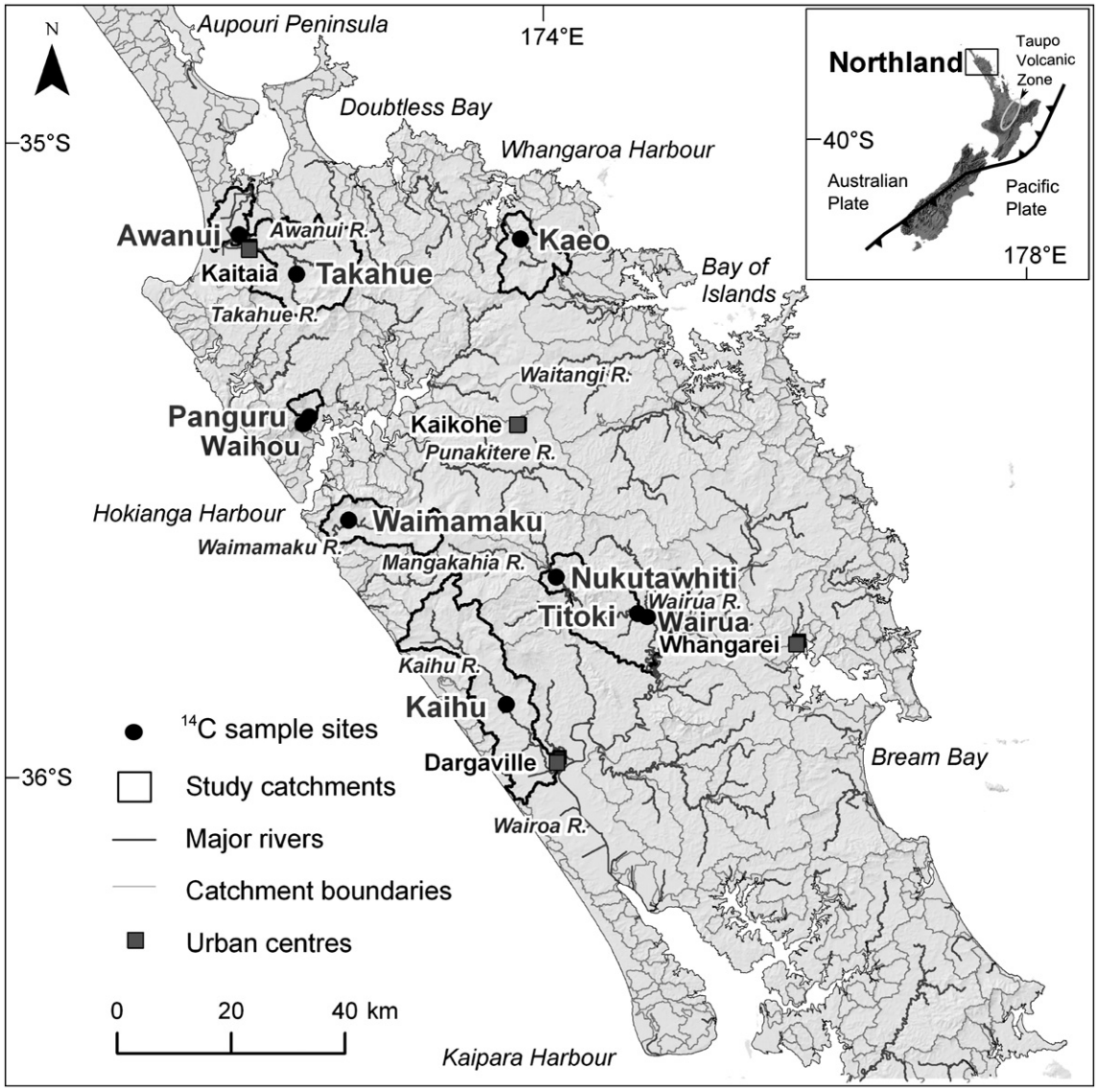

Fig. 1. Location map of study sites, catchment boundaries, major rivers, urban centres in Northland, New Zealand. Inset shows New Zealand tectonic setting.