RATES AND CONTROLS OF STREAMBANK RETREAT AND EROSION IN THREE TROPICAL STREAMS IN NORTH-EASTERN QUEENSLAND

Thesis submitted by

Benjamin Alastair Pearson BSc (Hons) ***JCU***

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James Cook University

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ABSTRACT

Streambank retreat is a natural fluvial process altered by a variety of direct and indirect human activities that is controlled by interactions between a range of hydrological, geomorphological and vegetative factors. These may include climate, discharge, bed slope, bank material and stratigraphy, bank height, bank angle, curvature and the various attributes of bank vegetation. There has been considerable progress in our understanding of these processes and their interactions in temperate regions, but our knowledge of bank retreat in tropical streams is relatively poor. Few quantitative studies of bank retreat or erosion are published for the tropics. In particular, there is a paucity of data on vegetation characteristics, their interaction with retreat-causing variables and their contribution to bank retreat or erosion. This thesis addresses these issues by investigating the response of 34 sites in three north-eastern Queensland streams (2 wet tropics, 1 wet-dry tropics) to the 2003/2004 wet season, observing rates and types of bank retreat and the suite of driving forces that were responsible for this retreat.

Variations exist in streambank retreat rate between climatological regions. Banks of streams in tropical environments tend to retreat at greater rates because they experience greater specific stream power, more frequent bankfull events and higher annual flows than streams in other regions. Global trends also exist between bank retreat and stream width and drainage area. However, no global trends appear to exist between bank retreat relative to channel size and stream width. Modelling retreat of the study banks against climatological regime showed that they retreated at equivalent rates to streams of similar size elsewhere but at lower rates than streams from similar climatological regimes. These comparisons are only valid as far as datasets of differing quality and quantity allow. Analysis of 2003/2004 wet season hydrology suggested that these low rates could be partly attributed to the high recurrence possibility of the wet season.

Variations in streambank retreat rate also exist within climatological regimes. The largely heterogeneous nature of streams and associated variability of dominant erosion driving forces is responsible for this variation. This study did not identify any direct relationship between streambank retreat and any measured variable. However, thresholds existed with regard to specific stream power (> 130 W m^{-2}), curvature (< 2.0), bank height (> 3.2 m) and bank angle (> 45º), which explained the variability of bank retreat rates. Bank retreat was low until these thresholds were passed. When these thresholds were exceeded, retreat rates were more variable, with the steep banks retreating faster than more gradually sloped banks. There was no

direct relationship between root area ratio (RAR) at any point on the bank and bank retreat. However, an exponential decay relationship existed between RAR at depths of 3 m and maximum bank angle: banks occupied by dense basal root networks were less steep, indicating an indirect relationship between bank retreat and basal RAR.

Variations in erosion at different depths down a bank can ultimately control overall bank retreat. Thus, variations in local factors and their control of erosion are as important to measure as retreat itself. Specifically, the variations in RARs and their interactions with other local factors, such as depth or sediment characteristics are a major control of scour rates. Erosion rate variability in the study streams decreased logarithmically with both increasing RAR and gravel content of the bank. Thus, those banks with denser root networks and greater coarse fragment content were less likely to erode. The absence of erosion of gravel-dominated strata in this study is anomalous, but may be partly attributed to the low magnitude and short duration of the flows of the 2003/2004 wet season.

Riparian influence on bank erosion and retreat is largely attributed to its effect on bank sediment strength and cohesion, but its influence on flow redirection away from the bank is also important. Root densities play a major part in these processes – greater densities provide increased cohesion, improved armouring of the bank from primary and secondary flows and sediment aggregation due to the input of organic matter. Root densities generally vary according to above-ground vegetation characteristics, sediment characteristics (moisture, texture, gravel content) and depth. There were linear relationships between root density (using RAR as the measure) and tree density that declined in strength with increasing depth at the 34 study banks. RARs at shallow depths were shown to be highly variable where trees were tall. RAR also varied greatly with depth. Wet tropics banks showed marked drops in RAR at depths of 2.5-3.0 m. A similarly significant decline was evident in wet-dry tropics banks at 2.0 m. No significant relationship existed between sediment and RAR.

This thesis has highlighted the multi-faceted and complex nature of bank erosion and retreat in tropical Queensland streams, as reported in the literature for many temperate systems and the few tropical systems that have been studied. It suggests that specific stream power, curvature, bank geometry, RAR and gravel content and the interaction between these variables are all important in understanding bank erosion and retreat. But despite the extremes of the climate in the study region, erosion responses to a flood of moderate magnitude were within the range expected from other studies, suggesting, albeit with a small dataset, an adaptation of these systems to regular flooding. A larger dataset, including data on their reaction to events of larger magnitude may alter this relationship. It is clear that knowledge of these fluvial processes and characteristics in association with an appreciation of other local and catchment-based processes is essential for the development of appropriate catchment-wide and reach-based management plans.

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