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Floodplains as Dynamic Mosaics: Sediment and Nutrient patches in a Large Lowland Riverine Landscape

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Abstract

Rivers around the world are under increasing pressure from a variety of human activities. Effective management of riverine landscapes requires an ecosystem approach and one that recognises the complex interactions between their physical, chemical and biological components. Perceptions of pattern and process are central to our understanding of riverine landscapes. Pattern and process operate over multiple scales to produce heterogeneous mosaics of landscape patches that change over time. Hierarchical patch dynamics provides a useful approach to unravel pattern and process at multiple scales in riverine landscapes. This thesis adopts a hierarchical patch dynamics approach to investigate floodplain sediment and nutrient dynamics within the Barwon-Darling River in South Eastern Australia.

The flow regime of the Barwon-Darling River is highly variable. As a result, it has a complex channel cross section featuring inset-floodplain surfaces that occur at multiple elevations within the channel trough. These surfaces formed the focus of this study. The texture of inset-floodplain surface sediments displays a patchy spatial distribution and one that did not reflect lateral or longitudinal gradients within this floodplain landscape. Rather a sediment textural patch mosaic was identified. Nutrient concentrations associated with the surface sediments of the inset-floodplains were also shown to vary significantly resulting in a nutrient patch mosaic. This spatial nutrient mosaic was enhanced by factors including the surface elevation of the floodplain surface.

Sediment and nutrient exchange between the river channel and inset-floodplain surfaces was measured during several flows in 2001, 2002 and 2005. Pin and sediment trap data showed that significant quantities of sediment were exchanged between the river channel and floodplain surfaces during inundation with both cut and fill processes occurring. Patterns in sediment exchange appear to be related to local sediment supply and seasonal sediment exhaustion, rather than the top down geomorphic constraints considered. These material exchanges resulted in a change to the spatial configuration of the sediment textural patch mosaic. Distinct new sediment textural patches were created following inundation, while other patches were lost post inundation and other patches changed sediment textural character to move into pre-existing patches. Thus a truly dynamic sediment textural mosaic exists within this floodplain landscape.

Nutrient concentrations associated with floodplain sediments also changed over time. While nutrient concentrations increased after the December 2001 flow event, they generally decreased after the March 2002 event, highlighting their dynamic nature over time. The spatial distribution of nutrient concentrations also varied over time, with a 40 percent change to the nutrient mosaic as a result of the March 2002 flow event. In addition to the influence of the changing physical template (sediment texture mosaic), nutrient concentrations were shown to be influenced by rainfall processes on non flooded surfaces, and also a number of top-down constraints and bottom-up influences operating over multiple spatial scales.

Overall, the inset-floodplains studied in this thesis acted primarily as sediment and nutrient sinks, and were a source for dissolved nutrients. Nutrient exchange was associated with the exchange of sediments in this riverine landscape, over both inter-flow and decadal timescales. It was demonstrated that water resource development within the catchment reduced the number, magnitude and duration of flow events down the Barwon-Darling River and as a result reductions in the exchange of sediment, associated and dissolved nutrients between inset-floodplains and the main river channel were calculated. The greatest reductions were with the release of dissolved nutrients (42-25 percent) and the exchange of sediment and associated nutrients from high level surfaces (43 percent).

Effective conservation and management of riverine ecosystems must occur at the correct scale. This study identified potential nutrient hotspots at several scales in the Barwon-Darling floodplain landscape that could be targeted by management. The low predictability of the location of nutrient hotspots at the inset-floodplain scale over time means that environmental flows should be targeted at high level surfaces (<25 000 MLD^{-1}) that provide long term sources of carbon to the river channel. Conserving flows of this magnitude will also reinstate flow variability, an important facet of the Barwon-Darling River's hydrology that has been changed by water resource development. The research presented in this thesis highlights the importance of not only considering pattern and process at multiple scales, but also the way in which these processes influence landscape patterns over time, leading to the identification of the appropriate scales that can best be targeted for the conservation of these systems.

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Scientific publications and presentations arising from this thesis

Publications:

Southwell, M. R., Foster, J. M., Lenon, E, and Thoms, M. C. (2004). The accumulation of organic matter and the influence of geomorphic variability along the Barwon-Darling River, Australia. *Proceeding of the 4th Australian Stream Management Conference*, *Launceston, Tasmania: Tasmania Department of Primary Industries, Water and Environment*: 542 - 547.

Southwell, M. R. and Thoms, M. C. (2006). A gradient or a mosaic of patches? The textural character of inset-floodplain surfaces along a dryland river system. *Proceeding of the International Association of Hydrological Sciences*, *Dundee: IAHS publication* **306**: 487-495.

Conference Presentations:

4th Australian Stream management Conference – 19th – 22nd October 2004, Launceston, Australia. Titled: *The accumulation of organic matter and the influence of geomorphic variability along the Barwon-Darling River, Australia***.**

36th Binghamton Geomorphology Symposium, 7th – 9th October 2005, Buffalo, United States of America. Titled: *Nutrient dynamics of inset floodplain sediments and the influence of inundation.*

International Association of Hydrological Sciences (IAHS) - 3rd-7th July 2006, Dundee, Scotland. Title: *A gradient or a mosaic of patches? The textural character of inset-floodplain surfaces along a dryland river system*

The 10th International Symposium on Regulated Streams (TISORSII) – 14th – 18th August 2006. Stirling, Scotland. Titled: *Nutrient patterns on inset-floodplain surfaces of a dry land river*