DISCUSSION

In this thesis I explored how natural and altered environmental conditions shape the ecology of riparian plant communities. In this final chapter I aim to summarise the contribution of my thesis to the greater body of riparian plant ecology and river restoration research, outline outstanding questions raised by my work, and present some possible avenues for future work.

*Biogeographic context*

The riparian plant communities described here were located primarily along coastally drained, mid-catchment rivers in partially constrained valley settings, spanning temperate and subtropical south-eastern Australia. A map showing field sites surveyed in Chapters 2-4 is shown below. Although no systematic review has summarised ecological knowledge of Australian riparian plant communities, more research attention appears to have been focused on semi-arid, inland-draining systems such as the Murray Darling Basin, or larger tropical rivers, than these smaller coastal systems.

Additionally, much of the canonical riparian plant ecology literature was written about alluvial river systems in Europe and North America (Nilsson et al. 1989; Naiman and Decamps 1997; Tabacchi et al. 1998; Naiman et al. 2005; Corenblit et al. 2007). Flow regimes in south-eastern Australia diverge considerably from this canon: the seasonal regularity which characterises nival European and North American rivers is often replaced by substantial year-on-year variability (Finlayson and McMahon 1988; Peel et al. 2004). South-eastern Australian plants do exhibit characteristic species-level responses to seasonality, although there is no general coordination of growth and reproduction phenologies as in the Northern Hemisphere (Ford, Paton & Forde, 1979). As such, Australian riparian plant communities are likely to be adapted to different environmental controls. In common with North American systems, however, the signature of rapid landscape modification has been etched deeply into fluvial landscapes. Many rivers have undergone irreversible state transitions following European settlement (Knopf et al. 1988; Fleischner 1994; Wasson 1994; Brierley et al. 1999), and the mid-20th century saw the rise of extensive flow impoundment schemes in both continents (Lloyd et al. 2004; Graf 2006).

TONE THINGS DOWN A BIT, MAKE SURE IT ISN’T CONTROVERSIAL OR WANKY

This body of work therefore contributes some fresh perspective to the global literature, from species pools subject to a different evolutionary history and operating under different environmental conditions to the most commonly described riparian ecosystems.



Figure 1. Map showing geographical distribution of field sites from Chapters 2 & 3 (blue) and 4 (yellow) (Google Maps 2015).

*Ecological responses of riparian plant communities to fluvial hydrology*

The relationship between environmental heterogeneity and biodiversity has been a key concern of ecologists since the early 1960’s (MacArthur and MacArthur 1961; Stein et al. 2014). Riparian landscapes provide particularly useful model systems for exploring hypotheses about environmental heterogeneity due to strong control of biotic assemblages by fluvial hydrology, and in tandem with disturbance, hydrologically-driven environmental heterogeneity has taken a central role in our conceptualisation of how riparian ecosystems function (Poff et al. 1997; Naiman et al. 2005).

Chapters 2, 3 and 4 tested hypotheses derived from this paradigm. Broadly, my work confirms the importance of hydrological heterogeneity and fluvial disturbance in shaping riparian plant assemblages. The specific contribution of these chapters to the riparian literature lies in our mechanistic, functional trait based approach. Through the lens of functional traits, we have begun to address questions about how flow regime influences ecological strategies of riparian plants at the community level, and how the functional organisation of communities varies along hydrological gradients.

In Chapter 2, we found that wood density, a functional trait associated with resistance to mechanical disturbance and drought tolerance (Falster 2006; Chave et al. 2009), varied strongly in response to patterns of hydrology. Community mean values of wood density increased with the intensity of fluvial disturbance and flow heterogeneity; communities which experienced more variable flow conditions were shifted towards the ‘slow’, conservative end of the spectrum of resource-economic ecological strategies (Reich 2014). We also found a humped relationship between community-weighted variance in wood density and the same combined gradient of disturbance and hydrological heterogeneity, lending evidence to general hypotheses (from outside of the riparian literature) that intermediate levels of disturbance should promote divergence in disturbance-response strategies (Grime 2006; Sonnier et al. 2010). This chapter adds to an embryonic corpus of work describing the use functional traits to quantitatively characterise relationships between flow regime and ecological strategy in riparian plant communities. As far as I am aware, it was the first study of its kind to be published.

This chapter quantitatively describes the relationship between ecological strategy and flow heterogeneity, informing a framework with which to understand how ecosystem functions are influenced by hydrology.

Given the substantial cost incurred in setting down dense woody tissue, as well as the flow-on effects on ecosystem nutrient cycling, i.e. slower remobilisation of nutrients and energy from denser woody debris (Mori et al. 2013),

Trait dispersion of wood density was also apparent

intermediate levels of disturbance have been theorised to promote divergence of disturbance-response strategies, resulting in a quadratic distribution of variance in associated trait values (Grime 2006; Sonnier et al. 2010).

and shifting resource-economic trade-offs to favour different ecological strategies

* All three field chapters tested hypotheses derived from this paradigm.
  + My work confirms importance of hydrological heterogeneity in shaping riparian plant assemblages
    - Briefly summarise what I found in each paper.
      * WD literature & fast / slow strategies
    - BUT it doesn’t appear to be equally important in all regions (all?)
    - More study of tropical river systems / developing world, and temperate systems from other regions e.g. NZ, south America, eastern US, which aren’t dominated by *Populus*/*Salix* –type ecological strategies.
  + Do Australian plant communities have a unique relationship with flow heterogeneity?
    - The Gondwanan species pool in Australia has evolved under a unique set of conditions, most notably the gradual transition towards aridification with the lack of extensive glaciation during recent global glacial maxima.
    - Radiation of Myrtaceae, Ericaceae, Protaceae, Fabaceae - replacement of less stress tolerant clades, retreat of rainforest assemblages to refugia
  + Future research:
    - In Ch4, FD was somewhat enhanced by EH, but negatively predicted by
    - Chapter 4 raises the question: what is the relationship between EH and resource & energy availability as controls on riparian plant communities?
    - Are they opposing forces? (provide some examples of metrics showing how this could be the case)
    - Or is a dimensional model a better way of conceptualising things?
      * Provide some examples of metrics
      * If so, how orthogonal are the axes?
      * What metrics might best describe one but not the other?
    - Is there something makes subtropical/tropical communities inherently different from temperate - is it something to do with species assemblages and differing evolutionary histories (i.e. differential adaptation to EH)?
    - Or is the whole thing an *issue of spatial scale?*
    - Need some research that frames questions around these issues of resource availability vs EH, and treats scale explicitly.
      * Smith, T.W. & Lundholm, J.T. (2012). Environmental geometry and heterogeneity–diversity relationships in spatially explicit simulated communities. J. Veg. Sci., 23, 732–744.
* Functional ecology
  + Riparian veg communities are great models systems for studying environmentally controlled community assembly due strong fluvial control on resource and energy gradients.
  + We found evidence that ecological strategies and associated trait syndromes strongly selected for flow response.
  + Tie-ins with disturbance ecology, invasion ecology

*Disentangling drivers - ecological responses to other environmental variables*

* Multiple drivers of community assembly
  + Reign of hydrology confirmed (all chapters)
* Anthropogenic variables
  + CO2
    - Further work?
  + Role of flow modification? Land use?
    - Further work?
* *Management*
  + Environmental flows
    - What’s my contribution to the env flows literature?
    - Could env flows realistically have a predictable effect on diversity in these systems?
    - Do fine-grained species specific studies need to be done?
  + Biodiversity / resilience / ecosystem functioning / ecosystem services
  + Climate change
    - CO2, climate variability
  + Invasion
  + Quantitatively derived flow-response guilds

Since the MacArthur brothers’ pioneering observations that bird species diversity tracked diversity of habitat foliage height (MacArthur and MacArthur 1961), environmental heterogeneity has come to be understood as an important driver of patterns of biodiversity (Stein et al. 2014).

understanding of biodiversity in terms of EH has been a mainstay of modern ecology (stein).

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* The relationship between environmental heterogeneity and diversity
  + Since the MacArthur brothers’ initial observations that bird species diversity tracked diversity of habitat foliage height (MacArthur & MacArthur 1961; Johnson & Simberloff 1974;), understanding of diversity in terms of EH has been a mainstay of modern ecology (stein). Riparian landscapes considered useful model systems due to strong environmental control, environmental filtering etc.. Therefore importance of hydrologically driven EH has been the dominant paradigm in riparian plant ecology ( Naiman & Decamps and Tabacchi)
  + MacArthur, R. & MacArthur, J.W. (1961). On bird species diversity. Ecology, 42, 594–598.
  + Johnson, M.P. & Simberloff, D.S. (1974). Environmental determinants of island species numbers in the British Isles. J. Biogeogr., 1, 149–154