Disturbance and resilience in riparian woodlands on the highly modified Upper Condamine floodplain

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ABSTRACT

Remnant ecosystems in agricultural landscapes are poorly understood in terms of their diversity, function and dynamics under altered disturbance regimes, and of how these influence resilience to future disturbance. Understanding native ecosystem responses to novel and multiple disturbances is a crucial foundation for adaptive management to maintain and enhance biodiversity and critical ecosystem services in production landscapes. This is particularly significant where environmental change drives irreversible threshold responses and ecosystem transitions to less functional, or less preferred, alternative ecological states. This research was conducted in remnant riparian woodland ecosystems along a regulated section of the Condamine River, southern Queensland, an ephemeral dryland river system draining an intensively farmed landscape in eastern Australia. Riparian woodland remnants on the Upper Condamine floodplain are subject to significant changes in hydrological regimes and land use intensity. They also exhibit dieback and limited recruitment of canopy species, as well as widespread invasion by the introduced perennial herb *Phyla canescens* (lippia); however, efforts to address these issues have largely failed to curb ongoing degradation, potentially due to a lack of understanding of the key drivers of ecological change operating in this complex socio-ecological landscape.

This research addressed questions about the drivers of floristic composition, functional diversity and woodland condition in fragmented riparian woodland communities associated with a regulated dryland river system, and embedded in a production landscape. In particular, it investigated ecological responses to the range of disturbances (including altered hydrology, land use intensity, resource availability, and key species interactions) prevalent in this highly modified landscape. Two of the four studies presented test the hypothesis that the composition and condition of riparian woodland remnants on the Upper Condamine floodplain are associated with current levels of longitudinal and lateral hydrological connectivity. These studies used a stratified sampling design which partitioned the study area into river sections, and also considered the influence of lateral overbank and overland flood flows, and grazing within ecosystem fragments (remnants). Full floristic sampling and condition assessments of mature *Eucalyptus camaldulensis/E. tereticornis* trees were conducted at a total of 24 sites in 2004/05. Significant patterns in floristic composition, functional diversity and woodland condition were explained by

differences in hydrological variability; however, the confounding influence of land use and interaction between within-remnant land use (specifically grazing) and hydrological factors for some measures, indicated response to a complexity of drivers.

A third study investigated the influence of local and landscape-scale hydrological and land use variables. It used a Bayesian model averaging (BMA) approach to identify informative model sets of explanatory variables, and key environmental predictors of floristic composition, community structure and ecological condition. A novel method was developed to examine dynamic transitions in species richness and abundance between reciprocal pairs of functional groups; this method used the ratio of species richness (or total abundance) in corresponding pairs of functional trait groups (e.g. C3:C4 species) as a community response variable reflecting the relative importance of each group along the environmental gradients tested. Groundwater decline was the primary predictor of ecosystem response, with lower floristic and functional diversity and more severe dieback associated with increasing depth to groundwater; this result suggests an overarching reliance on shallow groundwater resources for maintenance of ecosystem resilience not previously reported for this ecosystem type in Australia. Lippia abundance and dominant tree condition were also important biotic drivers of ecosystem condition in these communities, and key predictors of floristic composition and functional group richness and abundance transitions. Poor tree condition and loss of hydraulic function was associated with secondary impacts on less well adapted ‘terrestrial’ groundcover species, while the subdominant species *Acacia stenophylla* responded positively to competitive release due to poor tree function and reduced tree density. Lippia cover was also strongly associated with the density (positively) and mortality (negatively) of mature trees.

Small scale species interactions were investigated in a study which tested differences in groundcover vegetation composition and lippia cover, reproductive condition and growth habit between ‘distance from tree’ and topographic position treatments in a riparian woodland on the Upper Condamine floodplain. Sampling was conducted along twelve transects extending from the base of mature *Eucalyptus camaldulensis/E. tereticornis* trees into canopy gaps. Results indicated that scattered trees play a significant role in facilitating the abundance and condition of lippia in this landscape, with evidence of high lippia abundance, reproductive effort and consolidated clonal growth under trees canopies (described as a 'halo' effect). This interaction is likely to play a significant role in the persistence of this mesic, though highly adaptive, species in this drought prone landscape. Lippia cover greater than approximately 20% was also found to have a significant impact on the abundance and diversity of non-lippia species in these grassy woodlands.

Results of this research are synthesised in a conceptual resilience-based state and transition 'riparian woodland response' model identifying three critical transitions for riparian ecosystem condition and function related to effectively irreversible changes in the landscape: (i) transformation to a lippia-invaded landscape with the introduction, establishment and spread of lippia on the floodplain; (ii) transformation from riparian communities which are well buffered against drought, due to connection with shallow groundwater, to communities reliant on and susceptible to stochastic climatic variability; and (iii) population failure in the dominant functional canopy species complex, *Eucalyptus camaldulensis/E. tereticornis*, and transformation to non-eucalypt-dominant floodplain ecosystem types such as *Acacia stenophylla*-dominant woodlands, floodplain grasslands or lippia-dominant herblands with significantly reduced capacity to provide essential ecosystems services in riparian contexts.

In conclusion, this research indicates that observed condition in riparian woodlands on the Upper Condamine floodplain is an integrated response to a range of disturbances, but that certain changes (in particular, groundwater decline due to overextraction in combination with extended drought) may be critical to the long-term persistence and function of these remnants. This study indicates the importance of systems-based empirical research to developing better understanding of the function and dynamics of remnant ecosystems in highly modified landscapes subject to both natural and anthropogenic disturbance regimes. The resilience-based approach also focuses attention on the key drivers of stability and critical transitions in these complex socio-ecological systems. Such research is vital to evaluating and predicting changes in remnant native ecosystems and the provision of important ecosystem services, and as a basis for adaptive management in multi-use production landscapes.

CERTIFICATION OF DISSERTATION

I certify that the ideas, experimental work, results, analyses, discussions and conclusions reported in this dissertation are entirely my own work, except where otherwise acknowledged. I also certify that the work is original and has not previously been submitted for any other award.

____ Date: ……/……/… …

Signature of Candidate

ENDORSEMENT

____ Date: ……/……/… …

Signature of Supervisor (1)

____ Date: ……/……/… …

Signature of Supervisor (2)

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