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

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## Introduction

Remnant ecosystems in agricultural landscapes are poorly-understood in terms of their diversity, function and dynamics (resilience) under altered disturbance regimes. Landscape change and modification of critical environmental parameters mean that such systems may currently exist close to ecological thresholds; as such, they provide insight into how further disturbance such as climate change may play out across landscapes.

The rich arable floodplain of the Upper Condamine is highly modified in terms of landcover and hydrological regimes (including groundwater components) (Fig. 1). This region is also subject to significant climatic variability (Fig. 2a), and the combined effect of these factors (e.g. groundwater decline; Fig. 2b) may have significant implications for native vegetation[1]. Floodplain remnants are generally in poor condition (Plate 1), with significant dieback and limited recruitment of dominant canopy species, and widespread invasion by the introduced perennial herb, lippia (*Phyla canescens*).

This research takes a multi-faceted approach to develop an understanding of key drivers of ecosystem change in response to major landscape modification in the Upper Condamine floodplain landscape. Questions asked include: (i) to what extent are disturbances such as climate variability, land- & water-use, and invasive weeds associated with current ecosystem condition? and (ii) what are the critical changes in ecosystem composition and condition associated with these disturbances?

Plate 1. **Typical floodplain *E. camaldulensis/E. tereticornis* woodland remnant of the Upper Condamine**

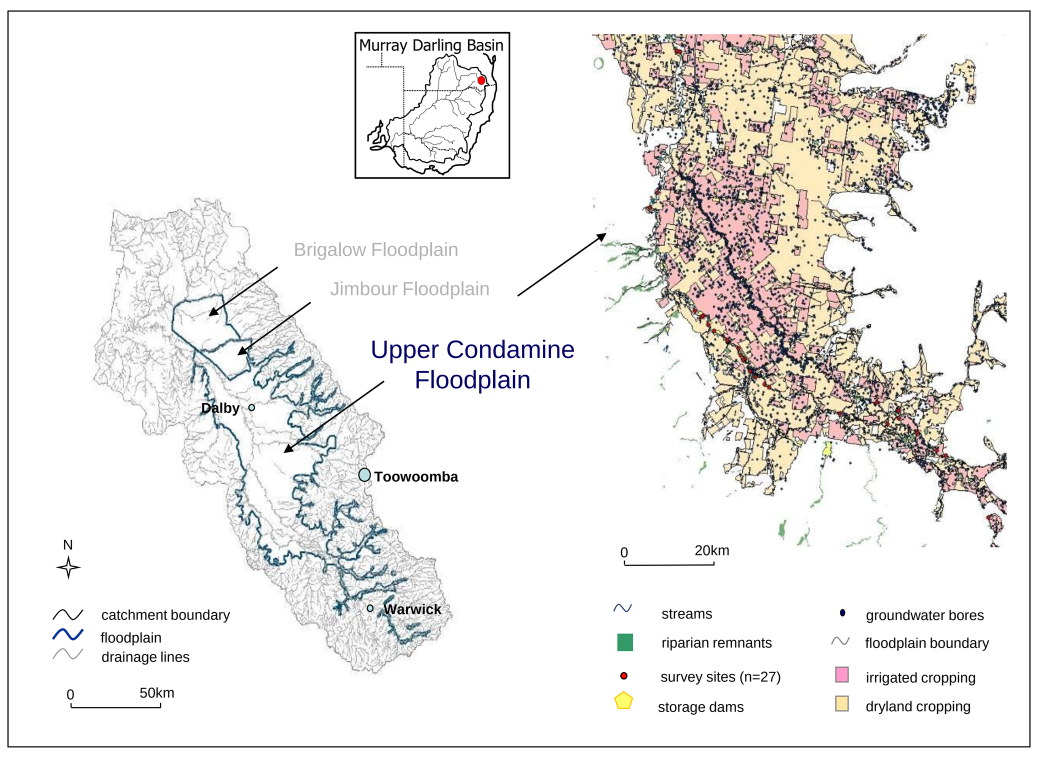


**Fig. 1.** Location of study area, showing spatial extent of floodplain modification

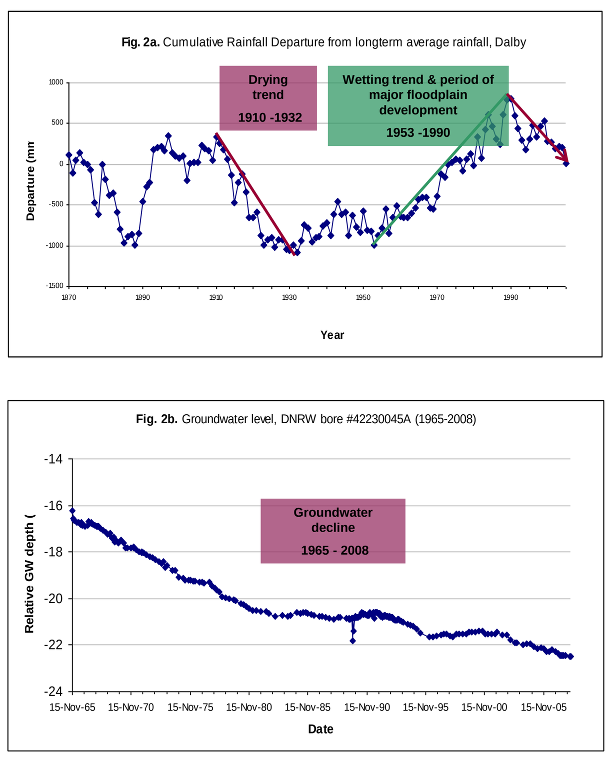


**Fig. 2.** Rainfall variability and groundwater bore level changes on the Condamine floodplain.

## Study Area & Methods

Remnant *Eucalyptus camaldulensis/tereticornis* woodland sites (*n*=27) along floodplain sections of the Upper Condamine River were surveyed using a nested quadrat sampling design. Abundance (frequency & projected cover) data was collected for all vascular plant species, and canopy health measures were taken. Indices of community condition (e.g. diversity, functional trait group representation, canopy health scores, incl. Weighted Wylie Index) were derived, and landscape- and patch-scale hydrological and spatial values were generated from both field measures and spatial layers in ArcGIS. A parsimonious set of variables was selected by retaining one only of any highly correlated (>50%) variables.

Multivariate community patterns were explored using nMDS and BIOENV procedures (PRIMER version 5), and Bayesian Model Averaging techniques (R version 2.9.0) were used to identify variables most likely to occur in models explaining observed patterns in vegetation response variables.

## Results & Discussion

Species composition (frequency) was best explained (BIOENV; Spearman R = 0.357) by a combination of environmental variables including mean groundwater depth (2004-5) and groundwater trend (m/decade) in monitoring bores within a 5km radius and cropping within a 2km radius of survey sites, proximity to upslope water storages, mature tree density and lippia cover. The strongest association with an individual variable was with groundwater trend (Fig. 3), which showed a mean decline across all sites of 0.79 (mean range: 0.02 to 1.81) m/decade.

## Results & Discussion (cont.)

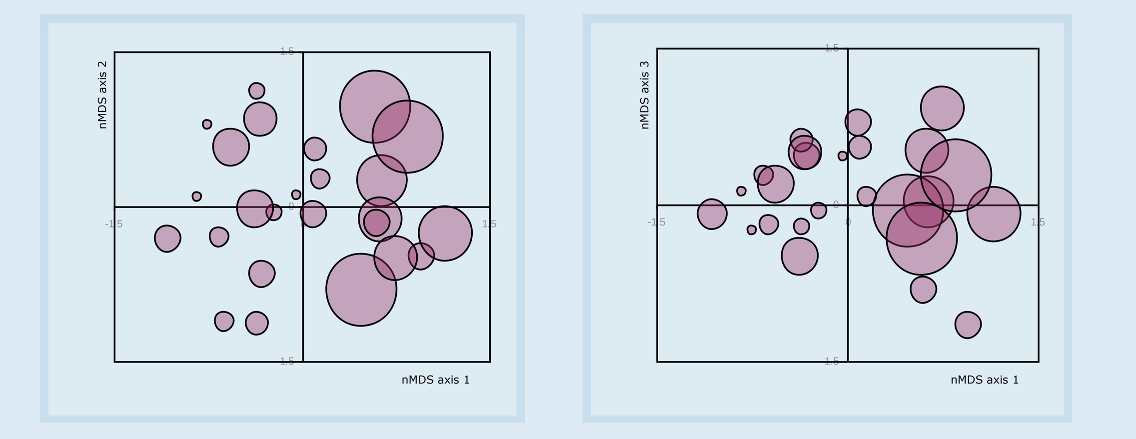


**Fig. 3.** nMDS (PRIMER) plot of sites, with 3-D spatial arrangement based on Bray-Curtis similarity and bubble plots indicating mean groundwater trend (m/decade) in DNRW monitoring bores within a 5km radius of each site.

Groundwater depth, groundwater trend and dieback severity were frequently associated with observed patterns in species composition variables, while land use indices were best associated with canopy species health (Table 1). Variables tested were only weakly associated with richness of wetland-dependent species or eucalypt recruitment, both of which are more likely to be influenced by temporal-scale hydrological variables (e.g. rainfall, flooding) or property-scale grazing regimes[2,3]

The introduced species, lippia, was the most abundant species recorded. Lippia cover was associated with hydrological variables (groundwater depth, and presence of irrigated cropping and water storages); it was strongly (negatively) associated with the density of dead trees ('stags'), but showed limited evidence of a major role in influencing individual community composition or health parameters (Table 1).

Extent of tree decline varied across the study area, with dieback severity ranging from moderate to extreme (Weighted Wylie Index categories), and canopy and tree frame indices ranging from 18 to 86% and 30 to 99% of 'healthy', respectively. Dieback severity was most likely to be associated with local-scale grazing and broader-scale cropping (Table 1). Evidence of association between dieback severity and several richness and diversity indices (also abundance measures, though not presented) indicates that healthy dominant canopy species play a key functional role in these ecosystems, and that their decline will have important biodiversity implications.

**Table 1:** Explanatory variables with a high probability (p>0.75) of inclusion in models

Red type indicates a negative relationship; minimum Bayesian Information Criterion (BIC) values indicate the relative reliability of the best models generated.

| Response variables | $n_{models}$ | Explanatory variables (p > 0.75) | Min. BIC | Max. $R^2$ |
|---|---|---|---|---|
| **1. Species richness (S) & diversity (H') measures** | | | | |
| total S | 102 | GWdepth5000 (0.93), irrigcropppn2000 (0.77) | -2.046 | 0.596 |
| total H' | 104 | GWdepth5000 (0.96), distdownweir (0.76) | -3.654 | 0.557 |
| native S | 111 | GWtrend5000 (0.91), cropnatratio2000 (0.84) | -2.58 | 0.683 |
| native H' | 119 | GWtrend5000 (0.97), cropnatratio2000 (0.91), WWI (0.85), grazppn500 (0.79) | -3.412 | 0.702 |
| alien S | 77 | GWdepth5000 (0.81) | -5.392 | 0.393 |
| alien H' | 90 | GWdepth5000 (0.86), WWI (0.76) | -3.813 | 0.63 |
| **2. Functional trait group representation (species richness)** | | | | |
| $C_3$ species | 80 | GW5000 (0.98), treedens (0.96), cropnatratio2000 (0.80) | -8.317 | 0.685 |
| short-lived species | 43 | drainage500 (1.00), GWtrend5000 (1.00), GW5000 (0.99) | -16.69 | 0.719 |
| clonal species | 43 | distdownweir (0.97), treedens (0.88) | -5.273 | 0.454 |
| wetland-dep. spp. | 71 | - | -1.316 | 0.299 |
| **3. Canopy condition, recruitment & lippia abundance measures** | | | | |
| canopy index | 50 | grazppn500 (0.95), cropnatratio2000 (0.94), GWtrend5000 (0.78) | -6.507 | 0.502 |
| dieback severity index | 46 | grazppn500 (0.98), cropnatratio2000 (0.95) | -5.593 | 0.48 |
| tree frame index | 61 | cropnatratio2000 (0.94), irrigcropppn500 (0.78) | -4.401 | 0.476 |
| stag density | 35 | grazppn500 (1.00), GWtrend5000 (1.00), lippiacover (0.98), GWdepth5000 (0.95) | -19.542 | 0.727 |
| eucalypt regeneration | 60 | - | 0 | 0.419 |
| lippia cover | 59 | GWdepth5000 (0.86), irrigcropppn2000 (0.86), distringtankUQ (0.83) | -7.095 | 0.565 |

**cropnatratio2000** = land use (all cropping: grazing/nature reserve) within 2000m of site; **distdownweir** = distance (m) to nearest in-stream weir downstream; **distringtankUQ** = distance (m) to nearest upslope ring tank; **drainage500** = length (km) of river channel/drainage lines within 500m; **grazppn500** = proportion of grazing land use within 500m; **GW5000** = number of existing groundwater bores within 5000m; **GWdepth5000** = average depth to water table (m) (2004-5 records) for groundwater monitoring bores within 5000m; **GWtrend5000** = average trend (rate of decline - m per decade) in water level of GW monitoring bores within 5000m **irrigcropppn2000** = proportion of irrigated cropping land use within 2000m; **irrigcropppn500** = proportion of irrigated cropping land use within 500m radius; **lippiacover** = mean cover (%) of lippia per site (1m x 1m quadrats); **treedens** = density of mature trees (#/ha); **WWI** = Wylie Index (weighted): site index of tree health (low WWI indicates good site health).

## Conclusions & Future Directions

In most models, significant variation in vegetation responses (e.g. composition and condition) was explained by both hydrological (e.g. groundwater depth) and landscape (e.g. spatial/landuse) variables; in particular, groundwater variables were consistently associated with community composition variables.

Few floodplain or riparian systems studied in Australia have enabled consideration of the role of groundwater decline in ecosystem processes[4]. Modified landscapes such as the Upper Condamine, where surface water harvesting and groundwater extraction, in combination with climatic variability, result in forced drying of the landscape, provide an opportunity to investigate such large-scale disturbance and ecosystem response as environmental conditions approach critical tipping points.

Information from this research will be used to develop a functional dynamic model of floodplain eco-hydrology in the Upper Condamine landscape. Such a model will provide a basis for future research of floodplain ecosystem responses to land and water use and climate change.

**References:**
1. Stromberg *et al.* 1995. *Ecol. Applications* 6(1), 113-131.
2. James *et al.* 2007. *Plant Ecology* 190 (2), 205-217.
3. Meeson *et al.* 2002. *Journal of Applied Ecology* 39, 247-258.
4. Jansson *et al.* 2007. Ecology 88(1), 131-139.

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