Ecological benefits of 'Environmental Flows' in the Eastern Mt. Lofty Ranges

by

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Declaration

This thesis contains no material which has been accepted for the ward of any other degree or diploma in any university or other tertiary institution and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I consent to the thesis being made available for photocopying and loan if accepted for the award of the degree.

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Summary

This thesis examined the impact of anthropogenic alterations in four riverine catchments of the Eastern Mt. Lofty Ranges, South Australia, to identify if creek restoration via environmental flows is a viable management option and if so, to determine;

1) Whether an aquatic / riparian viable seed bank was present and if so what was its composition
2) The ecological condition of selected riverine reaches. This in combination with the seed bank study would identify those creeks that would most benefit from the imposition of environmental flows
3) The response of key species to the water regimes likely to result from the imposition of environmental flows
4) The influence of nutrient enrichment under a fluctuating water level and to use this information to formulate best practice policy for environmental flows
5) Whether aquatic plants promoted by environmental flows were a significant fraction of the diet for higher trophic levels represented by Trichopterans and Amphipods.

The seed banks were of comparable density (ranging from 4,000 to 110,000 seeds m^{-2}) and species richness (ranging from 13 to 20 aquatic / riparian species) to the seed banks of other Australian rivers and wetlands, but this varied significantly among riverine sections and across catchments. Out of a total of 81 species recorded, 51 were classified as terrestrial (63% of all species recorded). What is of greater concern was the number of exotic (both aquatic and terrestrial) species recorded: 43% of the species recorded in the Angas, 47% of the species in the Finniss, 39% of the species in Tookayerta creek and 43% of the species recorded in Currency creek were exotic, which are significantly higher in comparison to other Australian studies. There were 24 to 28 aquatic / riparian species recorded in the extant vegetation of each catchment that were not recorded in their seed banks. Likewise, a number of species (3 to 7) were recorded in each catchments seed bank that were not recorded in the extant vegetation of those catchments. A species of particular interest is *Crassula sieberana*, which is on the State endangered plant species list.

Indices for assessing the ecological condition, health or integrity of a river or riparian habitat were employed to investigate the relationship between the river/riparian habitat and

the land and water management practices associated with those habitats. Of the four catchments surveyed, each catchment identified a unique set of site parameters (subindex indicators) that were strongly correlated with its ecological condition. Indicator species analyses revealed pasture grasses to be a significant indicator of reaches in very poor condition (p = 0.0010) along the Finniss and *Baumea juncea* of those reaches in good condition (p = 0.0230). Along the Angas, *Cotula coronopifolia* was an indicator of those reaches in average condition (p = 0.0240) and along Currency creek, *Cladium procerum* was an indicator of those reaches in good condition (p = 0.0190). However, when all 115 surveyed reaches were analysed together, those reaches of average to excellent ecological condition were all strongly correlated (R^2 = 0.50) with the subindex indicators: bank stability, % riparian cover, grazing, fenced, aquatic wood, and width of the riparian vegetation. This would indicate that these subindex indicators are the main site parameters determining the ecological condition of a riverine reach and hence its restoration potential. Those catchments or sub-catchments containing a high proportion of reaches classified to be in poor to very poor condition had significantly reduced seed banks.

The influence of water level fluctuations (±15 cm, ±30 cm and ±45 cm) on the growth of four species of emergent macrophytes (*Cyperus vaginatus, Phragmites australis*, *Typha domingensis* and *Triglochin procerum*) were species dependent. These species naturally inhabits different zones across the elevation gradient. *C. vaginatus*, which has a high elevation preference, was strongly inhibited by increasing water depth and fluctuations in water levels. In contrast, species with an intermediate elevation preference, such as *Phragmites australis* and *Typha domingensis*, were more tolerant to both depth and water level fluctuations. However, the biomass and relative growth rate (RGR) of *T. domingensis* and *P. australis* were depressed when grown under the combination of deep elevation and a highly fluctuating water level (±45 cm). Between the static and ±45 cm amplitude treatments, growth of *T. domingensis* was inhibited by 52%. The growth of *P. australis* appeared to be enhanced by fluctuating water levels and only showed a severe drop-off in growth in the deep elevation, ±45 cm amplitude treatment. In *C. vaginatus* the RGR was dependent of the average emergent surface area (and the implied rate of carbon acquisition) (p<0.0001; r^2=0.7196; F=87.276; n=36; RGR (mg g^{-1} day^{-1}) = -5.096 + 4.313 × ln (Average emergent surface area (cm^2)), but this was not the case in *P. australis* and *T. domingensis* (p>0.05) even when the photosynthetic canopy was partially inundated by rising water levels. Yet these two species demonstrated different growth rates when grown under different water regime amplitudes and at different elevations. Growth of *T. procerum* did not respond to either amplitude or elevation, but its RGR remained negative. This suggests that another factor(s) was limiting the growth of *P. australis, T. domingensis* and possibly *T. procerum*, a factor that varies with water level.

Cyperus gymnocaulos had significantly increased plant performance (p <.0001) with increased nutrient loading rates but this effect was significantly reduced under a fluctuating water regime (p =0.0007). Remarkably, under a fluctuating regime, *P. australis* had a significant reduction in performance with increased nutrient loading rates (p =0.0013), whereas *T. domingensis* performance was significantly limited (p =0.034) even with increased nutrient loading rates. *T. procerum* too had increased plant performance with increased nutrient loading rates but this effect was reduced under a fluctuating regime. The morphological response by *T. procerum* demonstrates that it is mainly limited by the nutrient loading rates and not the water regime. However, it was significantly limited/reduced by its increased turnover rates caused by a stochastic fluctuating water regime. Illustrating that in fact the effects of nutrient enrichment on *T. procerum* were independent of water regime but bearing in mind that water regime is the primary factor determining the productivity of this species. For those species with higher elevation preferences, e.g. *C. gymnocaulos*, or low elevation preference, e.g. *T. procerum*, the effects of nutrient loading are independent of water regime, whereas those species with an intermediate elevation preference, e.g. *P. australis* and *T. domingensis* the effects of nutrient loading are largely dependent on the water regime.

Amphipoda and Trichoptera selectively fed on succulent semi-emergent macrophytes across sites of average to excellent ecological condition (31-64% to 65-97% of diet), depending on availability. These semi-emergent macrophytes contained the lowest C:N ratio (≈10:1), closest to that of their consumers (≈5:1) and therefore the highest nutritional content. In degraded riverine reaches, there were limited food resources available, hence course particulate organic matter (CPOM) formed the main dietary components of Amphipoda (20-53% of diet) even though it had the highest C:N ratio (≈40:1). At site VP. 1, filamentous algae was the main dietary component of Trichoptera (48-64% of diet) due to its availability and its low C:N ratio (≈14:1) in comparison to the other primary sources available. The imbalanced consumer-resource nutrient ratios in these degraded riverine reaches are likely to impose constraints on the growth and reproduction of their aquatic shredder communities with probable knock-on effects at higher trophic levels.

The installation of environmental flows to restore and promote aquatic / riparian plant communities, which in turn would benefit higher trophic organisms, is a viable and realistic management option along selected reaches. Those selected reaches contain a significant aquatic / riparian seed bank and with sufficient physical habitat remaining to promote their germination and establishment. However, the imposition of environmental flows as a control measure to prevent the colonisation and dominance of particular species (*T. domingensis* and *P. australis*) was deemed to be redundant as a management technique given the limited water resources available.

Foreword

This thesis has been prepared as a serious of chapters in a format that will be suitable for future publication in scientific journals. To maintain the sense of individual chapters, this has inevitably led to some repetition between chapters.