The response of aquatic communities to water quality, land use, flow variability and extraction in an unregulated Australian coastal river

July 2014

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A thesis submitted for the degree of Doctor of Philosophy

The University of New England

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged.

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Acknowledgements

This thesis has been completed with the valuable assistance of Dr Darren Ryder and Professor Andrew Boulton. I would like to thank them for their positive feedback, advice and encouragement. I'd also like to thank Dr Keith Bishop for his assistance during the initial stages of this study.

This study was generously supported by Midcoast Water. I'd like to acknowledge the invaluable assistance of Anna Kaliska, Narelle Hennessy and the laboratory team. I am also indebted to the many people who assisted me in the field, particularly Greg Gill.

I was also very fortunate to have met many supportive and generous landholders who allowed me access to their properties, particularly David and Kath Neeley, Caparra Creek.

I would also like to extend my gratitude to my family and fantastically supportive partner Graham Hopkinson. His enthusiasm and encouragement during the difficult periods experienced through this journey gave me the strength to complete this thesis.

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Abstract

Stream ecosystems are greatly influenced by their catchments through the contribution of water and nutrients. While nutrients are an essential component in driving biological stream functions and processes, the continuing impact of changing land use and diffuse inputs has increased nutrient loads within most aquatic environments around the world. These increasing nutrient loads have resulted in artificial or cultural eutrophication, impairing water quality and aquatic ecosystem function. It is hypothesised in this thesis that catchment properties and agricultural land use increase total nutrient concentrations within the Manning River system on the north coast of New South Wales, Australia. Increases in nutrient concentrations, coupled with reduced flows, will have ecological impacts through increases in primary productivity and algal biomass.

To assess how land use and river discharge influences biogeochemical processes, this study measured water quality under various flow conditions and assessed the responses of biota to flow and water quality changes. Regionally-derived nutrient thresholds were identified, as was the influence of discharge on in-stream nutrient concentrations and ratios. Nutrient enrichment experiments, nocturnal water quality investigations and assessments of macroinvertebrate community structure responses were also undertaken to better understand ecosystem functioning.

The determination of regionally-derived reference water quality thresholds to assist in the protection and restoration of aquatic communities in the Manning River used the reference condition approach. Water quality at reference sites was used as a benchmark against which to compare sites which have greater human disturbance, with nutrient concentrations from non-reference sites compared to threshold values derived from reference sites. The resulting comparisons indicated sites within many sub-catchments of the Manning River, spread across upland, mid and lowlands, did not meet the regionally-derived thresholds for the protection of aquatic ecosystems for moderately disturbed coastal systems. The degree to which these thresholds were exceeded was dependent on the magnitude and extent of disturbance within the subcatchment as the multitude of agricultural impacts, urban development and mining pursuits altered baseline concentrations of nutrients to varying degrees. These thresholds, if continually exceeded, may result in ecological impacts including a loss of sensitive species.

Under low flow conditions within lower Manning River sites, periphyton biomass increased and the chemical and physical environment was altered for macroinvertebrates through reductions in habitat availability and variability, and changes in food resources. Under these conditions macroinvertebrate taxa richness was reduced at lower Manning River sites when compared to the less-impacted tributary sites. Functional feeding groups were indicative of differences in macroinvertebrate community structure between Manning River and tributary sites. The dominance of collector/filterers at Manning River sites compared to the dominance by gatherers and scrapers at tributary sites demonstrated the importance of the variety and type of food resources and habitat.

Understanding the resistance, resilience and directional responses of streams to low flows and possible climate change impacts will inform and improve catchment management. For the

management of the Manning system, which is relied upon for a number of extractive purposes including town water supply, the reduction of nutrients is likely to improve ecological outcomes under low flow conditions. These low flow events, if more frequent and of greater duration, may result in the permanent loss of species that are unable to resist chronic impacts. This is particularly true for macroinvertebrates, as their central role in ecosystem functioning makes them sentinels and integrators of impacts such as climate change.

This study shows that the combined effects of catchment properties, land use and water quality greatly influence ecological responses to low flows. While there is some understanding of how biota of lotic systems respond to low flows at a broad scale, there is still limited knowledge of how ecosystem processes such as nutrient cycling may change under low flow conditions and, if and how the system recovers from sustained disturbances such as prolonged drought. By understanding what critical low flow levels result in adverse consequences for ecosystem process and functions, and recognising that factors other than flow influence the resilience of a system to impacts, improved management in catchment and flow management can result. As greater diversity within an ecosystem improves its capacity to resist impacts, the maintenance of biodiversity is essential to protect ecosystem functions under variable conditions. To do this effectively, an integrated, adaptive approach to provide flexibility and responsiveness to change is needed.