The application of network analysis to assess the structure and function of aquatic food webs

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Abstract

The health of aquatic communities is under threat globally by anthropogenic impacts. A healthy ecological community is one that maintains its structure and function over time in the face of disturbance (i.e., they are stable). If we are to effectively monitor change in ecological health and instigate appropriate environmental management responses, then we first need to measure ecological health appropriately. Most methods of indicating ecological health in rivers measure structural aspects of a community, with little attention given to functional aspects. Ecological network analysis (ENA) provides a range of food web metrics that can measure both structural and functional aspects of ecological communities. The aim of this thesis was to apply ENA metrics to assess the structure and function of aquatic ecosystems and explore how they may change with habitat. In a general comparison of aquatic ecosystems, I found that rivers, lakes and estuaries have structurally similar food webs, except have lower neighbourhood connectivity which is reminiscent of unstable habitats. Through species extinction simulations of aquatic energy flow networks, I showed that aquatic food webs were most stable when trophic cascades were weak and average trophic levels were small. In examining the effects of riparian deforestation in Taranaki rivers, dietary changes altered the structure of riverine macroinvertebrate communities considerably and drove greater community respiration. In the Hutt River, I modelled changes in the biomass of trout (exotic predator) and periphyton, and showed that more periphyton, but not more trout, can result in greater community temporal variability. Furthermore, increased trout and periphyton can drive more interspecific competition. I also demonstrated the need for managers to consider the impacts of decisions on adjacent ecosystems as well as target ecosystem by showing that the Hutt River and Wellington Harbour respond substantially different to increases in algal biomass. Finally in rivers differing in nutrient enrichment the Manawatu, I showed that food webs in enriched rivers may be more stable to random species loss but more susceptible to species loss from floods. Similarly to riparian deforestation, highly enriched rivers had greater community respiration (excluding microbial activity), which may exacerbate hypoxic conditions and drive the loss of sensitive species.

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Further chapter-specific acknowledgements are included in the manuscript.

Preface

Each chapter of this thesis has been written as a standalone manuscript. As a consequence, there is some repetition of material between chapters. Chapters 1-8 are primarily my own work with, with input from my supervisors.

My chief supervisor, Professor Russell Death, provided guidance on methodology, manuscript development and editing, as such he is a co-author on all manuscripts prepared.

Erna Zimmermann is also a co-author on chapter four as she collected and provided the raw macroinvertebrate and physicochemical data for analysis.

Statements of Author contributions are in Appendix A.

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