Bioassessment of freshwater lentic wetlands using the reference condition approach

Toni Furlonge

August 2016

A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy in Applied Science

Institute for Applied Ecology
University of Canberra

Copyright notice

Statement of contribution

The thesis entitled **Bioassessment of freshwater lentic wetlands using the reference condition approach**includes a published paper (Chapter 4) and one manuscript prepared for publication (Chapter 5), which were written under the supervision of Dr. Fiona Dyer and Prof. Jenny Davis (Institute for Applied Ecology, University of Canberra).

These people provided guidance throughout the writing and comments on manuscript drafts. I have not received other assistance than stated above.

As chair of the supervisory panel I agree with the above statement.

....
Dr. Fiona Dyer

Date: 09 / 03 / 201

Acknowledgements

My first and foremost gratitude is to my supervisors Dr Fiona Dyer and Professor Jenny Davis. Thank you for your guidance,andencouragement to continue writing when I felt isolated. Thank you for being patient when you had to explain the same thing to me more than once. I thank TreforReynoldson and Professor Peter Davies for being available to discuss my questions, and Richard Norris in spirit for our initial research discussions. I also thank the other wetland macroinvertebrate scientists throughout the world for sharing their work and enthusiasm.

I thank Scott Schilg, Andrew Baldwin and Natural Resource Management North for supporting me during the research and in return please accept the outputs of the research. I hope wetland research and the use of the model continues.

I thank my good friend and work colleague Debbie Searle for introducing me to macroinvertebrates, rivers and wetlands. Thank you to Matt Taylor, Janet Smith, Jason Neasey, Alan Charlton, Craig Searle, John Gooderham, Di Thomas and Greg Stewart for assisting with selecting and sampling wetlands. The diverse range of protected wetlands sampled would not have been possible without assistance from Jason Neasey (World Heritage Areas; Tasmanian Parks and Wildlife Service; Liaweenee), Janet Smith (Resource Management and Conservation, DPIPWE) and Matt Taylor (Tasmanian Land Conservancy).

I thank my parents for having my girls while I went looking for waterbugs in wetlands, and Lydia, Skye, Amy and Alan for putting up with me while I wrote a PhD thesis.

To Amy, Lydia and Skye, please see this as a challenge for you to achieve more than you plan.

Abstract

Almost half of the world's wetlands have disappeared as a result of anthropogenic influences, with few wetlands remaining in an undisturbed condition in temperate regions. Conservation and restoration of extant wetlands need programs that can assess wetland condition and report on change. Rapid assessment methods are increasingly seen as central for the implementation of freshwater bioassessment and monitoring programs, with protocols well established for rivers and Great Lakes. Bioassessment programs that use the reference condition approach (RCA) and predictive models to assess river health, are common in the United Kingdom, North America, Australia and Canada. In this thesis, I develop and implement the RCA to biological assessment of lentic wetlands, using macroinvertebrates as indicators. My study is based in Tasmania, Australia (a temperate climate zone) where many wetlands are regarded as having high conservation values with more than 60% located within protected areas.

From an initial dataset of approximately 20 000 mapped wetlands and waterbodies, 80 were identified to be in best available condition and suitable for sampling macroinvertebrates for the purposes of my research. Using a Geographic Information System (GIS), existing spatial data, expert local knowledge and ground-truthing, sites located in a range of landforms in protected areas were selected. Sites were categorised using a broad scale classification, refined using a hierarchical rule set, then selected based on the absence of human disturbance and the presence of four habitats considered to be optimal for macroinvertebrate communities. Of these wetlands, multivariate analysis identified six groups, based on 40% similarity. The environmental attributes of land tenure, water regime, dominant habitat and protection zone were significantly associated with the six groups of wetlands. This method of site selection provided an accurate, rapid and cost-effective selection of sites required for this study and would be suitable for other monitoring programs to use.

To consider the influence of spatial and temporal variability on the application of field sampling methods, 48 macroinvertebrate samples were collected from two Ramsar wetlands over a three year period. Samples were collected from four discrete habitats at each wetland, from the austral spring 2009 to autumn 2011.A rapid assessment method was used, employing live picking in the field and family-level identification in the laboratory. No significant differences were detected in the composition of macroinvertebrate assemblages between habitats within wetlands, between seasons or between years. However, assemblages differed significantly between the wetlands. I concluded that a protocol based on the collection of a single (austral spring), macroinvertebrate sample (representing a composite of four within-wetland habitats) was appropriate for the rapid assessment of wetlands in this region.

The rapid assessment protocol was used to collect macroinvertebrates from 66 protected wetlands. Two hundred and eighteen taxa were identified with an average of 33 species (or morphospecies) and 18 families recorded per wetland. The wetland assemblages were idiosyncratic, four families contributed 21% of the total recorded and only two families contributed greater than 10%. Wetlands were not significantly nested on the basis of the composition of their macroinvertebrate assemblages. No single environmental attribute had a strong relationship with macroinvertebrate richness or assemblage composition and neither species richness nor assemblage composition varied significantly between different types of protected areas. The state of the proximal zone and the type of aquatic habitat present were the most important determinants of macroinvertebrate richness and assemblage composition across all types of protected wetlands.

Using the acquired data, four RCA models were tested. The best model was developed from 46 wetlands, using macroinvertebrate data at the family level with rare families removed. The four predictor variables identified to group similar wetlands were: type of aquatic habitat present, water colour, electrical conductivity and average annual rainfall. Model performance was evaluated using both independent reference-site data and simulated biological impairment data to test both Type 1 and Type 2 errors. The model performed well with respect to Type 1 errors by correctly assigning independent reference-sites to band A and Type 2 errors by correctly detecting three levels of simulated impairment.

The adoption of the RCA to bioassessment of temperate lentic wetlands has been limited, this thesis adds to the global knowledge of the bioassessment of freshwaters using the RCA. Finding environmental attributes associated with macroinvertebrate assemblages and predictor variables to group similar wetlands, is important for the global understanding of wetland macroinvertebrates. The findings have a crucial role in improving our understanding, management and protection of: freshwater ecosystems in Tasmania; wetlands in temperate regions of the world and, macroinvertebrate communities on a global scale. Results suggest that for temperate austral wetlands, bioassessment can be undertaken using macroinvertebrates as indicators and the reference condition approach.

Table of Contents

List of Figures

List of Tables