

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# **Spatial pattern in macroinvertebrate communities in headwater streams of New Zealand and a multivariate river classification system**

**A thesis presented in partial fulfilment of the requirements for the degree of**

**Master of Science  
in  
Ecology**

**At Massey University, Palmerston North,  
New Zealand**

**Manas Chakraborty**

**2008**



## **ABSTRACT**

Macroinvertebrate data collected from 120 headwater streams in New Zealand were used to test the ability of the Freshwater Environments of New Zealand River Classification (FWENZ) to explain spatial variation in unimpacted stream invertebrate communities. FWENZ is a GIS based multivariate river environment classification of the sections of national river network. The classification performance of the FWENZ was examined to determine the optimum classification level which could be used for the purpose of conservation and biomonitoring of New Zealand rivers and streams. The classification performance of the FWENZ was also compared to those of two other river classification systems, the ecoregions and the River Environment Classification (REC). Results of the analysis of similarity (ANOSIM) test showed that discrimination of the study sites based on interclass differences in macroinvertebrate community composition was optimal at FWENZ 100 class level which classifies the New Zealand rivers and streams into 100 different groups. The FWENZ 100 class level distinguished the biological variation of the study sites at a finer spatial scale than the REC Geology level. Although performance of the ecoregions classification was stronger than both the river environmental classifications, the REC and the FWENZ, but it was unable to explain the variation in local assemblage structures. Multivariate analyses of the macroinvertebrate abundance data and the associated environmental variables at three different spatial scales (upstream catchment, segment, and reach) were used to identify environmental predictors of assemblage patterns. Catchment-scale measures of climatic, topographic and landcover factors were more strongly correlated with macroinvertebrate community structures than segment scale measures, whereas reach-scale measures of instream physicochemical factors and riparian characteristics had the least association with assemblage patterns. Despite the strong influences of catchment-scale factors on macroinvertebrate communities, local factors like water temperature, stream velocity, reach elevation, percent canopy cover and percent moss cover were also involved in explaining the within-region variation in assemblage patterns, which indicates the importance of considering regional as well as local factors as surrogates of stream invertebrate communities to provide a base for stream bioassessment programmes at multiple scales.

## **DEDICATION**

To my parents

Sibangsu Bimal Chakraborty and Namita Chakraborty

who waited so long for this

And to my fiancé

Esther Emmanuelle

who was always beside me during this journey

## **ACKNOWLEDGEMENTS**

Undoubtedly, there are many individuals who have, either directly or indirectly, contributed to this thesis, and without their contribution this study was an impossible task. I apologise, if I have forgotten someone who would have deserved to be mentioned in these acknowledgements. First of all, I want to thank my supervisor, Dr Russell Death for his never-ending support from the very beginning of my Masters, and for his encouragement and valuable suggestions in every step of my thesis. I would also like to gratitude my co-supervisors Dr Mike Joy, and Derek Williams for their valuable advices and assistance regarding statistics and geographical information system (GIS). I am very grateful to Dr Timo Muotka from the University of Oulu, Finland, for funding this project. I would like to thank Dr Riku Paavola and Anna Astorga for stream surveying and collecting all the macroinvertebrate samples for this project and Fiona Death for her logistic assistance in the fieldwork. I want to thank Dr Ian Henderson for his sincere guidance in taxonomic identification and for introducing me to the taxonomic diversity of New Zealand macroinvertebrates. I also want to thank Dr Alex James, Dr Zoë Dawson, Jonathon Tonkin and Kate McArthur for their valuable advices and helps in many occasions. Finally, I want to thank Fleur Maseyk who deserves my deepest gratitude for her patience in reviewing of my thesis and for encouraging me with all her moral support till the end of my thesis.

# CONTENTS

ABSTRACT .....	2
ACKNOWLEDGEMENTS .....	4
GENERAL INTRODUCTION .....	7
<b>REFERENCES</b> .....	<b>9</b>
CHAPTER 1	
Linking stream invertebrate communities and GIS based multivariate river environment classification .....	9
<b>1 INTRODUCTION</b> .....	<b>11</b>
<b>2 MATERIALS AND METHODS</b>	
2.1 Study sites .....	13
2.2 Habitat characteristics .....	16
2.3 Invertebrate data .....	18
2.4 GIS data extraction .....	18
2.5 Data analysis .....	22
<b>3 RESULTS</b>	
3.1 Macroinvertebrate communities .....	23
3.2 Ordination .....	24
3.3 Similarity analysis .....	26
3.4 Species contribution to similarity analysis	
3.4.1 Ecoregions .....	29
3.4.2 River Environment Classification (REC) .....	31
3.4.3 Freshwater environments of New Zealand (FWENZ) river classification .....	34
<b>4 DISCUSSION</b>	
4.1 Optimal classification level of FWENZ and its classification strength .....	36
4.2 Effect of rare taxa, regional species diversity, and biogeography on classification performance .....	41
4.3 Implications for use of the FWENZ in conservation management .....	44
<b>REFERENCES</b> .....	<b>45</b>
CHAPTER 2	
Environmental predictors of macroinvertebrate assemblage pattern in headwater streams of New Zealand; regional or local influence .....	47
<b>1 INTRODUCTION</b> .....	<b>49</b>

<b>2</b>	<b>MATERIALS AND METHODS</b>	
	2.1 Study sites .....	51
	2.2 Habitat characteristics .....	54
	2.3 Invertebrate data .....	56
	2.4 GIS data extraction .....	56
	2.5 Data analysis .....	57
<b>3</b>	<b>RESULTS</b>	
	3.1 Regional pattern in stream characteristics .....	59
	3.2 Spatial pattern in macroinvertebrate assemblage structures .....	61
	3.3 Multivariate analyses .....	65
	3.4 Correspondence of environmental variables to macroinvertebrate assemblage patterns .....	66
<b>4</b>	<b>DISCUSSION</b>	
	4.1 Spatial pattern in macroinvertebrate assemblages .....	72
	4.2 Correspondence of environmental gradients to Macroinvertebrate assemblage pattern at different Spatial scales .....	75
	4.3 Implications for biomonitoring .....	77
	<b>REFERENCES</b> .....	79
	<b>GENERAL CONCLUSION</b> .....	83
	<b>APPENDIX</b> .....	86