

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.

Left in the Dark

The effect of agriculture on cave streams

Mahue i roto i te pō

Ko te ariā o te ahuwhehua i ngā hikuawa o ngā ana

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

Master of Science

in

Ecology

at Massey University, Manawatū,

New Zealand.

Pierce Malcolm McNie

2015

General Abstract

The ecology of cave stream environments has received far less attention than surface streams in New Zealand. As a result, the impacts of human stressors on the communities of caves are uncertain. The impacts of agricultural practices on surface stream communities are wide spread and well-studied. In the surface environment, agricultural use of the surrounding catchment has been associated with lower QMCI and EPT scores and influences the structuring of communities and trophic base. Given the knowledge that the effects found on the surface are so far reaching, the aim of this thesis was to establish the effect of agricultural land use on cave stream communities in comparison to surface stream communities, find principal stressors to the cave communities and to examine how land use practices alter the trophic bases of underground communities. The relationships between land use and cave stream communities were examined for four cave streams and their surface stream origins in the Manawatū region of New Zealand. The communities were sampled and in stream environmental measurements were taken. Catchment and riparian zones were mapped using GIS software to establish the extent of agricultural use of land. Stable isotope ratios of carbon and nitrogen were analysed for the communities at each site and for a few potential food sources to determine the source of energy for the communities. Cave stream communities were found to be influenced by surface land management practices. For both the cave and the surface environments, a negative relationship was found for QMCI and EPT against agricultural development. When cave and surface streams are considered apart, the relationship between QMCI and EPT with agriculture was not as steep. This was attributed to the attenuation of sediment transport through caves and the lack of photosynthetic ability limiting the negative impacts of nutrient sequestration. Although sediment attenuated through the cave, it was the primary stressor on stream communities both on the surface and within the caves. Between cave and surface environments within the same dominant catchment cover type, resource use was similar. Between catchment types, however, the use of resources was different with an increased reliance on biofilm derived energy in agricultural catchments for both cave and surface sites. Considered along with the change in functional feeding groups that was detected, it is likely that the changes in resource use by communities as a response to the different inputs from agriculture are reflected in a different community structure. Overall agriculture was found to have a definite impact on cave stream communities. It is likely that through sedimentation and changing resource uses, the communities are altered in a

way similar to what is found on the surface but to a lesser degree, reflecting the lower range of potential stressors on the cave from agriculture.

Acknowledgments

This research would never have been possible without the contributions of many, all of whom deserve thanks. First, to my parents Ian and Desiree M^cNie, who raised me, nurtured my passion for the outdoors and put up with all the setbacks along the way. To Kyleisha Foote, for all her help and support in writing and in field work, through the misery and cold of the caves, ngā mihi nui ki a koe. To my supervisor, Russell Death, for his contributions and help in putting this together, thank you. A big thank you to GNS and Karyne Rogers for their invaluable assistance with stable isotope analysis and to various other field assistants for their help in trudging through the mud and cold: Shaun Nielsen, Tessa Roberts, Felix Vaux, Matthew Dickson, Dominic van der Heuvel and Shan Truter. Finally, to the land owners, the Brislanes and the Browns for allowing access to their properties and caves.

Tēnei au, tēnei au
Te hōkai nei i tāku tapuwae
Ko te hōkai-nuku
Ko te hōkai-rangi
Ko te hokai o to tīpuna
A Tāne-nui-a-rangi
I pikitia ai
Ki te Rangi-tūhāhā
Ki Tihi-o-Manono
I rokohina atu rā
Ko Io-Matua-Kore anake
I riro iho ai
Ngā Kete o te Wānanga
ko te Kete Tuauri
ko te Kete Tuatea
ko te Kete Aronui
Ka tiritiria, ka poupoua
Ki a Papatūānuku
Ka puta te Ira-tangata
Ki te whai-ao
Ki te Ao-marama

Tihei mauri ora!

Contents

General Abstract	iii
Acknowledgments.....	iv
Contents.....	v
Table of Figures and Tables.....	vi
Chapter 1: Caves and Their Biological Communities	1
Introduction	2
Cave structure	3
Cave Biology and Ecology.....	4
New Zealand Cave Ecology	11
References	13
Chapter 2: The effect of agriculture on cave stream invertebrate communities	16
Abstract.....	17
Introduction	18
Methods.....	21
Results.....	26
Discussion.....	34
References	39
Chapter 3: The effect of agriculture on cave stream energy sources.....	42
Abstract.....	43
Introduction	44
Methods.....	47
Results.....	53
Discussion.....	57
References	62
Chapter 4: General discussion	64
Conclusion.....	67
References	68

Table of Illustrations

Two rock types in Piripiri cave	1
Chapter 1, Figure 1: Karst regions of New Zealand	11
Chapter 1, Table 1: Troglomorphic characters.	15
Agricultural stream just upstream of cave.....	16
Chapter 2, Figure 1: Location of study sites sampled between June 2014 and February 2015.	22
Chapter 2, Figure 2: Cave draining an agricultural catchment	22
Chapter 2, Table 1: Microhabitat distribution for four Manawatū streams.....	24
Chapter 2, Table 2: GIS and in stream variables for each reach.....	27
Chapter 2, Figure 3: Diversity and health metrics for invertebrate communities.....	28
Chapter 2, Figure 4: QMCI and EPT plotted against proportion of the stream bed covered in sediment	29
Chapter 2, Table 3: Correlation of habitat variables and NMDS axes for an ordination of stream invertebrate communities	30
Chapter 2, Figure 5: NMDS of cave and surface invertebrate stream communities.....	31
Chapter 2, Table 4: Correlation of habitat variables and NMDS axes for an ordination of guild proportions for communities.....	32
Chapter 2, Figure 6: NMDS of guild relative frequencies of invertebrate stream communities	33
The depths of Piripiri cave	42
Chapter 3, Figure 1: Location of study sites sampled between June 2014 and February 2015	47
Chapter 3, Table 1: Latitude and Longitude of cave stream sites.....	48
Chapter 3, Table 2: Percentage of microhabitat (e.g., runs, riffles and pools) at each sampling site.	49
Chapter 3, Figure 2: Number of species from each trophic level	54
Chapter 3, Table 3: Results of t tests between community metrics based on stable isotope measures.....	54
Chapter 3, Figure 3: Mean (± 1 SE) contribution of each resource to the overall community	55
Chapter 3, Figure 4 Mean (± 1 SE) utilisation of resources by invertebrate species estimated.	56
Waterfall at the exit of Piripiri cave.	64