STREAM RESTORATION: HOW YOUR ECOLOGICAL NEIGHBOURHOOD MIGHT INFLUENCE RESTORATION SUCCESS

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ABSTRACT

The majority of New Zealanders live in urban environments, and national and regional community surveys have shown that improving the state of our urban waterways and environment are high priorities. Similarly, increasing the state of rural waterways has come under close scrutiny in recent times. In all cases, typically we select a single catchment or part of a catchment or watershed as the unit of management. Aquatic ecosystems are valued, measured and monitored on this single unit and restoration opportunities are typically identified as small sectors within these larger units. Much less thought has gone into the inter-relationships of these selected restoration sectors both within and between catchments and the influence that neighboring waterways have on the success of rehabilitation. In this paper, the relationships between neighbouring aquatic ecological communities are explored and the relevance to catchment planning is discussed. In addition, the importance of regional vs local ecological values to achieving successful restoration outcomes is discussed with reference to urban and rural environments; and the role of neighbouring ecological communities in catchment management planning will be outlined. Recommendations for improving the likelihood of restoration success will be provided.

KEYWORDS

Stream restoration, ecological values, catchment management, macroinvertebrates

PRESENTER PROFILE

Ian Boothroyd is an ecologist with over 25 years' experience of assessment, monitoring, enhancing and restoring aquatic environments in urban, rural and industrial settings. Ian pioneered the 'pressure-state-response' framework and the 'streamwalks' methodology for use in catchment management, as well as the use of 'Report Cards' for environmental reporting. Ian has worked on projects in many sectors in New Zealand and is highly sought after to provide expert testimony. Ian is a Certified Environmental Practioner (CEnvP) and a Fellow of the Society of Biology. Ian is currently President of the NZ Chapter of the Environmental Institute of Australia and New Zealand (EIANZ).

1 INTRODUCTION

The majority of New Zealanders live in urban environments, and national and regional community surveys have shown that improving the state of our urban waterways and environment are high priorities. In recent times there has been much media coverage regarding the state of New Zealand's waterways, especially the more rural and favoured recreational rivers.

Recent initiatives by the New Zealand Government are initiatives have the state of rural waterways has come under close scrutiny in recent times. Auckland is New Zealand's largest city with both urban and rural communities and environments; its goal is to be the most liveable city in the world in 30 years, an ambition that will create opportunities for other cities and communities in New Zealand. Urban water quality contributes to several of the Liveability Elements and Indicators of the Proposed Auckland Unitary Plan. Stormwater management units tend to form the basis of catchment plans and environmental assessments and thus restoration initiatives. However, pressure data is generally available as a district-wide reference or specific to a particular area of interest, and information on quality of life is generally a city-wide phenomenon (Boothroyd and Drury 2006).

2 URBAN STREAM SYNDROME

Streams located in urban landscapes are subject to a range of pressures that result in a series of impacts or symptoms that are consistent globally. Typically these symptoms include a flashier hydrograpgh, increased concentrations of nutrients and contaminants, altered channel morphology and stability, and reduced biotic richness, increased dominance of a small number of intolerant species (Walsh et al. 2005). In many circumstances these symptoms can be added to from reduced baseflow or increased suspended sediments. In New Zealand this may also be accompanied by an increase in the variety and number of invasive species of plants and animals, especially fish.

3 ECOLOGICAL NEIGHBOURHOODS

3.1 DISPERSAL AND CONNECTIVITY

Understanding factors that determine species colonization and the composition of ecological communities is important for establishing the objectives, functionality and key success indicators of stream restoration. For stream restoration, abiotic features such as water chemistry, stream bed substrate, channel form, bank stability, and riparian vegetation have been shown to be important predictors of stream macroinvertebrate community composition. Biotic factors include life cycle and habitat requirements of specific species, food requirements and possible migration needs.

Amongst some of the requirements for successful restoration and recolonization is the proximity to sources of biota to colonise the newly restored waterway(s). Most aquatic biota require a connection through water to move and disperse to other habitats. Notwithstanding fish, most aquatic biota move with the unidirectional flow of water in a downstream direction. Aquatic insects have terrestrial winged stages that can also fly or maybe transported to other locations. One theory (Muller's Thoery) suggests that the winged adult stages of aquatic insects fly upstream as means of laying eggs in upstream habitats and thus replenishing the population; only later for the immature stages to drift downstream to repeat the cycle.

The proximity of potential colonisers for newly restored reaches of waterways is therefore an important consideration in the restoration of waterways. In this paper we consider the pattern of aquatic macroinvertebrates and the neighbourhoods exhibited by those within single mainstem catchments, and those amongst neighbouring catchments.

3.2 CASE STUDIES

3.2.1 TWIN STREAMS – SINGLE CATCHMENT

The commonly referred to 'Twin Streams Catchment' actually consists of several waterways: primarily the Oratia, Waikumete, Opanuku, and Swanson Streams all located near the Waitakere Ranges, Auckland, New Zealand. The catchment drain approximately 61 km², and drains into Henderson Creek and out into Waitemata Harbour. Macroinvertebrates (insects, snails, crustacean, worms etc.) are an important component of the biota of streams and are often used as indicators of stream health. Macroinvertebrate samples have been collected from throughout the respective catchments at Twin Streams. Observations of the distribution of these macroinvertebrate communities throughout the catchments can provide some insight into the proximity of similar communities and the proximity of catchments and parts of catchments to enhance restoration success.

The pattern of macroinvertebrate communities across the four catchments within the within the Twin Streams catchments is shown in Figure 1. The separation of the Waikumete and Opanuku Stream catchments along the x axis suggest little similarity of the aquatic macroinvertebrate communities. On the other hand, the distribution of the Oratia and Swanson Stream sites suggests similarities between all four catchments. Sites clustered to the upper right of Figure 1 all occur in natural forest typically in the upper catchment. Sites located to the left of Figure 1 occur in areas with a high degree of urbanization; those sites in the middle area are mid-catchment sites. Restoration activity (typically riparian planting) at a number of these mid-catchment sites has resulted in improvements to the streams as measured by macroinvertebrate communities.

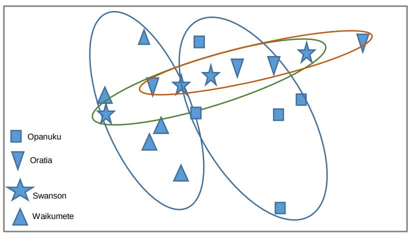

Fig. 1: Ordination of aquatic macroinvertebrate communities from sites within the "twin Streams' catchment, Auckland.

3.2.2 NORTH SHORE – NEIGHBOURING CATCHMENTS

The North Shore of Auckland City is characterized by a large number of generally short low order catchments. Boothroyd et al. (2003) developed a classification scheme for the North Shore City streams based on large-scale factors such as landuse, as well as local reach-scale attributes such as channel morphology and riparian vegetation. The same data was used to look for relationships amongst the aquatic macroinvertebrate communities (Fig. 2). Four stream types were recognised: High value low disturbance streams (Type 1), urban semi-modified streams (Type 2), urban modified streams (Type 3), and concrete channels (Type 4). In this case the similarities amongst catchments was mostly by habitat type and location along a stream length. The desired outcome of restoration would be to move stream communities along to the right of the x-axis and down the y-axis. Improving habitat is clearly an important paramenter but the desired biological outcome (at least in terms of the macroinvertebrate communities) will be influenced by where streams lie in proximity to the better sites.

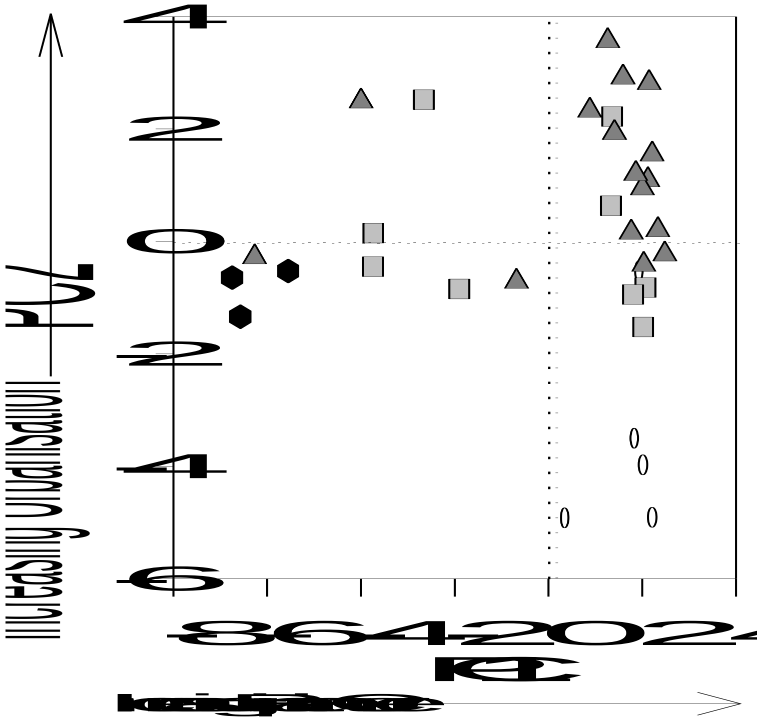

Fig. 2: Principle components bi-plot of aquatic macroinvertebrate community types from 21 streams on the North Shore, Auckland. Circles (Type 1 streams)), squares (Type 2), triangles (Type 3) and hexagons (Type 4); see text for further information.

4 NEIGHBOURHOODS AS CONTRIBUTORS TO RESTORATION SUCCESS

It is beneficial to consider the likely dynamics of recolonisation of restored streams before planned management and restoration strategies are implemented. Sources of invertebrates present in upstream habitats are considered a significant source of colonists for stream systems (Resh et al. 1988; Lancaster & Hildrew 1993), while aerial migration and oviposition can also provide significant colonists to new habitats.

Sunderman et al. (2011) showed that the restoration success of streams depends on the presence of source populations of desired taxa in the streams surrounding restored sites. In a study of 24 restoration projects in Germany, only where source populations of additional desired taxa existed within a 0-5 km ring around the restored sites were aquatic macroinvertebrate assemblages improved by the restoration. Sanderson et al. (2005) found that the importance of the species composition of neighbouring sites in determining local species assemblages differed markedly between taxa. This they concluded was a result of the dispersal abilities from neighbouring sites. Similarly, Tonkin et al. (2014) also concluded that the overall taxa pool was the most important driver of the likelihood of colonization followed by distance to nearest source. In their study (Tonkin et al. 2005) concluded that the first kilometer of of proximity was particularly important.

In terms of the examples outlined above a deeper analysis will reveal whether an optimum distance or circle of influence will enhance restoration efforts. It would appear that where there is good regional richness of taxa and suitable proximity of the restored site to the source of colonists then there may well be a positive and measurable response to habitat and riparian improvements. Such attributes for restoration success may be more limited for North Shore streams due to the more fragmented nature of the catchments and the high degree of modification (and a thus smaller pool of regional taxa for colonization); whereas the larger, better connected and the larger pool of taxa of the Twin Streams catchment means that chances of restoration success are likely to be greater.

This means that expectations of biotic communities reflecting high quality may not occur simply because there are no representatives in the local area, irrespective of the quality of the chemical and physical environment. Thus the best efforts at restoration and management may not yield the anticipated results.

ACKNOWLEDGEMENTS

We thank staff of the Auckland Council and their antecedent organisations fo earlier permissions to use the data collected.

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