Restoring in-stream values and habitat for Canterbury mudfish in Okeover Stream, Christchurch

Leanne O'Brien[1]
School of Biological Sciences
University of Canterbury, Private Bag 4800, Christchurch, New Zealand
Rachel Barker
Parks and Waterways Unit[2]
Christchurch City Council, PO Box 237, Christchurch 8001, New Zealand
rachel.barker@ccc.govt.nz

ABSTRACT

Since the 1990s there has been a changed approach to managing streams throughout Christchurch City. The focus has moved away from managing drainage channels to restoring streams for the plants, fish, invertebrates and birds they support — and to make streams an enjoyable part of our daily lives. In the Okeover Stream, Christchurch City Council and the University of Canterbury have gone a step further and created a special project that is the first of its kind in Christchurch.

The Okeover Stream has changed considerably over the past few years; this project is the latest in a series of focused habitat restorations. Previously, the upper section of the stream was often dry, due to reduced flow from the ground water springs that once fed it. This reach was looking doomed until the Maths and Computer Science building was constructed. This building is air-conditioned using aquifer water which is pumped round the building and then piped into the stream at its upper end. This produces an adequate flow of good quality water. However, the air-conditioning is not always on, and when it is turned off, such as during University holidays, little water is left. This restoration project was designed to mediate the impacts of these fluctuating water levels on the aquatic community.

One species which thrives in such fluctuating spring-fed streams is the acutely threatened Canterbury mudfish (*Neochanna burrowsius*). Mudfish habitats often dry up, but mudfish are quite amphibious — if pools go stagnant they can breathe air at the water surface, or leave the water. If the whole area dries they can survive for months, so long as they are moist. So mudfish appear perfectly suited to this type of waterway. When establishing a species it is important to consider food resources and habitat requirements, particularly for vulnerable stages of development. Extensive habitat development has been conducted with the site excavated to construct deep pools to retain water during low flow. An innovative feature of this restoration is the creative use of engineering structures such as gabions (wire baskets filled with river stones) to line pools and direct flow, creating refuge and backwaters within the stream. Backwater areas are important for mudfish as they provide a still habitat for the vulnerable fry stages. Native aquatic vegetation, which is important to mudfish for spawning, will also be established in these backwaters. Our vision is to have a thriving population of Canterbury mudfish located on the University campus, where their progress can be monitored and researched over the long term. We hope that lessons learned from establishing this population can be used to direct conservation initiatives in other habitats where mudfish could gain a stronghold.

INTRODUCTION

Since the 1990s there has been a changed approach to managing streams throughout Christchurch City. The focus has moved away from managing drainage channels to restoring streams for the plants, fish, invertebrates and birds they support — and to make streams an enjoyable part of our daily lives. In the Okeover Stream, Christchurch City Council and the University of Canterbury have gone a step further and created a special stream project that is the first of its kind in Christchurch (O'Brien 2003).

[1] Present address: 26 Main South Road, Concord, Dunedin, i_niche@xtra.co.nz
[2] Editor's note: now known as the Greenspace Unit.

 Greening the City. ISBN 0-959-77566-8
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A combination of ecological and social goals predominately guide the Okeover Stream project. This paper details methods which have been implemented in the process of achieving these goals, in particular the vision of developing an aquatic community representative of lowland Canterbury, including the acutely threatened Canterbury mudfish (or kōwaro; *Neochanna burrowsius*; Fig. 1) and freshwater crayfish (or kōura; *Paranephrops zelandicus*).

The campus waterways project initially focused on conducting riparian plantings along the Avon River. The emphasis changed when the Okeover Stream was identified as having high restoration potential, while also experiencing the greatest pressure from university activities. The university represents a large area, open to the public and its campus encompasses almost the entire length of Okeover Stream. This situation offers considerable potential for restoration, and the proximity to the University provides the opportunity for research and teaching in the future (Heremaia 2000).

OKEOVER STREAM PROJECT

Attempts to halt degradation and rehabilitate the Okeover Stream began in 1998. Initially the project focused on riparian planting to stabilise the frequently slumping stream banks and improve habitat. However, it was noticed that little in-stream improvement could be expected without a change in maintenance methods. In 1999, guidelines were developed to maintain, as near as possible, natural aquatic and riparian processes, while removing litter and highly aggressive plants. Placements of boulders and large native logs within the stream were trialled in 2000. The development in 2001 of a relatively large pool area planted with species representative of a kahikatea swamp, with its adjacent small raupō swamp, marked the start of extensive projects with a more focused ecological approach. The latest of these projects involved the creation of habitat suitable for Canterbury mudfish, and included visiting remnant mudfish habitats in Canterbury to guide the design process.

CHALLENGES

The Okeover Stream faces challenges common to many urban lowland streams, predominantly siltation, stormwater runoff, and modified hydrology. Hydrological changes have included the reduction of ground water springs and an increase of artificial inputs, such as carpark runoff and air-conditioning discharge. Stream bank instability, extensive siltation, and low in-stream heterogeneity due to adjacent building development and the use of traditional maintenance methods (Fig. 2A,B), have also precipitated a decline in macroinvertebrate species richness.

ECOLOGICAL GOALS

The general ecological goals of this restoration project are divided into three aspects; species, community and ecosystem-level objectives (Fig. 3). To increase the abundance of species presently in the stream, and to promote establishment of others, food sources and habitat components are being rehabilitated, leading to increased habitat heterogeneity. The restoration of representative animal and plant communities also requires the provision of habitat that ensures the resistance and resilience of species to urban disturbance. Furthermore, the revitalisation of ecological functioning and integrity will promote a self-sustaining system requiring reduced human intervention.

SOCIAL GOALS

The Okeover Stream project also has a spectrum of social goals, which include:

- Raising awareness of the campus waterways
- Developing understanding of the species, communities and ecosystem functioning of the stream
- Increasing participation in developing the vision and actions for Okeover Stream
- Achieving guardianship of the university waterways.

The project has raised greater awareness of Okeover Stream by enhancing people's experience of the stream, and its connection with the campus landscape. People now have greater access to it, with on-site interpretation panels providing information, careful design of a sequence of spaces to travel through, and places to sit and enjoy the stream environment.

The value of the stream for teaching and research provides an exemplary example useful in a variety of university courses. Restoration protocols are being developed to guide actions and increase understanding of the functioning of the stream ecosystem. Education objectives include promoting representativeness, such as developing riparian vegetation that illustrates previous plant communities present in the area. Another education objective is the inclusion of rare plant and animal species, particularly those from Canterbury, which will also provide significant educational value. For example, the proposal to re-establish freshwater crayfish could rehabilitate habitat, revitalise ecosystem function, as well as increasing the representative nature of the stream.

Participation in the management and research of Okeover Stream has strengthened considerably since the Okeover project began. A recent initiative was the formation of a Waterways Advisory Committee in 2003 that will eventually have representatives of all interest groups, and will guide the vision and actions taken to achieve a self-sustaining stream system. The guardianship of Okeover Stream is becoming a more tangible goal, and one that may be achieved in the near future.

The Okeover Stream has been separated into six management sections; the restoration projects initiated in two of these sections are detailed in this paper.

1. THE WETLANDS SECTION

During 1998–1999 a considerable stretch of this section periodically became stagnant. This was caused predominantly by insufficient downstream flow due to the dwindling ground water springs. This stretch has a very low gradient and flow was also impeded by upstream pressure from air-conditioning water which was discharging perpendicular to stream flow (Fig. 4). Additionally, the stream bed was over-wide and thoroughly smothered with sediment (Fig. 5). This wide channel may have been representative of past higher flows, but was also likely exacerbated by bank slumping. These factors combined to severely limit the potential for this section to sustain aquatic life. Thus, the principle objective was to improve the hydrological characteristics, with the specific goals of preventing stagnation, narrowing the stream, controlling siltation and stabilising stream banks. Initiatives involved the rehabilitation of habitat components; in this case allowing aquatic vegetation to develop, and the modification of stream morphology, such as installing gravel bars.

REHABILITATING HABITAT

Redirecting flow

Two of the School of Engineering buildings are built directly beside the stream, and one of these buildings discharges air-conditioning water into a large pool (Fig. 4). In 2001 this pool was restored under the theme of ‘kahikatea swamp’ with a main objective of improving downstream flow to prevent stagnation of upstream reaches. Gravel islands and beaches were successfully used to redirect the flow of the air-conditioning discharge (Fig. 6). Boulders and sunken kahikatea and tōtara logs were also used and eco-sourced plant species of wetland, kahikatea swamp forest and dry terrace habitats were established in natural associations (Fig. 7). Additionally, a 600 mm deep, rock-lined pool was excavated to function as a sediment trap to assist in protecting the restored reaches downstream from further siltation.

Sensitive maintenance

Simple changes to in-stream maintenance practices proved to be both an ecologically effective and cost efficient method of narrowing the stream, and have led to improved water flow and reduced siltation. The first step was to allow aquatic vegetation, mainly watercress, to fully establish (Fig. 8). Aquatic vegetation growth was then assessed and channels cut through patches that impeded water flow. As the watercress grew it trapped silt in its roots and confined flow which facilitated the development of a naturally meandering channel with increased water velocity (Fig. 9). Changed maintenance now promotes this natural meandering by only removing watercress from within this central channel. This has led to a narrower stream, rehabilitated habitat (Fig. 10), and areas of ‘reclaimed’ stream bank that will be planted with wetland species. Additionally, less stream substrate is now smothered with silt. This process of change is summarised in Fig. 11.

2. THE HEADWATERS SECTION

Previously, the headwaters section was mostly dry, due to reduced flow from the ground water springs that once fed this stream. This reach was looking doomed until the Maths and Computer Science building was constructed in 2000. This building is air-conditioned using aquifer water that is pumped around the building and then discharged into the stream at its upper end. This produces an adequate flow of good quality water. However, the air conditioning is not always on, and when it is turned off, such as during university holidays, little water is left. An underlying objective in this section was to mediate the impacts of these fluctuating water levels on the aquatic community. One approach is to improve the resistance of the community, by restoring habitat which will reduce the number of individuals removed from the reach by either being washed down during high flow or killed when flow stops and the stream dries. To this end extensive habitat development was conducted with deep pools excavated to retain water in the section during low flow, while backwater refuge was created and stream bank interstitial spaces were provided by gabion baskets.

Excavation of pools

Two types of pools were excavated; two large pools that will act as sediment traps (Fig. 12A,B) and four narrow, lined ‘mudfish’ pools with structured backwater areas (Fig. 13A,B). The mudfish pools were designed with a structure in the middle which helps to direct flow, and creates a backwater area. Backwater areas are important for mudfish as they provide a still habitat utilised by their prey and their vulnerable fry stage. The sediment pools will play an important role by collecting sediment, and when these traps fill up the sediment can be removed from the stream. Additionally, their depth allows improved connection with groundwater springs, as discovered during construction.

Gabion baskets

An innovative feature of this restoration is the creative use of engineering structures such as gabions (wire baskets filled with river stones) to line pools and direct flow, creating refuge and backwaters within the stream (Fig. 13B). Siltation is a pervasive problem in urban areas which acts to smother interstitial spaces of the stream bed. This can be detrimental and reduce the ability of invertebrates to survive periods of extreme flow fluctuation. The interstitial spaces of the gabion baskets may impart a similar function as interstitial spaces of the stream bed. They may also provide refuge for adult mudfish, especially if conditions dry, as mudfish can wriggle between the stones, deep into the moist bank.

FUTURE GOALS

Revitalising ecosystem function

There are many deciduous trees lining the Okeover Stream and during autumn many leaves enter the stream, reducing oxygen levels as they slowly decompose. Freshwater crayfish (Fig. 14) can shred large quantities of leaf litter into fine particulate organic matter that can then be utilised by other stream invertebrates. It has also been found that freshwater crayfish can redistribute sediment, exposing substrate, allowing algal and invertebrate colonisation, and increasing organic processing rates. This may be particularly important for the recovery of streams suffering from siltation. Freshwater crayfish have also been found to control the abundance of macrophytes. Thus, the addition of freshwater crayfish to the Okeover Stream has the potential to improve ecosystem functioning.

Representativeness and rarity

Due to the previously degraded state of the stream, existing fish populations, including upland bully (*Gobiomorphus breviceps*; Fig. 15) and long-finned eel (*Anguilla dieffenbachii*; Fig. 16) are low. These populations will need to be regularly assessed as an indicator of the effectiveness of the stream restoration work.

As suggested, one species that thrives in fluctuating spring-fed streams is the Canterbury mudfish. Mudfish habitats often dry up, but mudfish are quite amphibious. If pools go stagnant they can breathe air at the water surface, or leave the water. If the whole area dries they can survive for months, as long as they are moist. So mudfish appear perfectly suited to this type of waterway.

When establishing a species it is important to consider food resources and habitat requirements, particularly for vulnerable stages of development. The backwater areas created will be important for mudfish as they provide a still habitat for the fry stages. Native aquatic vegetation, which is important to mudfish for spawning, will also be established. Our aim is to have a thriving population of Canterbury mudfish located on the Canterbury University campus, where their progress can be monitored and researched over the long term.

CONCLUSION

Urban streams are highly modified environments that are often degraded due to siltation, stormwater inputs and altered hydrology and morphology. However, the Okeover Stream project demonstrates that urban streams can also offer unique opportunities to rehabilitate species, restore communities and revitalise ecosystems. Through the collaborative efforts of the University of Canterbury and the Christchurch City Council, this humble urban stream has responded positively to more sensitive maintenance practices, increased riparian planting, rock and log placements in stream, wetland creation, improved water flows and creation of specialised habitat in the headwaters. Given the right conditions, improved food and habitat, increased habitat heterogeneity, diverse stream communities, and ecological functioning and integrity, we believe it is a tangible goal that urban streams may become self-sustaining systems. It is also possible that urban streams can offer safe havens for rare and endangered aquatic species, as well as maintaining representative species and ecosystems.

There is also a unique opportunity for the university to monitor progress and study further the ecological restoration of this stream. Lessons could be learned from the habitat improvements and the process of establishing a Canterbury mudfish population that could guide conservation initiatives in other habitats where mudfish could establish and gain a stronghold.

ACKNOWLEDGEMENTS

We would like to sincerely thank everyone who has helped make this waterways project possible, and especially Kate Hewson, Jeff Weston, and Angus McIntosh for providing photographs for this paper.

REFERENCES

Heremaia, C. 2000: Education strategy, waterways and wetlands. Ko te aratohu poipoi e whai ake ki te mātauranga a ngā arawai repo. Christchurch City Council. 12 p.

O’Brien, L. K. 2003: Developing the freshwater fauna and flora in Okeover Stream: discussion and proposals. Prepared for Parks & Waterways Unit, Christchurch City Council, report number CCCECO 03/03. May 2003. 15 p. Available at http://www.ccc.govt.nz/reports/2003/okeoverflorafaunareportaugust2003.pdf.

Fig. 1 Canterbury mudfish (or kōwaro; *Neochanna burrowsius*).

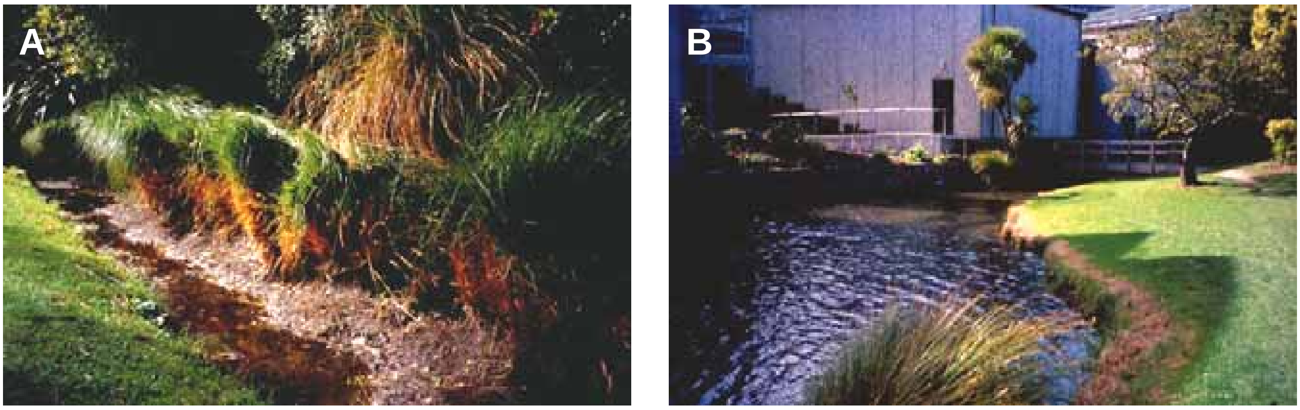

Fig. 2 Examples of traditional maintenance practices. **A**, overhanging vegetation is cut back, which reduces habitat and shade; **B**, banks are closely mown and sprayed, which can increase bank instability.

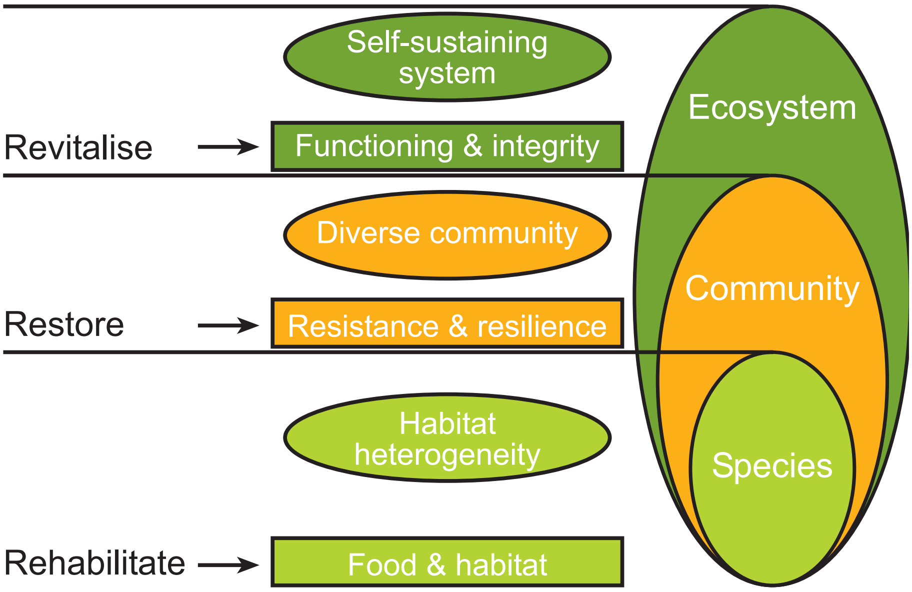

Fig. 3 Generalised ecological goals of the Okeover Stream project targeted at the species, community and ecosystem level.

Fig. 4 Previous flow pattern showing how air-conditioning water discharged from a School of Engineering building impeded flow by pushing water upstream. Photo taken looking upstream. Arrows indicate water flow patterns.

Fig. 5 Silted and over-wide stream bed. The low water velocity allowed silt to smother the stream bed, which reduced the habitat value. Traditional maintenance practices also disturbed the habitat and the removal of vegetation and branches prevented formation of stable in-stream structure.

Fig. 6 Gravel bar constructed to redirect air-conditioning discharge flows and to narrow the stream. Hay bales were used as sediment control during construction. Arrows indicate water flow patterns.

Fig. 7 Rehabilitated wetland habitat with boulder placements and in-stream plantings to help direct flow downstream.

Fig. 8 Cessation of traditional maintenance practices initially resulted in vigorous new growth of aquatic vegetation. Sensitive maintenance is now applied and is regularly assessed and modified.

Fig. 9 Sensitive maintenance allowed stream to narrow and a stable channel to form. Meanders have developed and flow is improved. Margin plants can now be planted into reclaimed berms.

Fig. 10 Natural processes have rehabilitated habitat and reduced siltation. Allowing a stream to shape itself allows natural stream patterns to develop, such as meanders and pool, run, and riffle sequences, which are commonly seen in unmanaged streams. These patterns in turn create diverse habitat patches, promoting biodiversity. Arrows indicate water flow patterns.

Fig. 12 Excavation of deep pools provides aquatic refuge when flow stops and also act to trap sediment reducing extent of siltation downstream. **A**, during construction; **B**, completed pools.

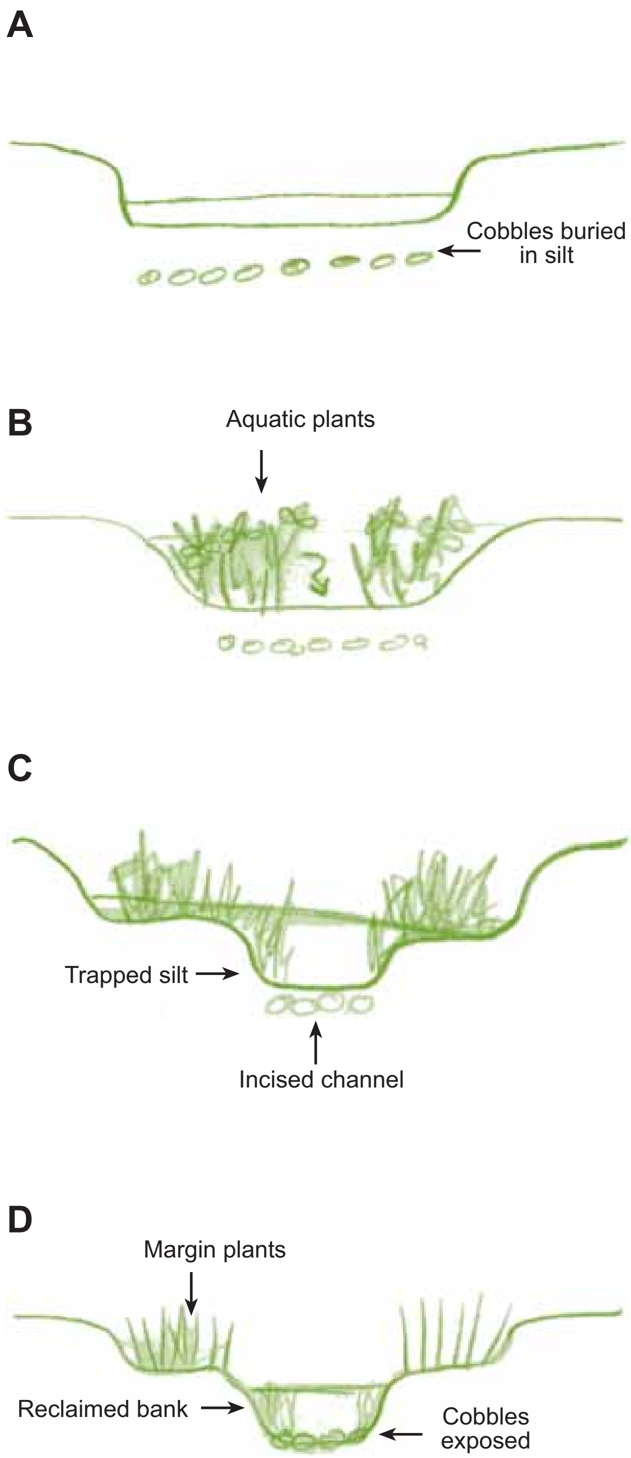

Fig. 11 Development of channel morphology after maintenance practices were changed along the wetlands section of Okeover Stream. **A**, previously the stream channel was overwide, flow was sluggish, and the stream bed was smothered with silt; **B**, aquatic plants were left to establish, their presence narrowed the stream, leading to increased water velocity; **C**, silt was both trapped by plant roots, and flushed out by high flows in the narrowed channel; **D**, buried cobbles were exposed and the accumulated silt formed berms that were planted with terrestrial margin species.

Fig. 13 Special pools designed to provide backwater habitat. Wire baskets of cobbles (gabion baskets) also provide interstitial space and refuge during drying. **A**, during construction; **B**, completed pool with backwater habitat at right.

Fig. 14 Freshwater crayfish (or kōura; *Paranephrops zelandicus*).

Fig. 15 Upland bully (*Gobiomorphus breviceps*).

Fig. 16 Long-finned eel (*Anguilla dieffenbachii*).