Reconstructing Hamilton's Indigenous Ecosystems: The Waiwhakareke Natural Heritage Park

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Photography as credited

Introduction

The practice of ecological restoration is becoming an increasingly common and effective method to address the environmental degradation of ecosystems around the world. This approach is widely applied to urban ecosystems, which can be significantly degraded by human impacts. Urban ecological restoration strives to improve biodiversity, ecosystem function, resilience, and services, and also enhance environmental aesthetics, educational opportunities, and people's engagement and connection with nature. In New Zealand, ecological restoration has been focused mainly in large national parks and reserves. However, in the last decade, the research and practice of restoration has been expanded to focus on urban ecosystems, which present different challenges and opportunities.

The islands of New Zealand have been isolated in the South Pacific for around 60 million years (Pole 1994), resulting in a unique and highly endemic terrestrial flora and fauna. Recent human settlement (around 1,000 years ago) and the associated habitat destruction and exotic introductions have significantly disrupted many native ecosystems across the country (McGlone 1989). There are now approximately 2,264 introduced species (comprising 30 mammals, 34 birds, and 2,200 plants) that are naturalised in terrestrial habitats and competing with, or predating upon, New Zealand's indigenous species (King et al. 2009). The displacement of native flora and fauna by these introduced species is a primary challenge faced by conservation and restoration practitioners (Norton 2009).

Another key challenge in protecting our unique biodiversity is the scale of landscape transformation and urbanisation of New Zealand. Some 86 percent of the population are urban dwellers and there is a highly fragmented pattern of urban and peri-urban indigenous habitats. Indigenous vegetation cover in the built-up matrix of New Zealand's 20 major urban centres (mean population of 118,764) ranges from less than one to eight percent (Clarkson et al. 2007). These modified ecosystems often include the last representations of depleted coastal and lowland ecosystems and are thus a priority of biodiversity protection and restoration.

Hamilton City

Hamilton (population of 171,600), is an inland city straddling the Waikato River in northern North Island of New Zealand. Its natural ecosystems have been almost completely

ABOVE Six-year-old planting around Horseshoe Lake at the Waiwhakareke Natural Heritage Park (Photo courtesy of Catherine Bryan).

destroyed and only 1.6 percent of native land cover remains in the wider district (Clarkson and McQueen 2004). Those ecosystems that remain are constantly under pressure from disturbances such as habitat destruction, invasion by pest animals and plants, microclimate alteration, land drainage, and residential development. Many ecological restoration projects are underway across the city (Clarkson and McQueen 2004), but Hamilton is increasingly becoming home to a different kind of environmental repair—ecological reconstruction.

In the late 1990's, the lack of natural habitats dominated by indigenous plants and animals in Hamilton City led to a search for ecological restoration opportunities. An area of undeveloped council land around Horseshoe Lake in north-western Hamilton, land-banked by a former mayor Michael Minogue, was identified as being available. However, at this 60-hectare site, almost every element of the native flora and fauna had been removed; there was very little that could be restored. Instead, the City Council, University of Waikato (UOW), Waikato Institute of Technology (Wintec), local iwi, and community groups developed a plan to undertake one of New Zealand's first urban ecological reconstruction projects and named it the Waiwhakareke Natural Heritage Park (WNHP).

An ecosystem reconstruction is the rebuilding of natural elements to create a functioning ecosystem similar to that of a pre-disturbance environment. This process essentially involves "starting from scratch" and thus requires robust scientific information to inform management decisions and minimise mistakes. The pioneer restoration ecologist A.D. Bradshaw pointed out as early as 1983 (Bradshaw 1983) that the ultimate challenge for restoration ecologists is to reconstruct ecosystems. Staff from the UOW have been involved in this project since its conception in 1998, when the former CEO of Wintec, Dr. David Rawlence, proposed it as a millennium project. Since then it has evolved to have a strong ecological approach. The activities at WNHP need to be underpinned by practical experience, local knowledge, and ecological theory. Researchers at the University's Environmental Research Institute provide the ecological expertise needed in the planning, design, and monitoring of the project. WNHP has been set up as a long-term experiment to understand the practical aspects of bringing indigenous nature back into the city.

As many urban environments around the world are significantly degraded, the WHNP project is being undertaken not only to amend this problem in Hamilton City but to also provide a model for the restoration of natural ecosystems in cities across the world. By strongly underpinning our restoration activities with ecological theory and scientific testing, we will be able to provide robust advice on the most successful restoration principles and practices. This can then be disseminated and implemented in other urban ecological restoration or reconstruction projects around New Zealand and internationally.

The land around Horseshoe Lake was deforested, drained, and converted to agricultural pasture 150 years ago. Road and residential development took place in its surrounds and the council-owned land was leased for cattle grazing. WNHP now presents an ideal location for ecological reconstruction; not only because it is effectively a "blank canvas" but also because the varied topography and soils provided the opportunity to recreate the full range of historic local ecosystems.

ABOVE A young volunteer helps with planting at Waiwhakareke Natural Heritage Park (Photo courtesy of Catherine Bryan). BELOW A group of Waikato University staff and students at a recent Waiwhakareke Natural Heritage Park Arbor Day planting event where 30,000 native trees and shrubs were planted by approximately 1,700 people in three hours (Photo courtesy of Marie Brown). RIGHT Satellite images of Horseshoe Lake in the Waiwhakareke Natural Heritage Park showing ecosystem reconstruction progress in 2004 (A) and 2010 (B) (Images courtesy of Google Earth).

Ecosystem Reconstruction at Waiwhakareke Natural Heritage Park

After fencing out the grazing livestock, the first native pioneer plants were planted in 2004 around the lake margins. In just seven years, almost 15 hectares have been revegetated by council staff and volunteers, including school and university students, international visitors, neighbouring residents, and many different community groups.

A range of lowland ecosystems that were once prevalent in the local region will be reconstructed at WNHP. These reconstruction plans are based on historic ecosystem assemblages and ecological theory. Investigations into pollen records, historic archives, and local remnant ecosystems provided the information needed to understand the past compositions and structures of the hillslope, ridge top, alluvial terrace, wetland, and lake ecosystems. As well as this information, local knowledge and practical experience from the city's long standing gully restoration programme have been invaluable (Wall and Clarkson 2006, 60).

The reconstruction of these ecosystems relies on understanding ecological patterns and processes that predict which plants and animals should be reintroduced at each stage. The entire planting plan at WNHP has been designed to mimic natural successional trajectories because research has shown that restoration projects are more successful when pioneer species are planted first, followed by secondary, then tertiary species, and when animals are introduced into appropriate, well established habitats. To understand the progress and ecological processes, permanent vegetation plots, input drains, and the water column are regularly monitored by Waikato University staff.

Restoration that follows a successional framework works because some plants are suited to colonise a site while others do best in an established community. Each group of plants ameliorates the environmental conditions and facilitates the arrival of the next plant group. For example, in the pasture around Lake Waiwhakareke, fast-growing herbaceous New Zealand flax or harakeke (Phormium tenax) and manuka (Leptospermum scoparium) shrubs were planted first because they quickly out-compete the pasture grasses and provide bare soil for the planting of local secondary species that are susceptible to smothering by grasses.

The following section describes the main ecosystem types being reconstructed and the methods being used.


A
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B
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Hillslopes

Hillslopes of the Waikato region were originally covered in mixed broadleaved podocarp forests, dominated by tawa (*Beilschmedia tawa*), a member of the laurel family, and rimu (*Dacrydium cupressinum*), a tall emergent podocarp (Burns and Smale 2002). This forest ecosystem had many other tree and shrub species including the lancewood (*Pseudopanax crassifolius*), a distinctive small tree that changes its leaf form between juvenile and adult stages, and rewarewa (*Knightia excelsa*), a member of the protea family with scarlet honeysuckle-like flowers. Flowering climbers from the genera *Metrosideros* and Clematis were common and nest epiphytes *Collospermum* and *Astelia* were prominent in the treetops.

Many pioneer or early-succession trees and shrubs have been utilised in the initial plantings for this forest type, including karamu (*Coprosma robusta*), kohuhu (*Pittosporum tenuifolium*), lacebark (*Hoheria sexstylosa*), and mahoe (*Melicytus ramiflorus*). In tandem with the planting programme, parts of the hillslope zone were selected as experimental sites to trial different treatments for weed suppression and the promotion of moisture retention. Treatments included the use of 100-milimetre-thick mulch, planting straight into the ground with no mulch, and the placement of recycled paper plates around the base of the plants (eco cover) (Hamilton City Council 2010).

While the paper plate treatment proved ineffective, as resident swamp hen or pukeko (*Porphyrio porphyria*) removed them to access invertebrates, survival rates were strongly influenced by drought and ground cover. Significant losses were recorded in areas that were not mulched during an unusually long drought period. Two years later, the unmulched hillslope had half the canopy cover of the mulched area and a greater abundance of weed species. These findings were immediately adopted in new plantings with other drought-prone areas being mulched (Hamilton City Council 2010).

Ridge crests

Ridge crest forests originally consisted of conifer-broadleaved forest with species adapted to well-drained soils. Most notable was the mighty kauri (*Agathis australis*), a member of the ancient Araucariaceae family. This tree is a canopy emergent which can exceed 30 metres in height, more than two metres in diameter, and live in excess of 1,000 years (A*hmed and Ogden 1987*). Resin or gum exuded from trunk wounds of former kauri forests can still be found in the soils of the surrounding Rotokauri district. Trials are being conducted to compare the success of directly planting the kauri with treatments where either small-leaved shrubs and trees (*Leptospermum and Kunzea*) or broadleaved trees (e.g., *Pittosporum or Hoheria*) provide an initial nursery cover. Also included in the ridge crest plantings is *Phyllocladus trichomanoides*, the celery pine which has distinctive flattened stems in place of leaves.

Alluvial terrace

The Hamilton area was historically dominated by forests of alluvial floodplains and swamps but these have been almost completely removed for agricultural land use (Burns and Smale 2002). These forests were dominated by tall kahikatea (*Dacrycarpus dacrydioides*), but also contained other trees such as the large buttressed pukatea (*Laurelia novae-zealandiae*), and the regionally rare swamp maire (*Syzygium maire*) (Burns and Smale 2002).

The alluvial terrace plantings were initiated in 2004. Permanent monitoring plots have been established and are remeasured annually. The variables which are monitored within these plots include height, width (canopy cover), plant health, browse presence, weed presence, and the presence of flowers and fruits. In addition, ground cover is assessed throughout each of the plots using a point-height intercept method (Cornes et al. 2008).

To understand the most effective restoration techniques, a variety of planting combinations were trialled on the bare sites. The hypothesis here, as in other zones, was that plantings would be most successful when they followed a successional framework. This involved planting early successional species first, followed by enrichment planting of secondary and tertiary species. Monitoring results support this hypothesis and clearly show that late successional species have poor survival rates when planted out into an environment without the shelter of a colonising canopy.

Soil fertility had been enriched by the previous agricultural land use and this has led to fast canopy development in the early succession plantings. In sites with most rapid growth, canopy closure was achieved after only two years at a height of two to three metres. Once canopy closure was achieved, weed species were suppressed and native seedlings of the canopy species established. After four years, ferns began to colonise the site, and after six years, fern diversity had increased. One seedling of a native species not planted in the park was found after six years, showing the onset of regional dispersal and recruitment. Survival of plants was strongly affected by micro-habitat variation: areas that are under water for a few months of the year had relatively high losses, especially of woody species (Cornes et al. 2008).

Wetland

Wetland ecosystems are being reconstructed around the margins of Horseshoe Lake. Restiad bogs were the main wetland ecosystems in the Waikato region but less than 10 percent now remain. They are low nutrient peat-accumulating systems, which are dominated by the peat forming species wire rush (*Empodisma minus*) and cane rush (*Sporodanthus ferrugineus*), both members of the Restionaceae family (*Clarkson 2002*). The wire rush is the keystone species or ecological engineer of this system with its upward-growing peat-forming cluster roots (*Clarkson 2008*). These restiad bog types are unique to New Zealand and include several threatened species, including the cane rush, which is host to the recently-discovered "world's thinnest caterpillar"—*Houdinia flexissima*; black mudfish (*Neochanna diversus*); the North Island fernbird (*Bowdleria punctata veleae*); and several herbs and ground orchids. Other species of interest include carnivorous plants such as sundews (*Drosera*) and bladderworts (*Utricularia*).

Restoration research on these restiad bog systems (Schipper et al. 2002) has been applied to the reconstruction of a bog at WNHP which required the establishment of a peat mound and introduction of the two key species: wire rush and cane rush. The reconstructed bog is 15 by 25 metres on the north-eastern side of the lake. Existing vegetation at the site was removed along with the upper, fertile layers of soil. This resulting depression was filled with a mound of peat that was sourced from a bog remnant in the northern Waikato (Torehape). Juvenile cane and wire rushes were planted with five to six plants per square metre. Weed control has been undertaken regularly (Clarkson 2008).

Two years after reintroduction at WNHP, over 80 percent of plants were flowering: this is a promising sign for the natural regeneration of the ecosystem. Furthermore, there are encouraging signs that the rare moth species (*Houdinia flexissima*) continues to thrive in the culms of the transplanted cane rush (T. Cornes, The University of Waikato, pers. comm. 2011).

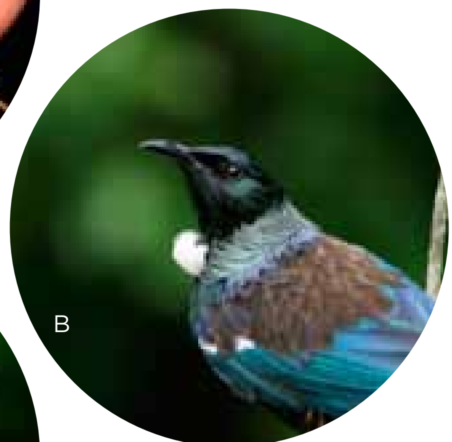
Lake

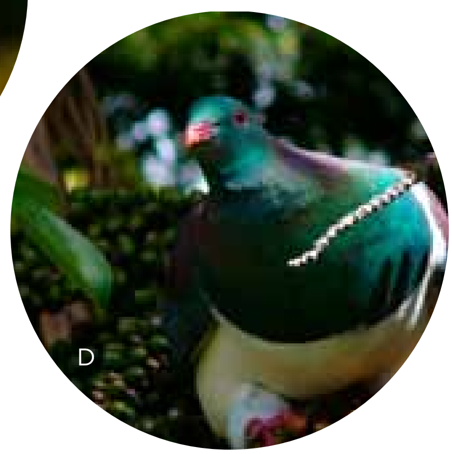
Horseshoe Lake is a peat lake formed through isolation by a natural levee of the Waikato River some 15,000 years ago. This ecosystem is targeted for both restoration and reconstruction because some natural elements are still present. The lake was historically dystrophic and therefore characterised by large quantities of organic mineral, high acidity, low nutrient levels, and low productivity. However, the recent human disturbance and surrounding agricultural land use have led to an influx of nutrients and lake eutrophication. The restoration challenge will not only be returning the lake to its original dystrophic peat lake condition but also mitigating ongoing nutrient and contaminant input from surrounding residential and farmed areas (Corkill 2009). Results from a recent lake nutrient budget study suggest that mesotrophic status is a realistic outcome of revegetation of the catchment (Duggan 2011).

Freshwater surveys in Horseshoe Lake have identified both native and exotic fauna. Fortunately, koi carp, which cause problems in other Waikato lakes, are not currently present, but brown bullhead catfish (*Ameiuris nebulosus*), rudd (*Scardinius erythrophthalmus*), and other pest fish are present in significant numbers (Duggan 2011). Electro-fishing and capturing is a potential method to control pest fish numbers. Monitoring will be continued so as to keep track of population changes and assess the potential of reintroducing absent native species.

Eco-sourcing

All the plants that are used at WNHP are eco-sourced: the seeds used for propagation have been collected from the local ecological region. The advantage of eco-sourcing is that the plants are adapted to local soil and climatic conditions, thus increasing their likelihoods of survival. Because species often have local gene pools, eco-sourcing also preserves the genetic integrity of the region. As ecological





ABOVE Threatened or uncommon indigenous species that could be reintroduced to Waiwhakareke after the installation of a predator-proof fence: giant weta (*Deinacrida rugosa*) (A), tui (*Prosthemadera novaeseelandiae*) (B), fantail (*Rhipidura fuliginosa*) (C), and kereru (*Hemiphaga novaeseelandiae*) (D). (Photos courtesy of Kahori Nakagawa, JimTheGiantEagle, The Waxhead, and Catherine Bryan).

restoration has become common practice in New Zealand, nurseries have begun to meet the demand for native eco-sourced plants. It has taken some time but there are now seven nurseries in the Hamilton area that source for seeds and grow quality local plants. These include the Hamilton City Council nursery, which practices eco-sourcing for the restoration of council properties. Eco-sourcing is also promoted by the regional council and all parties involved in the WNHP (Hamilton City Council 2010).

Education

As the park is on the north-western edge of urban Hamilton, in close proximity to the city's zoo, and as the city is still expanding, the park is ideally located for education and recreation experiences. Project managers are planning a connection between the park and zoo so as to provide a diverse and interactive ecological experience for visitors in the future. To facilitate environmental education, the construction of a Conservation Education Centre is planned in a location central to the two attractions. The park is already used in ecological, horticultural, economic, and tourism teaching at both the University of Waikato and Waikato Institute of Technology. It is anticipated that the area will play an important role in tertiary, secondary, and primary schooling as the ecosystems mature. This could include studies from almost any subject area, making the park a very important educational facility (Hamilton City Council 2010).

Pest control

As already explained, invasive pest species out-compete and/or predate upon indigenous birds, plants, and insects. Because native species have a long history of evolutionary isolation, they are generally vulnerable to fast-growing, aggressive pest species. It is therefore imperative that WNHP has appropriate pest control during all stages of development. In time, it is intended that most of the park will be enclosed by a predator-proof fence to keep unwanted exotic plants and animals out. Predator-proof fences were first designed in New Zealand for a small private conservation project (*www.xcluder.co.nz*). The design was then applied to the large scale pest-eradication project at the Maungatautari Ecological Island and is now installed at 14 sites across New Zealand and at two sites in Hawaii.

The key characteristics of this fence are: the rolled hood that prevents climbing mammals such as cats from jumping over; the fine mesh that inhibits penetration, even by juvenile mice; and a buried mesh skirt that denies access to animals capable of tunnelling. It is also possible to install a monitoring sensor system that informs managers of fence damage after tree fall, and so forth.

This fence should be relatively easy to install along the clear edges of the WNHP but will require a significant financial commitment, which is often the main obstacle to the effective employment of this conservation tool (Scofield et al. 2011). The costs as opposed to the benefits of predator-proof fences are widely debated in New Zealand (*www.forestandbird.org.nz/what-we-do/publications/forest-bird-magazine/articles-archive/both-sides-the-fence*). Those in opposition of it often argue that the funding of the fence could be more effective in other conservation activities, while advocates argue that, since there is no other way to remove pests completely, the opportunity to restore and understand natural ecosystem processes that were previously displaced by pests is priceless.

Staff at the Environmental Research Institute support the plan to install a predator-proof fence at the WNHP as part of a vision to create a network of protected forest patches across the Waikato region that will provide sanctuary, habitat, and resources for native fauna. The predator-proof fence will allow for the reintroduction of threatened species, such as the North Island brown kiwi (*Apteryx mantelli*), brown teal (*Anas chlorotis*), and giant weta (*Deinacrida rugosa*). The pest-free haven will also attract many other bird species from surrounding areas, including locally uncommon species, such as the fantail (*Rhipidura fuliginosa*), grey warbler (*Gerygone igata*), kereru (*Hemiphaga novaeseelandiae*), and tui (*Prosthemadera novaeseelandiae*), and most importantly, provide them with predator-free nesting sites. These species have lost the majority of their native habitats as a result of human activities and competition or predation from introduced species. Therefore, reintroducing species or enhancing their breeding opportunities in the urban matrix of Hamilton City will provide great benefits to New Zealand's wider conservation efforts, not only in boosting population numbers but also by increasing urban residents' awareness, engagement, and appreciation of their own natural heritage.

ABOVE Predator-proof fence at the Maungatautari Ecological Island, near Hamilton. A similar fence is planned for Waiwhakareke Natural Heritage Park in the future. (Image courtesy of Catherine Bryan and Xcluder).

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