Restoration planting in urban environments

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Since the year 2000 we have been involved in numerous restoration planting projects in urban environments. Our work has focussed mainly on sites within the city of Hamilton, but we have also been involved with projects in other New Zealand cities, such as New Plymouth and Tauranga. Our approach to restoration planting has involved a combination of science and practice.

While the main aim is always to restore, reassemble or reconstruct plant communities dominated by native species, we also try to inject as much science into our projects as possible – research by management. The science underpinning is essential to understand specific site conditions, species selection, species composition, ecosystem processes and to monitor progress.

Findings from our work have helped shape the best practice techniques for restoring indigenous plant communities in urban environments. Some main restoration planting principles are covered below along with two case studies from Hamilton. While we have focussed on urban settings, the principles and examples given are broadly applicable to plantings in the peri-urban and rural zones, especially riparian planting.

Start with a plan

Successful restoration plantings start with a plan. The plan does not have to be too complex or detailed but it should map out the main steps needed to achieve the aims of the project and provide lists and quantities of the plants needed over the lifetime of the project. The Gully Restoration Guide describes how to develop a simple concept plan and outlines the nine main steps in restoring a Hamilton gully site.

Historical ecology

The best way to guide what to plant on your site is to define a reference ecosystem – what you are aiming for. Understanding the historical ecology of a site is important for setting realistic restoration aims and defining a restoration target. A frequent aim of restoration is to produce an ecosystem which is similar in function, structure and composition to the forest or other vegetation that would have historically been on the site. This may entail using a nearby undisturbed site as the model or reference ecosystem.

A reference ecosystem is an actual ecosystem or a conceptual model used in setting objectives and planning a restoration project, and later in its evaluation and assessing success. In some situations the reference ecosystem is assembled from a combination of historic records, multiple nearby sites and from other sources.

Every planting site has a unique set of physical conditions that will influence plant growth. Local site characteristics such as distance from the coast, the direction the slope faces, topography, soil type and drainage will all determine what will successfully grow there. Matching species preferences to site conditions by careful site selection is rewarded by greater survival and growth of the species planted.

Successional framework

Plant communities change as late arriving species grow up in the shade and shelter of the first stage or pioneer plants. Understanding natural processes of succession and regeneration is important when it comes to restoring a forest or wetland and putting plants in the ground. We can use natural succession as a guide or model for when to successfully plant a given species at a restoration site. However, special consideration needs to be given to urban sites heavily affected by human activity. Soils, for example, may have higher than normal nutrient status or be heavily compacted and require some amelioration.

Early succession – pioneer or early stage species such as karamu, manuka and kanuka grow well in the open and their fast growth helps to quickly suppress weeds. However, because many of these pioneers are short lived they lose vigour after about 10 or 20 years. This dieback will let weeds re-invade unless the middle and late stage species are already well established. The middle and late stage species such as tawa and pukatea require less light than the early species, and their juvenile stages are often frost sensitive so they cannot be planted until you have established some cover.

In urban sites you often need to enrich pioneer plantings with these later succession

species as they may be in low abundance or a long way from the restoration site. Both the seed source and the dispersal agents, large native birds such as kereru, are often limited or missing.

In Hamilton, well drained sites with initial planting of lacebark, kanuka, totara, matai, wineberry, lancewood and kowhai need to be under-planted or enriched with tawa, mahoe, hangehange, kawakawa and tanekaha and mapou after 10 or 15 years. Planting these into canopy gaps or light wells opened up by hand or as they form naturally, will increase their growth rates.

On moister sites, karamu, manuka, swamp sedge, wheki and ribbonwood are often planted as pioneers and later enriched by under-planting with pukatea, swamp maire, rimu, kiekie and swamp coprosma. Hardy broad tolerance species such as kahikatea, cabbage tree and harakeke are usually planted with the pioneers.

Epiphytes and vines

Ecological restoration is not only about the trees and shrubs. The temperate evergreen rainforests of New Zealand are structurally multi-layered. Each of these layers supports a range of life which play an important part in the functioning of the forest. Just as late successional tree species may need reintroducing, so too is the case for shade tolerant late successional shrubs. Forest plants which are regularly overlooked in restoration research and planning are in the canopy – the epiphytes, vines and mistletoes.

Epiphytes are plants that perch on other plants without a parasitic connection, vines are the climbers in the forest and mistletoes are hemi-parasites which remove water and some nutrients from their hosts. New Zealand have surprisingly abundant and diverse epiphytes that contribute to the water and nutrient cycles of the forest as well as the provision of habitat and resources for animals. Although there is much still to be understood about these aerial plants, a restored forest, even in an urban environment, should have canopy plants.

Our research indicates that the main limitation for canopy flora in urban forests is humidity. Unlike large tracts of native forest, humidity in fragmented urban forests fluctuates with any change in the surrounding built environment. Canopy plants rely on moisture and nutrients from the atmosphere, so the inconsistent urban humidity appears to be inhospitable for this component of forest life. The inclusion of epiphyte and vine species in ecological restoration requires reintroductions by relocating juvenile or mature plants, or introducing seed into suitable substrate. Where possible, epiphytes should be planted near or in existing epiphyte groups because they indicate suitable conditions. In new plantings, epiphytes should not be introduced until the trees are large enough to provide structure and support.

Ecosourcing

Ecosourcing refers to the use of local plants and seed for restoration planting. Where possible, plants should eco-sourced from naturally occurring populations in the same ecological district as the planting site, with a focus on plants from similar landforms. This is because plants growing naturally in the nearby region will be well adapted to local conditions. Sourcing plants locally also ensures genetic variation between populations throughout New Zealand is maintained, which may be important for the long-term species survival.

It is also important that high genetic diversity is maintained among the plants at the restoration site. Eco-sourced plants should be supplied from as many sites and covering as large an area as possible within the ecological district. Information on the location of the parent plant should also be recorded.

Hamilton case studies

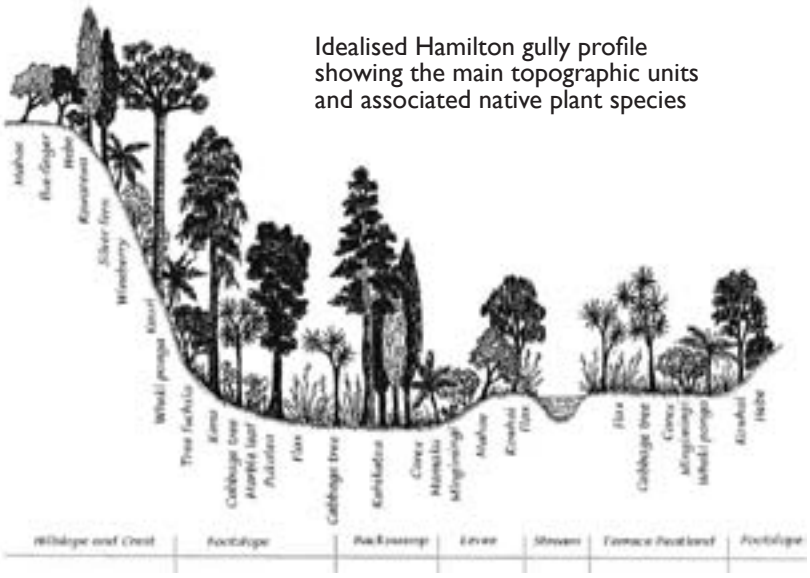
Gully network

The Hamilton City gully network, which occupies about eight per cent of the city's total area, has been the focus of a city-wide restoration of indigenous ecosystems. The formation of the gully landforms started around 15,000 years ago when the Waikato river cut down into its present course exposing springs along the riverbanks. As water drained from the surrounding land, these springs undermined the banks, causing slips and creating a network of streams draining into the Waikato river. This process was regularly repeated giving rise to erosion and the formation of the steep-sided and intricate network of gullies that adjoin the river.

Many of the gully forests feature a developed canopy of native and introduced trees over a sparse understory and a ground cover consisting of exotic herbs and dense mats of wandering Jew. The understory is often characterised by a reduced number of native species in comparison to rural old-growth forests surrounding the city.

The original pre-human gully vegetation has been deduced from historical records, the composition of extant remnants and from macrofossil deposits. This information provides us with a template for developing restoration objectives and selecting the native plants appropriate for restoration plantings in a gully system. Many of Hamilton's gullies originally contained semi-swamp forests dominated by

kahikatea, pukatea and swamp maire. However, currently the exotic deciduous tree grey willow has displaced much of the kahikatea because it rapidly colonises disturbed sites, has much faster growth rates and has the ability to maintain dominance by vegetative reproduction. A challenge to restoration and native planting in Hamilton's gullies is to reinstate a native evergreen dominated canopy.



Idealised Hamilton gully profile showing the main topographic units and associated native plant species

The Hamilton City Council, local community groups and private landowners have been intermittently undertaking restoration within the gullies since the mid-1970s, with a more ecologically guided approach from the early 1990s. This has involved a range of different restoration strategies, including complete weed clearance and replanting of the site, canopy manipulation of grey willow and other exotics, and enrichment planting.

Our research has shown that the seed, rain and soil seed banks in urban forests have much higher exotic species richness, including many woody species capable of displacing native canopy trees such as shining privet, Chinese privet, Japanese honeysuckle and ivy. These findings underscore the need for enrichment planting, particularly for native species with limited dispersal or short-lived seeds. Clearing weeds from a site should also be immediately followed by dense native planting to ensure the disturbance does not enable a new crop of weeds to regain dominance.

Waiwhakareke Natural Heritage Park

In the late 1990s a lack of natural habitats dominated by native species led to a search for further restoration opportunities in Hamilton city. This resulted in the 60 hectare site containing a peat lake, known as Waiwhakareke, being designated as a natural heritage park in 2004. This area of land had been deforested, drained and converted to pasture more than 150 years ago. As a result of years of grazing and fertilisation the lake was severely degraded. Waiwhakareke represents the ultimate challenge to restoration, to completely re-construct the full range of local indigenous ecosystems from lake edge wetlands to ridgetop forest

The reconstruction plans are based on historic ecosystems as well as ecological theory. Historic archives, pollen records and nearby remnant forests have provided the basis for planting composition. The ecosystem types to be reconstructed include –

- Kahikatea-pukatea semi-swamp forest
- Harakeke-sedge lake margin and swamp
- Kauri/kanuka ridge crest forest
- Tawa/rimu hillslope forest
- Lake/aquatic habitat

Historically, semi-swamp forest and swamp vegetation were the most characteristic vegetation types within the Hamilton basin, being widespread on the large areas alluvial floodplains, the lake margins and gully bottoms. The poorly drained gully floors and their associated back-swamps were dominated by kahikatea, pukatea, swamp maire, cabbage tree and pokaka.

Understorey and ground cover species included mapou, fuchsia, lancewood, pate, *Coprosma rotundifolia, Astelia grandis,* kiekie and supplejack. Swamp shrubland grew on low-lying sites of the plains, gully bottoms and the margins of the peat lakes and bogs where the water table did not permit tall forest. Here flax, cabbage tree, sedges, swamp coprosma, *Coprosma propinqua,* manuka, *Dianella nigra,* and *Hypolepis distans* dominated.

Replanting native vegetation at Waiwhakareke began in September 2004. Successive plantings have taken place over the years and to date some 24 hectares have been planted. Baseline monitoring plots were established during the early stages of restoration plantings to assess –

- Canopy cover and closure in plantings
- Plant health and survivorship rates
- Animal browsing impacts on plants
- Reproductive output of plants
- Groundcover composition.

The results from our monitoring plots guide future plantings. We have also developed a geographic information system to help with determining species composition and quantities for forward ordering of enrichment plantings.

Conclusions

The strategy adopted for restoration planting varies

depending on a range of factors including the site conditions, access to volunteer labour and the need to protect extant plant communities. Our two case studies contrast what is needed to replace grey willow forest and other exotics in Hamilton gullies and how to reconstruct native plant communities from scratch on long farmed grazing pasture.

Our studies show that it is possible to establish indigenous dominated closed canopy low forest between five and seven metres on a ridge or hillslope, or a harakeke and sedge swamp with sapling kahikatea and swamp maire within seven to

Kikirikiriroa Gully, Hamilton showing kahikatea and harakeke semi-swamp forest 22 years after clearance of grey willow and crack willow forest

Mangaiti Gully, Hamilton showing a *Carex secta* sedge dominated wetland seven years after clearance of grey willow and crack willow forest

Horseshoe Lake at Waiwhakareke Natural Heritage Park, Hamilton showing restoration planting, on the lake margin all less than 10 years old

Main restoration strategies and steps for restoration planting

12 years. However, the thresholds for dominance of the seed rain or seed banks needed to change to native dominance in the absence of intensive active management do not begin to assert until at least 20 years.

Many of the native species become reproductively mature earlier than we expected and regeneration from seed of planted trees and shrubs may begin as early as five years. However, the threshold for significant regeneration by native species is not reached until at least 20 years. Native ferns do not need to be planted and colonise restoration plantings without assistance as the canopy closes and provides suitable shaded habitat.

Using a successional framework, focusing on getting the right plants in the right microsite, and regular releasing and aftercare, all enhance the chances of success. Enrichment planting before the decline of the pioneer canopy trees and introduction of late successional species which have colonisation limitations are important. Broadening the range of indigenous species currently used may build greater resilience to future change. Changing ecosystem dominance from exotic deciduous trees to indigenous evergreen trees will help, but not completely solve, some of the current weed problems. Shifting the local seed rain balance from exotic to indigenous brings us closer to the threshold where it will be more likely that regeneration and recruitment will be of indigenous species rather than ubiquitous exotics. Consideration of all components of the ecosystem, not just the trees, promotes development of a fully functioning restored ecosystem.

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