Urban Greening Manual

How to Put Nature into Our Neighbourhoods

Application of Low Impact Urban Design and Development (LIUDD) Principles, with a Biodiversity Focus, for New Zealand Developers and Homeowners

Maria Ignatieva, Colin Meurk,
Marjorie van Roon, Robyn Simcock
and Glenn Stewart

Manaaki Whenua PRESS

Landcare Research Science Series No. 35

Coastal plant signature featuring sand coprosma, sea spurge, sedges, ngaio and cabbage trees, New Brighton, Christchurch. Photo: Colin Meurk

Scree garden plant signatures on the Wellington Waterfront – featuring sedges, knobby clubrush, silver and other tussock grasses, rengarenga, pohuehue, NZ iris, NZ linen flax and reeds in swales beyond. Photo: Colin Meurk

Governors Bay native bush and rock gardens, the latter employing korokio, pohuehue, mikimiki, NZ flax, lancewood, and cotulas in the lawn. Photo: Colin Meurk

Large scale formal native (and adjacent conventional English) garden with totara, matai and miro hedges, kahikatea avenue, copses of different tree types and a diverse New Zealand border of trees and shrubs, Broadfields, near Prebbleton, Canterbury. Photo: Colin Meurk

Urban Greening Manual

How to Put Nature into Our Neighbourhoods

Application of Low Impact Urban Design and Development (LIUDD) Principles, with a Biodiversity Focus, for New Zealand Developers and Homeowners

Maria Ignatieva, Colin Meurk, Marjorie van Roon,
Robyn Simcock and Glenn Stewart

Manaaki Whenua PRESS

CATALOGUING IN PUBLICATION

How to put nature into our neighbourhoods : application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners / Maria Ignatieva … [et al.]. -- Lincoln, N.Z. : Manaaki Whenua Press, 2008.
(Landcare Research Science series, ISSN (print) 1172-269X ; no. 35)
ISBN: 978-0-478-09397-1
ISSN (electronic) 1178-3419

1. City planning -- Environmental aspects -- New Zealand. 2. Biological diversity conservation -- New Zealand. 3. Urban ecology -- New Zealand. I. Ignatieva, Maria E. II. Series.

UDC 502.33:711.4(931)

Published by Manaaki Whenua Press, Landcare Research,
PO Box 40, Lincoln 7640, New Zealand

Contents

Introducing LIUDD

Low Impact Urban Design and Development (LIUDD) is a **sustainable living** concept. Urban sustainability and health are achieved through effective management of stormwater, waste, energy, transport and ecosystem services. The greening of cities by planting ecologically with local species is also a vital part of the overall well-being of ecosystems and citizens. **Biodiversity** (Box 2) or nature heritage contributes to enduring **sense of place** or identity – a key element of **nationhood**.

This manual is for the town dweller, developer, landscape designer and planner – and provides practical applications from nearly a decade of LIUDD research across New Zealand. It summarises and links to information regarding the physical and built environment, but its **focal point is nature heritage** and overcoming attrition and critical loss.

LIUDD implements principles of landscape, urban and catchment ecology and design in action. These principles and associated methods are summarised in Appendix 1. Specified links throughout the manual emphasise the integrated nature of LIUDD. Here we concentrate on methods that specifically involve vegetation planning, protection, restoration, planting and maintenance. Follow-up manuals in this series will focus on other methods in Appendix 1.

LIUDD emphasises 'going with the flow' or modelling urban catchments on natural river systems by installing **treatment trains** (Section 2.1) - from green roofs to detention ponds. Energy and carbon efficiency is now a 'convenient truth'. Cost-effective design and development works *with* nature – creating community environments that respect, conserve, and enhance natural processes and achieve **landscape legibility**[1] by retaining landforms and remnant vegetation, and using **plant signatures**[2] to profile biodiversity. By creating **stepping stones** or **green corridors** of favourable habitat we encourage native birds back into cities. Harmsworth (2004) expresses in the following a tangata whenua perspective, integral to LIUDD philosophy:

> The challenge in the future is to develop forward thinking strategies that encourage people towards more sustainable forms of development, to move away from: short term piecemeal planning, highly consumptive waste behaviour, high and increasing demands on energy use, rising infrastructure costs, rising transport demands, greater demands on land and building space, increasing urban human health problems, decreasing environmental quality, neglect of cultural issues and factors, the domination of artificial human environments over natural systems, the decreasing role the natural environment plays in the lives of urban populations, and a lack of awareness and understanding of the significance of natural ecosystems and ecosystem services within urban environments, especially for human well-being.

For biodiversity to be culturally relevant, and therefore wanted, it must be visible and readable (Meurk & Swaffield 2000, Louv 2006). Thus city-dwellers must see nature where they live if the highly threatened habitats and species of lowlands and coasts (quite different to the largely protected mountain nature) are to become identified with, and thereby secure. We hope here to demonstrate the surprising potential of, and methods for, enhancing natural biodiversity in urban environments. Natural heritage may then rightly share the stage with valid cultural layers. So, here is how you can try something new and make a difference.

---

[1] Legibility is about reading our history as we walk through the landscape – including the cityscape where most people live.

[2] Plant signatures are combinations of plants that are particularly memorable and identify a particular place (Robinson 1993). They do not mimic specific wild habitats but are reminiscent of them (inside front cover).

Part One: Structure planning methods for sustainable subdivisions

These methods are about anticipation of effects, achieving energy and transport efficiency and sustainability, accommodation, optimisation and integration of diverse values, and conserving history. The process is recently demonstrated in the development of the Taupo West, Long Bay and Flat Bush structure plans. Website links for these structure plans are: www.landcareresearch.co.nz/research/built/liudd/casestudies/case_taupo.asp ; www.nscc.govt.nz/our_environment/Long_Bay/overview.htm and www.manukau.govt.nz/default.aspx?id=382 respectively.

1.1 Survey to identify and protect significant natural vegetation and other values[3]

Patches of original native vegetation (no matter how degraded) are precious heritage and are essentially irreplaceable. Contemporary landscape patches may be composed of remnant or restored native trees, shrubs, ferns and/or grasses, and also exotic woods – which may also have some value as habitat or nurseries. **Avoid removing** such **habitat** at all cost! We don't have much left in the low country of New Zealand.

Old, historic or **noble**[4] trees, that are indigenous, or are beneficial 'safe' exotics, should be protected in place and when they decline replaced with longer-lived and more beneficial species with a larger indigenous component (minimally 10-20%). Old water races (such as on the Canterbury Plains) and stream banks that support swamp kiokio[5], sedges and rushes should be carefully protected and managed back to health where they have become weed-infested or otherwise degraded. These are often all that remains of the once abundant wetland vegetation of lowland plains and it is always easiest to build habitat around remnants (Figure 1) (even an individual bush or fern) rather than clean everything out and start from scratch, in the belief that mitigation is compensation!

Be careful about 'reclaiming' or converting marshy paddocks into ponds, because wet *land*, with all its rare diminutive plants, is not the same as relatively sterile or eutrophic *water*. Stagnant ponds and lakes full of mallard ducks are now a common commodity because of such conversions. More ponds is a good thing, but a botanist may need to check the minutiae of the wet paddock before it is turned into something of less value; if it has been cultivated in the past it is unlikely to retain much of interest.

By protecting vegetation in place, topsoil and subsoil, along with their crucial fauna, fungi and bacteria, are also protected. The properties of the upper subsoil (0.2 to 1 m depth) can be critical in supporting ecosystems, and may be altered dramatically when subjected to earthworks, particularly in fine-textured soils.

Within this context, archaeological and other cultural artifacts or associations must receive due attention. These considerations are however beyond the scope of this manual.

---

[3]Expands on methods 3.1.1 to 3.1.7 in van Roon & van Roon (2005).

[4] 'Noble tree' is a term used in Europe to denote the grand, long-lived and characteristic trees of the continent – oak, elm and linden. In a New Zealand context we are talking about podocarps (totara, rimu, matai), elaeocarps (hinau, pokaka), lemonwood, ribbonwood, lacebark and cedar; confined to the north are kauri, pohutukawa, rewarewa, puriri, taraire, tawa, titoki and maire tawake; then in drylands the smaller kowhai, kanuka and cabbage trees may have this status. Large trees also store the most carbon by far, so planting more long-lived podocarps, etc., affords urban environments a role in slowing climate change.

[5] Common plant names are used in the text where they are unambiguous. The scientific name equivalents are listed in Appendix 2.

Figure 1: *Water race with spike sedge, tussock sedge and swamp kiokio (fern), but also the attractive introduced weed kaffir lily (*Schizostylis coccinea*). Water races are now the last bastion of wetland plants and wildlife across large tracts of the Canterbury Plains. Photo: Colin Meurk*

1.2 Respect existing topography and landforms as part of the legible landscape[6]

The microtopography of even relatively flat plains tells stories about former coastlines, river meanders, and floods or cultural disturbances. It is desirable to preserve these features – old sand dunes, oxbow lakes and river terraces – rather than filling and planing them off flat. The Canterbury Plains are a good example where there is so little natural relief it is especially destructive to lose these subtle landforms, which may otherwise, if interpreted innovatively, embody a history and create a distinctive sense of place.

1.3 Identify green connections or links that ensure natural values and healthy catchment processes are maintained and enhanced[7]

Some structural elements of the landscape function not only as drainage conduits for the catchment, as borders, contour erosion control, or shelter, but also as **green corridors** for wildlife. Visually there are also horizons such as the Christchurch, Port Hills ridgeline or inland ranges. These vistas and landmarks should be protected, featured or windowed to provide context and orientation and thereby form the structural framework for subdivision planning. Protection needs to include legal protection via such mechanisms as covenanting or fairly compensated acquisition with appropriate conservation status.

Types of green corridors

Rivers, streams, water races, drains, floodplains, shelter belts, hedges, field boundaries, road and rail verges, embankments and tracks may all act as preferential pathways for wildlife and plant dispersal (Figures 2 and 3). These linear features may be **continuous** corridors (rivers), or fragmented **stepping stones** (hedges and woodlots). Many terrestrial animals are quite capable of jumping or flying from patch to patch. At the same time **discontinuous barriers**, such as discrete patches of dense riparian vegetation, create framed windows that can inspire mystery and surprise. This, together with stretches of wide panoramic views, fulfills a range of aesthetic preferences while ensuring habitat integrity along those stretches where the river or pond edge zonation forms an intact sequence or gradient.

[6]Expands methods 3.2.38 to 3.2.39 in van Roon & van Roon (2005).

[7]Expands methods 3.4.13 to 3.4.16 in van Roon & van Roon (2005).

Figure 2: *Green corridors for Lincoln village, South Island, New Zealand. Design: James Rea, 2006.*

Figure 3: *Power line – bike trail corridor. Design: James Rea, 2006.*

Another form of discontinuity is mixed-species corridors allowing for some areas of indigenous dominance, some of exotic species, and other stretches with a combination – again encapsulating the diverse heritage of the land.

When providing walking, cycling or horse-riding paths along linear features such as river flood plains, ensure that they don't take up only the best, most central and productive part of the corridor, but provide for representative protection of all the environments and experiences. Paths should have most of their length near the edges of corridors to reduce disturbance and fragmentation of core 'sanctuary' habitats (as shown in Figure 4). Predator control may be needed along connective corridors as they may be used by pests as well as by native wildlife.

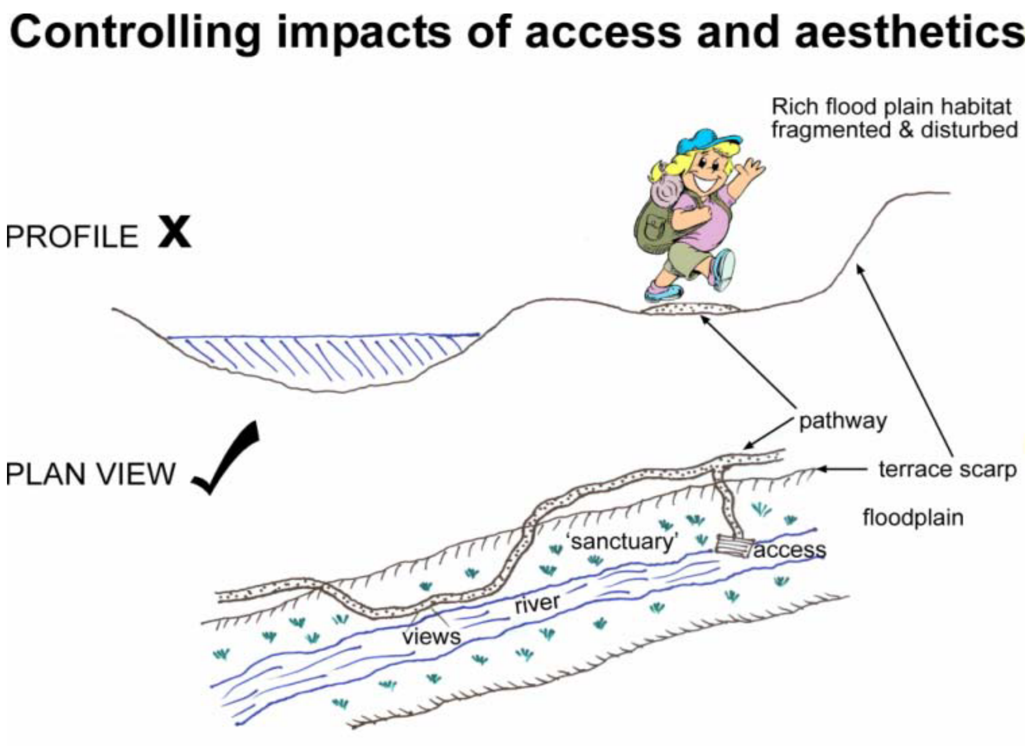


Figure 4: *Track siting (lower plan view) to optimise views, recreational landscape experience and representative protection of riparian habitats.*

Native plants for stream corridors according to wet and dry zones[8]

Soil and moisture conditions vary greatly close to water bodies (streams, rivers, ponds or lakes). In a dry climate, not only do soil conditions change from aquatic to semi-arid within the space of a few metres (depending on the steepness of the bank), but these conditions fluctuate according to prevailing weather.

It is common to speak of **zonation** along such margins – parallel bands of distinctive vegetation that reflect the underlying average moisture or flooding conditions. These, in an idealised profile, are described in various streamside planting guides but are summarised as water's edge, lower bank, upper bank, levee crest, floodplain backswamp, lower terrace scarp, upper terrace scarp, and terrace top (or tread) as designated in Figure 5 and diagrammatically depicted in Figure 6. Not all zones are always present. In general, zones that are frequently flooded have herbaceous, fern, reed or tussock species, whereas further away from the channel are shrubs and trees. Introduced willows can disrupt this natural sequence. Optimum sites are permanently moist (yet not waterlogged) and fertile and support the largest trees.

Water's edge and periodically wet floodplain

Pukio (*Carex secta, Carex virgata*), toetoe, NZ flax/harakeke, rushes (*Juncus edgarae*, *J. sarophorus*), mikimiki (*Coprosma propinqua*), koromiko, cabbage tree, manuka, swamp maire tawake (in north), kahikatea, pokaka (pukatea in north) and *Astelia grandis*, kohuhu, lowland ribbonwood/manatu, lacebark (use the local species) and wineberry. Once the initial cover is

[8]All planting lists in the text are, except where otherwise qualified, first-stage or 'front line' structural species that are generally fast growing and robust and can tolerate frost, exposure and competition. A large number of other ground, vine or more tender species can be added later according to more detailed lists (see links elsewhere). However, many of these later-stage species are not readily available from plant nurseries at present. Species lists are either in sequential order along a gradient (such as wet to dry here), or are in order of preference – vigour, suitability and abundance, or grouped as trees, shrubs, herbs, grasses, etc.

established, then swamp kiokio and other ferns can be planted along the water's edge along with kaikomako and turepo under trees and shrubs.

Free-draining and drier sites
Cabbage tree, karamu, lowland ribbonwood, lacebark, kohuhu, lemonwood, broadleaf, kowhai, kanuka, totara, matai and along edges - mikimiki/small-leaved coprosmas (*C. propinqua, C. crassifolia, C. virescens*). Marbleleaf, mahoe, lancewood, five-finger, and in the north, ramarama and toro, will generally do better as secondary species.

For more detailed information on stream zone species composition, refer to the Christchurch City Council brochure *Streamside Planting Guide* (Figure 5) and other regional lists[9].

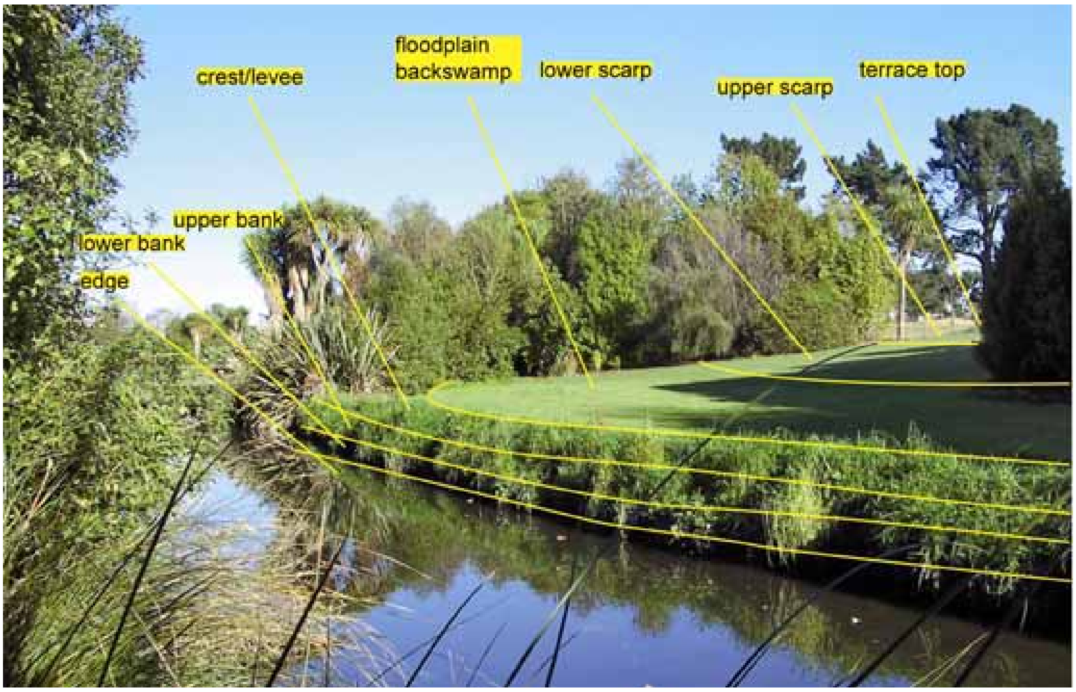


Figure 5: *Riparian planting zones, Heathcote River, Christchurch, New Zealand. Note, for smaller streams and swales, the lower zones are missing. Photo: Colin Meurk*

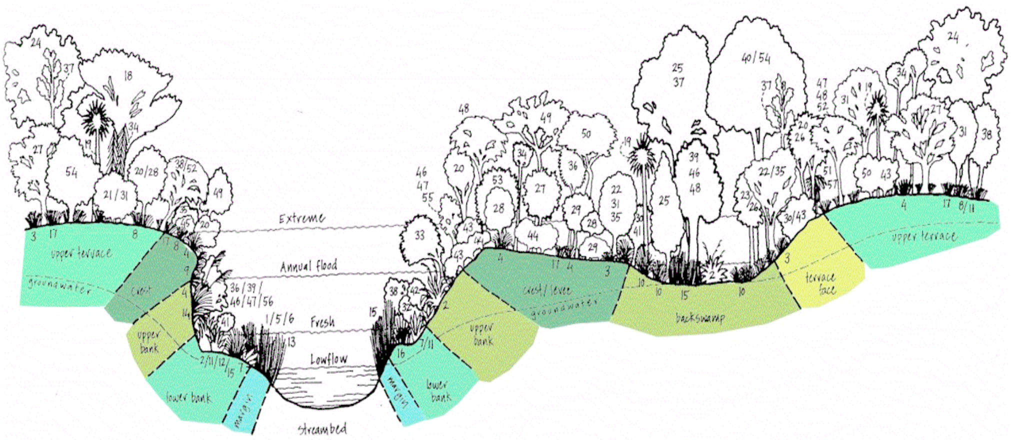


Figure 5: *Idealised stream profile with water's edge, bank, levee, floodplain backswamp, scarp and terrace top. Source: Christchurch City Council Streamside Planting Guide. See detail on line in* www.ccc.govt.nz/parks/theenvironment/streamside_profiles.asp

9 www.bush.org.nz/planterguide; www.ew.govt.nz (wetland restoration guide).

Shelterbelts and hedgerows

Shelterbelts and hedgerows with native plants provide shelter while reinforcing landscape biodiversity and or natural character as visual and biological corridors. They may combine attributes of both traditional exotic hedge plants (thorny gorse and hawthorn) and indigenous species such as kohuhu and karamu and the vinous scrambling pohuehue, bush lawyer and New Zealand jasmine. However, in the end, bird-dispersed, shade-tolerant trees such as hawthorn, elderberry, blackberry and ivy should be phased out.

Native plants for shelterbelts and hedgerows

Mikimiki (various small-leaved coprosmas), scrambling pohuehue, shrub pohuehue, tauhinu, korokio, koromiko, NZ flax, toetoe, and red tussock can be used for hedges, whereas shelter-belt planting may initially incorporate shrubs, but the taller trees will be cabbage tree, lacebark (use local species), kohuhu, karamu, lowland ribbonwood, wineberry, lemonwood, kanuka, broadleaf, red beech, and totara (inside front cover)[10]. In the less frosty or coastal north other species that can be used are taupata, puka, karaka, karo, and rangiora.

Generally it is better to avoid scorched earth approaches that involve clearing all established trees such as macrocarpa, pine, willow and poplar, and then planting slow-growing, initially tender native species in the open. A lot of carbon is released when cutting down large trees! Instead one can gradually enrich shelter planting by progressively thinning the pre-existing trees and inter- or under-planting with more wildlife-friendly native species.

1.4 Clustering houses: saving energy and space for habitat[11]

Localised high-density and medium rise, mixed-use subdivisions allow larger areas of public open or green space. This creates more opportunities for core sanctuary habitat, rather than small fragmented or linear features with inadequate buffer zones (Figures 6, 7 and 8).

Figure 6: *See caption over page.*

[10]For detailed composition of these corridors in the south, refer to: Environment Canterbury and Isaac Centre for Nature Conservation 2003. *Establishing shelter in Canterbury with nature conservation in mind*.
[11]Expands on methods 3.1.1. to 3.1.7 in van Roon & van Roon (2005).

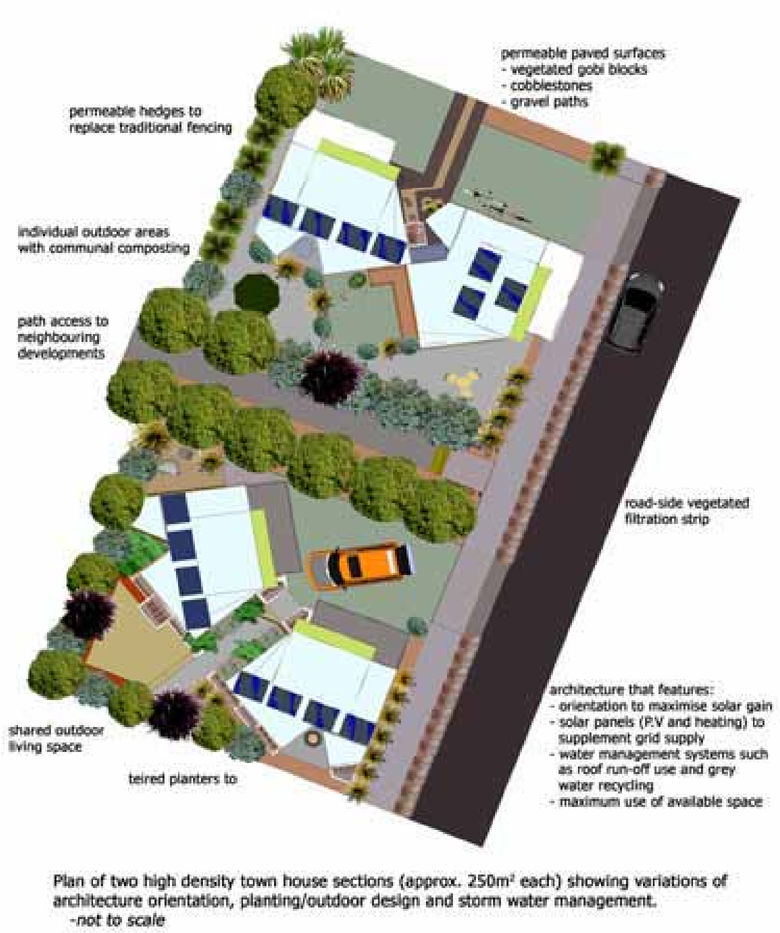


Figure 6: *Concept plan and cross-section of the two high density town house sections for Liffey Spring Subdivision, Lincoln, South Island, New Zealand. Design: Jason Collett, 2007*

The Flat Bush development (and in particular Regis Park within it, Figure 7) in Manukau City and the Long Bay Structure Plan demonstrate how a balance between built and open space can be achieved (see Part 1 introduction).

Figure 7: *Concept plan for Regis Park Subdivision. Design: DJ Scott, Auckland, New Zealand, 2003*

Figure 8: *Multistorey housing accommodates desired population while freeing open space for wetlands and forest. Varsity Lakes, Robina, Queensland, Australia. Photo: Marjorie van Roon*

Vegetated open space so created must be legally protected, for example by covenant or public acquisition, to prevent future infilling, destruction of vegetation, and attrition of minimal patch density (Figures 9, 16).

Figure 9: *Clustering of development at Palm Beach, Waiheke Island (North Island, New Zealand) in an area with high ideals for landscape protection. Photo: Marjorie van Roon*

1.5 Pedestrian-linked and interconnected green space

The emphasis here is on the organisation of common open spaces with ecological reserves and pedestrian linkages while avoiding dead-end streets or cul de sacs. These should always provide pedestrian rights of way to adjacent streets. Recreational walkways and cycle loops with links from all roads within the subdivision should form a passive transport catchment.

1.6 Narrow walkable street layout with more green space for pedestrians, biodiversity and on-site stormwater retention[12]

This is achieved in quiet residential neighbourhoods through street swale construction and planting, use of 'noble' street trees, a meandering street form, neighbourhood ecological parks, traffic calming, and decreased impervious surfaces. This creates a walkable and safer street layout that diminishes the dominance and speed of cars. Vegetation softens street edges, creates additional habitat for wildlife and a more interesting and varied streetscape, while filtering stormwater and road runoff (Figures 10–13).

Figure 10 (a) and (b): *Street edge alternatives, Seattle, USA, in 2004 (left; photo: Marjorie van Roon) and in 2007 (right; photo: Maria Ignatieva)*

Figure 11: *Narrow road, Talbot Park subdivision, Auckland, New Zealand. Raingarden on right treating road runoff and forming a traffic-calming feature. Photo: Maria Ignatieva*

Figure 12: *Narrow road, Lincoln, Christchurch, New Zealand. Photo: Robyn Simcock*

[12]Expands on methods 3.2.12 to 3.2.16, 3.4.11 in van Roon & van Roon (2005)

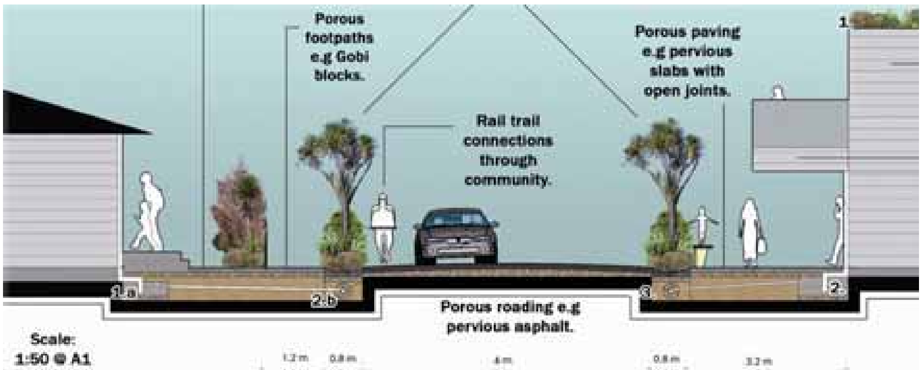


Figure 13: *Cross section of narrow street for proposed new Liffey Spring Subdivision in Lincoln Village, South island, New Zealand. Design: Simon Moultrie, 2007*

Box 1 Landscape connectivity

We now have a better understanding of forest dynamics across the landscape and how to integrate nature and production. This is based on observing and modelling dispersal, regeneration and forest succession processes (Meurk & Hall 2006). By linking this to theory of ideal reserve design (in terms of size, shape and spacing) we can plan optimal forest patch configurations for cultural landscapes that ensure their ecological and cultural sustainability. This means that indigenous nature is not only viable but always visible and accessible to the community – so everyone grows up experiencing, knowing and wanting to protect it (Meurk & Swaffield 2000). Natural heritage is also projected to visitors at high profile locations and becomes inextricably associated with sense of place (Figure 14).

Figure 14: *Riccarton Bush, Christchurch, New Zealand. Iconic remnant patch of kahikatea – visible from busy Riccarton Road. Photo: Maria Ignatieva*

Approximate minimum targets for forest patch size and density, for rural and urban environments are depicted in Figure 15. This configuration is built around a pattern of nested forest patches of various sizes that are known to provide minimal security for a range of plants, including those that are frost- or wind-sensitive, and at least the more common iconic wildlife – fantails, bellbirds, tui, kereru, tomtits, brown-creepers, lizards and invertebrates.

>5-ha patches at about 5-km spacings
>1-ha patches at about 1-km spacings
0.02-ha groves at about 200-m spacings

The ecological goal is for buffered core habitat, at spacings conducive to interpatch dispersal, with indigenous elements of the urban matrix and of corridors combining to make up 5-10% of the cultural landscape (Figure 16). This minimum represents an important extinction threshold for many species. No doubt these indicative values will be refined over time, but they represent a good starting point. The long-term viability of vulnerable species will also depend upon a hinterland with large reserves to provide seed sources and deeper refuges for sensitive wildlife. Also integral is landscape connectivity and a suburban or farmland matrix that has food or safe resting places scattered though it. This may include both native and exotic plants, but a key component of a wildlife-friendly neighbourhood will be rigorous predator and weed control.

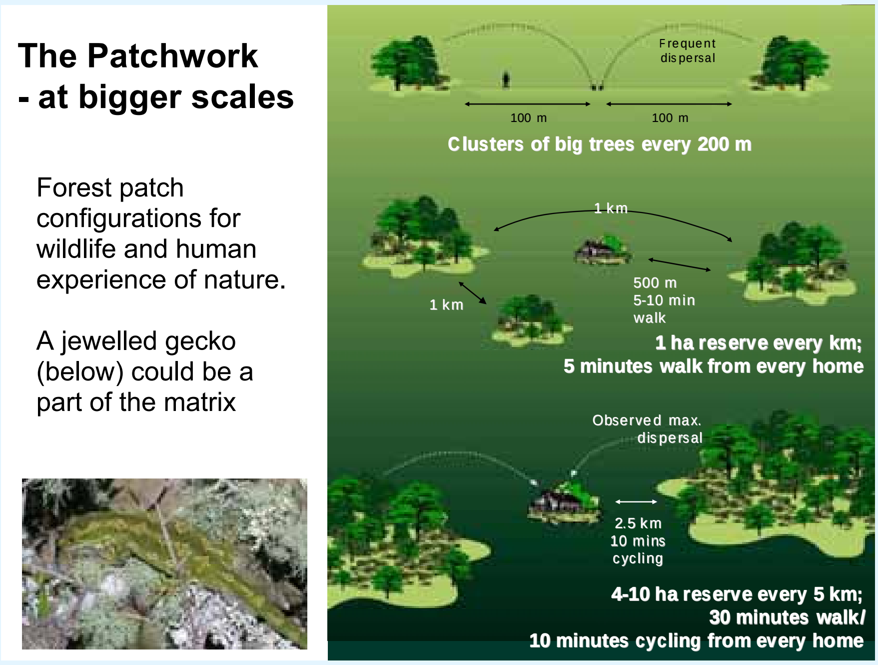


Figure 15: *Optimal stepping stone distances for wildlife and accessibility for people (Meurk & Hall 2006) providing both ecological and cultural sustainability of urban nature. Even native grass and shrub patches such as green roofs and rock gardens can be homes for lizards and insects.*

Figure 16: *Genesis, Coomera, Queensland, where large woodland patches across the landscape and ecological corridors between them have been retained during subdivision. Photo: Marjorie van Roon*

Part Two: Formation of stormwater treatment trains[13]

2.1 Treatment trains

The key principle is to use plants and substrates to detain, filter and reduce the amount of stormwater and suspended contaminants moving across a landscape (Dunnett & Clayden 2007). A treatment train, therefore, is a series of elements or devices linked together from the top to bottom of the urban catchment (roofs to gardens, swales and streets to ponds, groundwater and rivers to the ocean) that lengthen and slow the passage of water.

2.2 Green roofs for an individual property

A green roof is partially or fully covered by plants. Modern green roofs have been categorised as extensive, semi-intensive or intensive (Figures 17– 22, inside back cover).

Extensive (thin) green roofs

Extensive green roofs feature drought-tolerant plants growing in a *thin* layer (50–150 mm) of lightweight soil (<150 Kg per m^2). They are too fragile to be accessible to the public. The main function of this type of green roof is stormwater reduction, retention and filtration, moderation of the urban heat island effect, and creation of habitats for insects, plants, birds, and even lizards (Figure 15). In northern continents the most commonly used species for extensive green roofs is stonecrop, *Sedum* spp., but these are weeds in New Zealand, so we need to consider local alternatives.

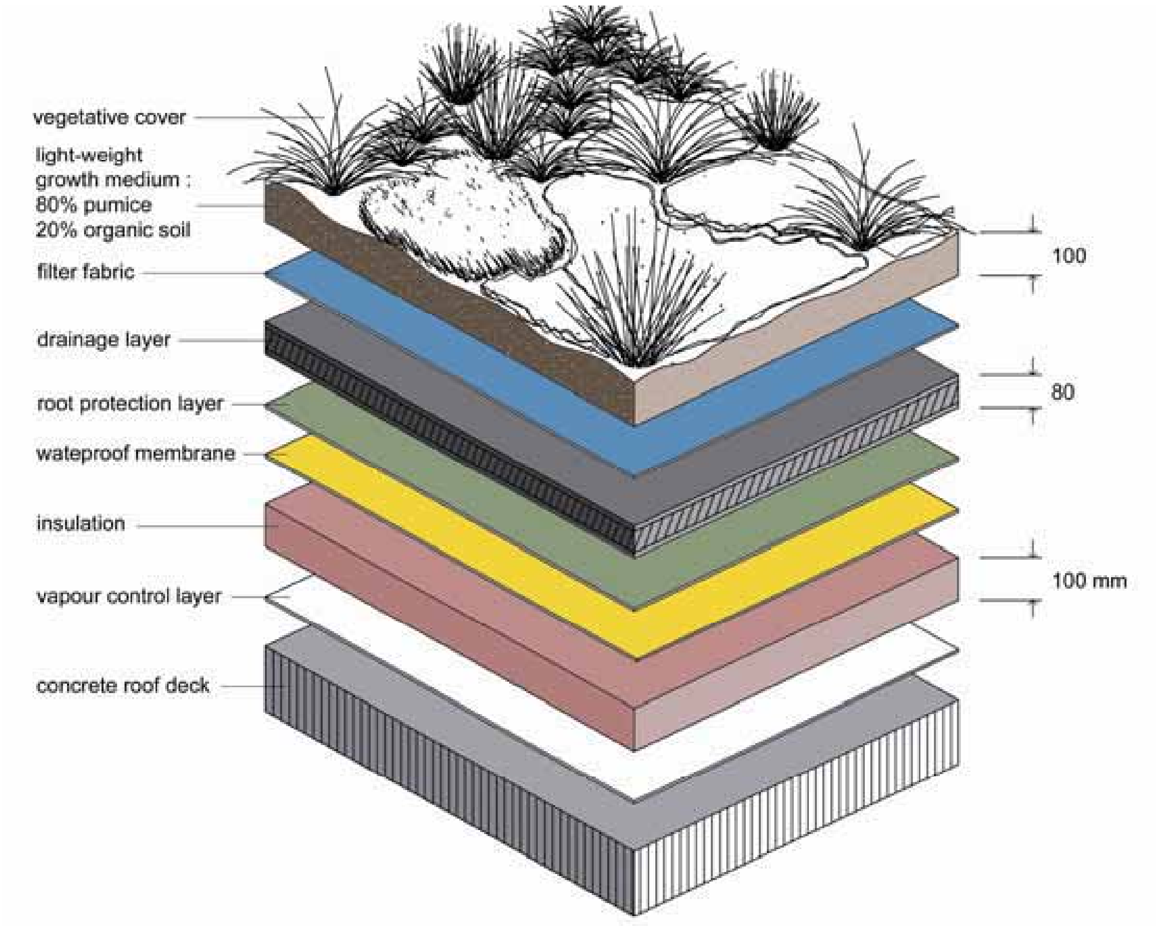


Figure 17: *Extensive green roof profile for a New Zealand house. Design: Lucas Adam, 2007.*

[13]Expands on methods 3.2.1 to 3.2.23 in van Roon & van Roon (2005).

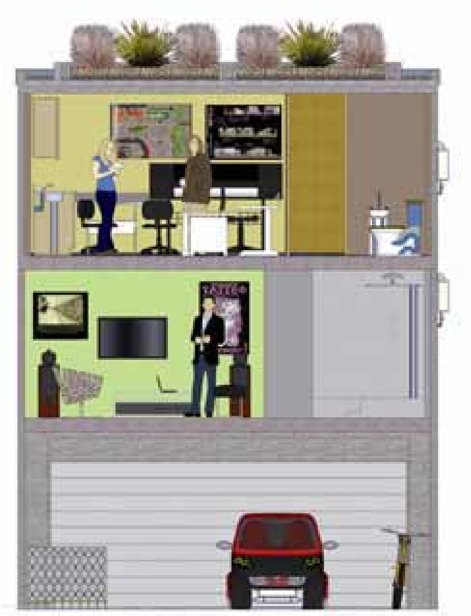


Figure 18: *Extensive green roof. Design: Jason Collett, 2007*

Figure 19: *Extensive green roof on a private house in Matakana north of Auckland, New Zealand. Photo: Marjorie van Roon*

Figure 20: *Waitakere Civic Centre (New Zealand) extensive green roof at about 16 months old. Extensive roofs are generally self-watering from rainfall. Photo: Robyn Simcock*

Semi-intensive (thick) green roofs

Semi-intensive green roofs (also called semi-extensive) have deeper soil (150–300 mm) and can support a greater variety of subshrub plants. However, their depth makes them heavy and they require a relatively strong structure to support them.

Intensive (partial) green roofs

Intensive green roofs usually consist of irrigated containers of deep soils, allowing the growth of shrubs and even small trees (Figures 21 and 22). They require *intensive* maintenance in terms of watering and weeding. They are usually designed to provide accessible amenity space. Because they require considerable structural support they are much more expensive than extensive roofs, and impractical in most domestic situations.

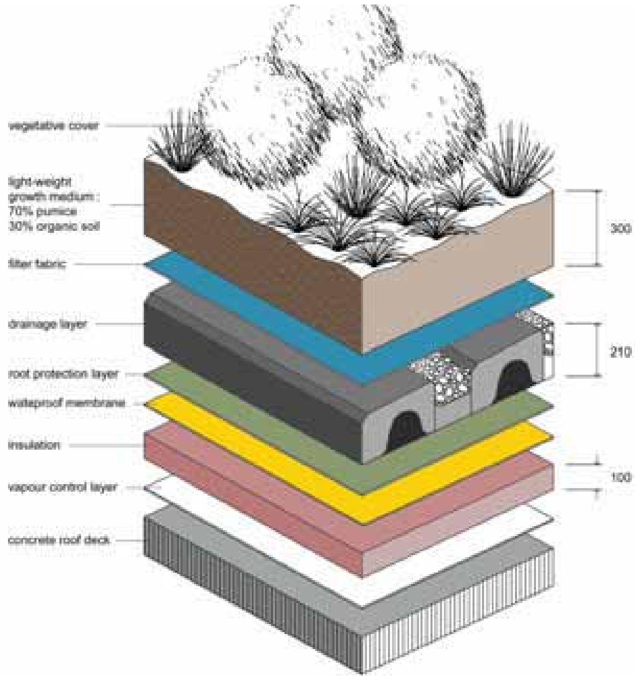


Figure 21: *Intensive green roof profile for New Zealand houses. Design: Lucas Adam, 2007.*

Figure 22: *Intensive green roof, Environment Canterbury, Christchurch, New Zealand. Photo: Maria Ignatieva*

Green roofs offer a range of benefits not provided by conventional roofs, such as:

- √ Stormwater reduction, retention, transpiration and filtration;
- √ Cost savings in heating and air conditioning due to the insulating effect of the growing medium and plants;
- √ Protection of the roof from UV damage;
- √ Habitat for insects, plants, birds, and even lizards;

√ Moderation of the urban heat island effect;
√ Noise reduction (inside the building);
√ and they look interesting and pleasant!

Demonstration mini-green roofs have allowed us to trial a range of local, drought-tolerant plant species in the Canterbury and Auckland environments. In the Christchurch Botanic Gardens flat and pitched roofs support semi-intensive green roof assemblages of plants from grassland, riverbed, dry rocky and coastal environments. Similarly in Auckland trials are testing a range of drought-tolerant but robust even woody species for green roofs in a higher rainfall climate.

Plants for green roofs

The following native plants are candidates for extensive green roofs, but many are only now being tested. Plants listed for Auckland include some from outside the Auckland Ecological Region; nevertheless, this is better than spreading stonecrop! Asterisked plants in the Auckland list have survived for up to 2 years – early results indicate that a minimum substrate depth of about 100 mm is necessary to maintain a range of species; plants with a double asterisk have tolerated the thinnest and driest substrates. Asterisked plants in the Christchurch list are currently being trialed. The range of plants can be increased by increasing substrate depth, providing afternoon shade, or gently sloping the roof to the south. Increasing the pitch of a roof beyond 5 degrees increases stress for plants near the ridgeline.

Plants for Auckland green roofs (moist northern)

*Crassula sieberiana***, sand convolvulus**, *Oxalis exilis,* NZ iceplant**, *Epilobium brunnescens, Epilobium nummulariifolium, sea spurge, Haloragis erectus,* NZ linen flax, knobby clubrush, *Lachnogrostis spp., Leptinella dioica, Dichondra repens*, NZ spinach, holy grass, Leptostigma/Nertera setulosa*, Libertia peregrinans**,* NZ groundsels, *Cotula coronopifolia, Mazus spp.*, Acaena microphylla*,* danthonias, *Festuca coxii**, Poa anceps,* silver tussock, *Pyrrosia eleagnifolia*, Selliera radicans*,* rice grass, mat pohuehue*, leafless pohuehue, *Pimelea prostrata*, Coprosma petriei*,* sand coprosma**.

Plants for Christchurch green roofs (dry southern)

Crassula sieberiana, Zoysia minima, Oxalis exilis*,* NZ St John's wort*, *Acaena buchananii*, A. microphylla*, Cotula australis, Carex breviculmis, C. resectans*, Geranium sessiliflorum*, Gnaphalium audax,* NZ iceplant*, onion-leaved orchid, sun orchid, sand convolvulus*, *Convolvulus verecundus, Epilobium cinereum, E. nummulariifolium, E. rostratum, sea spurge, Haloragis erectus, Lachnogrostis spp.*, Leptinella minor*, L. serrulata*,* NZ linen flax, blue tussock, *Deyeuxia avenoides, plume grass*,* blue wheat grass, rice grass, *Poa lindsayi, P. imbecilla*,* danthonias*, *Dichondra brevifolia*, D. repens,* adders tongue fern, *Gonocarpus aggregatus,* knobby clubrush, *Stackhousia minima, Stellaria gracilenta,* NZ iris, scabweeds *(Raoulia australis, R. monroi, R. tenuicaulis)*, Pyrrosia eleagnifolia, Einadia spp., Helichrysum filicaule,* holy grass, NZ groundsels, silver tussock, *Festuca actae*, F. novae-zelandiae, F. coxii,* mat pohuehue*, leafless pohuehue*, *Coprosma atropurpurea, C. petriei and Leucopogon fraseri.*

Plants for intensive green roofs

Appropriate species are large shrubs and tussocks, similar to those in stormwater planters (below). Examples are cabbage tree, broadleaf, shrub pohuehue, korokio, *Coprosma linariifolia*, olearias, koromiko, flaxes and bush lilies. Almost any moderately drought- and exposure-tolerant tree/shrub will survive, especially with regular irrigation. Tall plants on exposed roofs need to be staked or secured.

2.3 Stormwater planters

Stormwater planters are above-ground boxes filled with a free-draining soil. They are sited directly against a building and receive roof runoff from downpipes or from paved areas (e.g. decks), and may be small in size (Figure 23). They usually have 100–200 mm of freeboard to allow water to pond, and must always have an outlet drain. This ensures water is filtered and primarily evapo-transpired. Native plants for planters are similar to those used in raingardens or intensive green roofs and may occasionally require supplementary water if the catchment area is small, the volume of the container is small (and plants are large and leafy), or if the area has a large expanse of concrete and/or buildings that cause increased temperature, wind, and consequently water use by plants.

Suitable herbaceous plants are oioi, knobby clubrush, various other short tussocky sedges, hunangamoho, holy grass, creeping fuchsia, inkberry and mountain flax, whereas shrubs may include cabbage tree, broadleaf, whau, marbleleaf, five-finger, houpara, shrub pohuehue, marsh ribbonwood, korokio, *Coprosma rubra*, *C. crassifolia* and *C. linariifolia*.

Figure 23: *Planter boxes can treat stormwater from patios and roofs. Portland, Washington, USA. Photo: Marjorie van Roon*

2.4 Rain tanks for an individual property

These and rain barrels reduce runoff to waterways and provide water for garden irrigation without tapping into finite aquifers or potable supplies (Figures 24, 25, and 41). Rainwater tanks and the retention of vegetation on upper-catchment large lots are a mandatory requirement in specific northern districts[14].

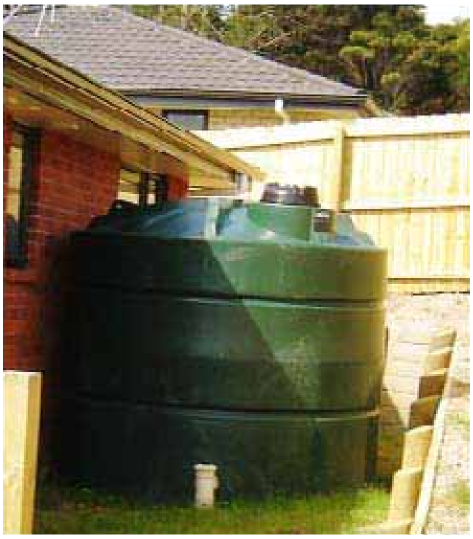


Figure 24 (a) and (b): *Rain barrel and rain tank serve private houses. Left: The Netherlands, Photo: Marjorie van Roon. Right: North Shore City, New Zealand Photo: Penny Lysnar.*

[14] Long Bay District Plan Variation 66 (www.northshorecity.govt.nz) and under the recent North Shore City District Plan Change 22, rain tanks are a required method for preventing stormwater generation and reducing potable water consumption under the North Shore City District Plan Change 22.

Figure 25: *A series of half-buried rain tanks partly screened with native shrubs, Russell, Bay of Islands. Photo: Robyn Simcock*

2.5 Permeable ecological surfaces for individual properties

One of the most effective means of ameliorating rapid stormwater runoff is to minimise hard surfaces and use only permeable materials for hard wearing or vehicle standing. Typical examples are paths, decks, driveways and car parking areas (Figures 26–30). For construction materials and designs refer to existing manuals[15]. Permeable paving is best used where there is low traffic loading, light vehicles (cars, not trucks), and relatively clean stormwater – this limits compaction and sealing of the surface with sediment. The most effective materials have a moderate to high infiltration rate (or permeability, at least 10 mm/hour and up to 1000 mm/hour) and water storage volume. Coarse materials such as gravel and wooden decking generally have the highest infiltration rates. The volume of water that can be temporarily stored is increased by thickening the depth of sand that often forms the stable base for permeable surfaces.

Figure 26: *Concrete block permeable paving with mown grass, Morning Star Apartments, Auckland, New Zealand. Photo: Maria Ignatieva*

15 http://www.nzwerf.org.nz/publications/sw602/sw602.html – On-site stormwater management guideline, Section 5.6

Figure 27: *Permeable car park with discrete concrete blocks and mown grass between. Stormwater from the parking area runs into a grassed swale (centre). Photo: Robyn Simcock*

Figure 28: *Courtyard with four different permeable surfaces: wooden decking, gravel, permeable pebble pavers (around tree) and grass, at Waitakere Civic Centre, Auckland, New Zealand. Photo: Maria Ignatieva*

Suitable native plant species for pavements of various types and wastelands (untended building sites and early successional urban vegetation) include pennyworts, *Leptinella* spp., biddibid, *Pratia* spp., *Cotula coronopifolia*, *C. australis*, willowherbs, *Pseudognaphalium luteoalbum*, *Gnaphalium* spp., NZ groundsel, harebell, *Oxalis exilis*, mat and leafless pohuehue, *Geranium sessiliflorum*, *Dichondra* spp., *Poa imbecilla*, *Lachnagrostis* spp., *Deyeuxia avenoides*, *Carex inversa*, *C. resectans* and woodrushes.

Figure 29: *'Friendly' concrete – relatively large gaps between pavers planted in grass or broadleaved groundcovers – reduces runoff. Photo: Robyn Simcock*

Figure 30 (a) and (b): *Strong plastic grids increase bearing strength, reduce compaction of substrate, and allow plants to grow. Melbourne, Australia. Photos: Marjorie van Roon*

2.6 Swales and filter strips

A swale is an ephemeral watercourse for overland flow of stormwater. It is a shallow, linear depression in the ground that is designed to collect and channel stormwater runoff along gentle slopes (Dunnett & Clayden 2007, p. 106), and in the process allow settling and filtering of coarse sediments and contaminants. Meanders increase the path length and efficacy of swales. Some evaporation and subsurface filtration may occur, but generally most stormwater is transported to a raingarden, infiltration basin, wetland, pond, or piped infrastructure. Vegetation may be a thick (50–100 mm) mown turf (Figure 31), perennial groundcovers (Figure 32), or taller vegetation. Where vegetation is bulky (Figure 33) the cross-sectional capacity will be slightly larger to accommodate water flows as well as the vegetation. Swales are only suitable for gentle slopes (<5 degrees); steeper topography requires steps or energy-dissipation structures (Figure 34). Grass swales require substrates with high bearing strength to minimise rutting and compaction during mowing. Rutting creates preferential flow paths and localised ponding, while excessive compaction will inhibit plant growth and favour weed ingress.

Where swales are designed to infiltrate water they will often be under-drained with perforated pipes. Increasingly, modern road berms or central median strips provide the space for these infiltration- and filter-strips. The type of swale, its structure and composition, is dependent on the slope, ground water level, and soil physical properties (Figures 34–36)[16].

16For further details refer to the swale design information in Stormwater treatment devices (Chapter 9); Auckland Regional Council (www.arc.govt.nz/arc/index), and from Christchurch City Council Selection and design of stormwater devices (www.nzwwa.org.nz/section3.pdf) and On-site stormwater management guideline (www.nzwerf.org.nz/publications/sw602/sw602.html).

Figure 31: *(Left) - Mown grass swale treating runoff from adjacent footpath (the grate covers the entry to a pipe taking water to an infiltration bed). Photo: Robyn Simcock*

Figure 32: *(Right) Carex cultivars cover swale surface at Wharewaka, Taupo. Stone detention dams reduce stormwater velocities and erosion during high runoff events. Note the absence of a curb; instead a drop discourages vehicle entry. Photo: Robyn Simcock*

Figure 33: *Vegetated swale behind the building previously tenanted by Waitakere City Council in Henderson. Photo: Marjorie van Roon*

Figure 34: *Swale, Auckland Netball Centre car park, with prostrate coprosma groundcover. Boulders deter cars from trafficking over the swale and have also been placed around the grate that pipes overflow to a pond – to disrupt the water flow. Photo: Robyn Simcock*

Figure 35: *Bioretention swale, Landcare Research, Auckland, uses Carex against the building with low groundcovers Selliera radicans, Pratia angulata, and Acaena microphylla. Raised wooden barriers allow unimpeded (sheet flow) runoff into the swale while excluding vehicles. Photo: Robyn Simcock*

Figure 36: *Mini-soakage areas (non-linear swales) with grass inset add interest to and reduce runoff from a large paved area outside an art gallery, Minneapolis, Minnesota, USA. Photo: Robyn Simcock*

Native plants for vegetated swales

Vegetation in swales should form a dense, even groundcover, preferably 100–200 mm in height, that will ensure that stormwater flows in an even sheet, particularly along the base of the swale – this ensures runoff is filtered rather than diverted or concentrated. This is conventionally achieved with mown, exotic sward grasses. If flows are concentrated, e.g. between tussocks, erosion can be increased and sediment may be re-suspended rather than removed. Tree and shrub species can be used in a swale, but should have naturally upright growth forms with minimal shading, e.g. cabbage tree, ribbonwood and lancewood, or be pruned to ensure a dense groundcover can be maintained beneath. Alternatively, dense mats of leaf litter between tussocks and shrubs will act as a sponge and dissipate the erosive energy of stormwater. Long-lived trees should only be planted in swales in rural areas or light to moderately trafficked residential roads where inputs of contaminants are low, or collect only roof runoff. The low input of contaminants means swales are unlikely to require renovation within 20 years. However, swales treating runoff from roads with more than about 10,000 vehicles per day are likely to require renovation and substrate replacement (involving removal of vegetation) every 5 to 15 years.

Asterisked woody plants will initially need regular limbing to ensure a dense groundcover can be maintained beneath them. Detailed regional lists are available from streamside planting guides for Auckland, Christchurch and Waikato, although these vary little across the country.

Swales with permanently wet/moist bases

Tress on slopes of large swales
Lowland cabbage tree, ribbonwood, narrow-leaved lacebark, manuka, kohuhu*, broadleaf*, lancewood, kowhai, marbleleaf, kaikomako, maire tawake (in north), toro (in north), cedar, totara, kahikatea, pokaka, pukatea (north), matai, beech and rimu (in rain forest).

Shrubs and tussocks in swale base (Figure 37)
Oioi, NZ flax, toetoe, *Carex virgata*, umbrella sedge, *Juncus edgarae*, *J. sarophorus*, *Baumea* spp., *Coprosma propinqua*, marsh ribbonwood, karamu, weeping mapau and raupo (where bulk doesn't matter).

Figure 37: *Bioretention strip planted mainly with oioi, rushes and other sedges. The wooden walkway covers an overflow structure. Waitakere City Centre car park, Auckland, New Zealand. Design: Meghan Wraight, Wraight & Associates. Photo: Maria Ignatieva*

Mown or short sward swales
Mowing height may be adjusted to prevent invasion by taller species – especially exotic grasses. Turf or 'flatweed' species are: Māori onion, *Juncus planifolius*. *J. caespiticius*, bristle sedges, spike sedge, *Centella uniflora*, *Gunnera* spp., *Mazus* spp. (Figure 38a), *Leptinella dioica*, *Cotula coronopifolia*, *Pratia* spp., *Hypsela rivalis*, *Plantago triandra*, *Nertera* spp., *Selliera radicans* (Fig. 38b), silverweed, pennyworts, swamp willow weed, milfoil and willowherbs.

Figure 38 (a) and (b): *Alternatives to mown grass: Mazus pumilio (left) and Selliera radicans (right). Photos: Robyn Simcock*

Summer-dry swales

Tress in dip and slope
Cabbage tree, lowland ribbonwood, manuka, narrow-leaved lacebark, kohuhu, broadleaf, kanuka, karamu, kaikomako, kowhai, akeake and totara.

Shrubs and tussocks
Wind grass, rushes (*Juncus distegus*, *J. australis*, *J. pallidus*), oioi, knobby clubrush, hunangamoho, koromiko, *Coprosma propinqua*, *C. crassifolia*, *C. virescens*, *C. rubra*, *Olearia bullata*, korokio, weeping mapau, bush lily, shrub pohuehue, NZ iris, inkberry and mountain flax.

Mown swales
Cotulas including *Leptinella maniototo*, biddibid, pennywort, *Pratia* spp., *Plantago triandra*, *Gnaphalium* spp., (Fig. 61), NZ dock, mat coprosma species, mat pohuehue, *Oxalis exilis*, *Dichondra brevifolia, D. repens* and *Selliera radicans.*

2.7 Raingardens for an individual property

Raingardens filter, detain and evaporate water (Figures 39–43). They are essentially a densely planted, deep, porous bed in which water usually ponds to between 100 and 300 mm depth for several to 36 hours after rainfall. The bed is generally vegetated with dense, medium-low plants, although trees can also be planted depending on scale. Raingardens are placed in low-lying areas. The excavated bed may be lined with a geotextile, if groundwater contamination is an issue, before layers of growth and drainage media are added. Raingardens are usually under-drained and always have an overflow or bypass through which the majority of runoff from large storms passes. With the appropriate species for the area, raingardens are self-watering and self-fertilising once established, and particularly suitable for supporting street trees in dry urban environments. Raingarden design details are found in various local government manuals[17].

Figure 40: *Hunt Street (Hamilton) raingardens have a fine gravel mulch; water enters from the road through slots in the curb (Megan Wraight – Wraight and Associates Landscape Architects). Photo: Robyn Simcock*

Figure 39: *Raingarden with boardwalk, Landcare Research, Auckland. Shrub pohuehue, Hebe speciosa and NZ iris are the prominent species. Photo: Robyn Simcock*

Figure 41: *A vertical water tank separates areas in an outdoor residential courtyard and the overflow spills as a water feature into several raingardens. Designers: Douglas, Kirsten Sach and Zoe Carafice, Unitech, for Ellerslie International Flower Show, Auckland, 2007. Photo: Maria Ignatieva*

[17] www.arc.govt.nz/arc/index – Auckland Regional Council *Stormwater treatment devices* (Chapters 4 and 9); www.nzwwa.org.nz/section3.pdf – Christchurch City Council *Selection and design of stormwater devices*; www.nzwerf.org.nz/publications/sw602/sw602.html – *On-site stormwater management guideline.*

Figure 42 (a) and (b): *Raingardens with minimal ponding depth in downtown Minneapolis, Minnesota, USA – right is the outlet to the downpipe – in this case a deep bark mulch replaces the more usual and longer lasting stones underneath the discharge point. Photo: Robyn Simcock*

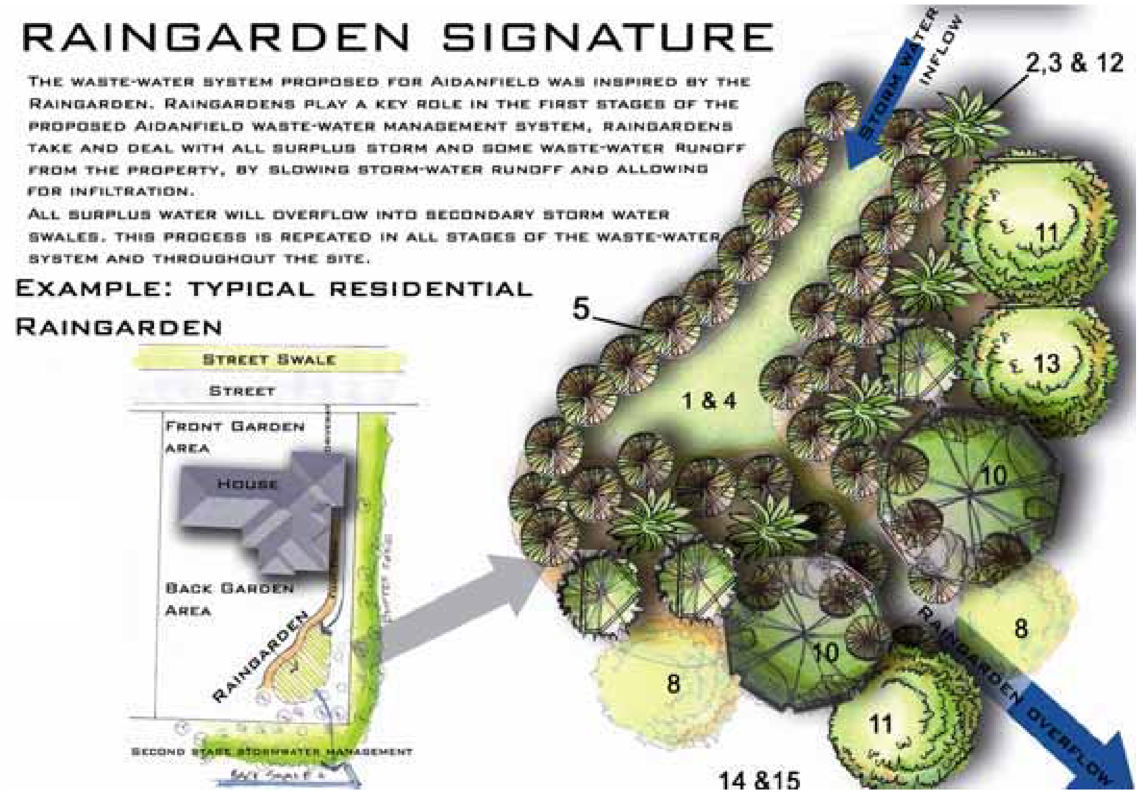


Figure 43: *Raingarden proposal for residential property in Aidanfield, Christchurch, New Zealand. Design: Frazer Baggaley, 2005.*

Native plants for raingardens

Plant species are separated into those suited to 'high' and 'low' rainfall climates. 'Higher rainfall' species are also suitable for gardens in drier climates where there is imperfect drainage and have a relatively large catchment, such that even 1–2 mm of rain delivers considerable water to the raingarden. Conversely, low-rainfall species should be considered in 'wet' climates if the raingardens are very large, sandy (low water storage), or in areas with infrequent, but high-volume rainfalls.

High rainfall gardens
Carex geminata, *Carex virgata*, bush lily including *Astelia grandis*, inkberry, rushes, oioi, *Baumea* spp., red tussock, tuhara, *Leptinella dioica*, *Pratia* spp., *Gunnera* spp., silver weed, swamp willow weed, *Coprosma propinqua* and maire tawake. Note that plants with hairy leaves adjacent to high-density traffic, such as car parks, are prone to being clogged with mud.

Low rainfall gardens
Carex virgata, *C. flagellifera*, *C. comans*, *C. testacea*, other short tussock sedges, NZ iris, inkberry, rushes, oioi, *Chionochloa flavicans*, knobby clubrush, wind grass, sea spurge, sand convolvulus, *Coprosma propinqua*, sand coprosma, korokio, shrub pohuehue, scrambling pohuehue, tauhinu and mat pohuehue.

In northern New Zealand kikuyu grass will have to be eliminated initially and prevented from reinvasion. Likewise in the south, uncontrolled prairie grass and cocksfoot will overwhelm smaller tussock species.

2.8 Detention ponds

The same riparian species used above (Section 1.3) are suitable for pond margins. For further information on construction of ponds refer to the detention pond design details in manuals prepared by Auckland Regional Council and Christchurch City Council[18].

Front-line native plants for detention ponds (Figure 44):

Wet margins
Pond weeds, milfoil, Lake clubrush, bamboo spike sedge, spike sedge, Carex secta, NZ flax, umbrella sedge, toetoe and rushes.

Drained slopes
Coprosma propinqua, weeping mapau, koromiko, manuka, cabbage tree, lowland ribbonwood, kohuhu, karamu, maire tawake, shining karamu, local lacebark, kanuka, broadleaf, lancewood, wineberry and many other tree species in moist sites and the North Island.

Figure 44: *Vegetated swale and overflow detention and infiltration pond, Aidanfield, Christchurch. Photo: Colin Meurk*

[18]' www.arc.govt.nz/arc/index – Auckland Regional Council: *Stormwater treatment devices* (Chapter 9); www.nzwwa.org.nz/section3.pdf – Christchurch City Council: *Selection and design of stormwater devices*; www.nzwerf.org.nz/publications/sw602/sw602.html – *On-site* stormwater *management guideline*.

2.9 Streams and instream values

The treatment train ends when the stormwater from roofs, swales and rain gardens finally issues into streams and rivers on its way to the ocean. The amount of sediment and contaminants transported to the rivers, estuaries and inshore waters will depend on how well LIUDD principles and their associated filtration systems, as described above, have been implemented.

Riparian zones and water features

Suitable species are detailed in various streamside planting guides and computer links (Figure 46).

Figure 46 (a) and (b): *Dense riparian tussock sedges (umbrella sedge and pukio), New Zealand flax, koromiko and cabbage tree protects the riverbank and suppresses weeds. Photos: Colin Meurk*

Once new systems are in place, it is desirable to monitor them in order to ensure they are working according to plan. Steven Moore (Landcare Research, personal communication, 2008) points out that water managers around the world use freshwater life as indicators of the state of streams and rivers. Freshwater invertebrates (aquatic insects, crustaceans, snails, worms etc) are the most commonly used indicators because they are usually abundant and easy to sample, and (with experience) easy to identify. We also know much about the habitat and water quality requirements of many invertebrate groups, and there are various protocols and indices designed to assist with the interpretation of invertebrate results.

Information on monitoring methods in New Zealand can be found on:
http://limsoc.rsnz.org/ProtocolsManual2.pdf (for professional ecologists),
http://www.landcare.org.nz/shmak/ (for farmers monitoring streams),
http://www.waicare.org.nz/ (for community monitoring groups).

Examples of New Zealand freshwater invertebrates can be viewed on:
http://www.landcareresearch.co.nz/research/biosystematics/invertebrates/freshwater_invertsCD/

Landcare Research has assessed the state of Auckland region streams in urban, farmland and forest areas, and this work has highlighted the generally poor state of urban streams and their biota. Urban stream habitats are often degraded (or destroyed) by piping, channel straightening, concrete lining, and the erratic flows caused by urban drainage networks. The latter problem is the result of large areas of impervious surfaces (road, concrete, roof areas) which drain directly to stormwater networks, rather than allowing water to seep into the ground and gradually feed back into streams.

These urban stream habitat problems can make it impossible to 'restore' streams in the medium term to the point that they support their pre-urban aquatic fauna. Stream faunas are more likely to respond to rehabilitation strategies such as improving riparian vegetation and reducing contaminant sources, if the stream channel form and hydrology is not significantly modified.

A further consideration is aquatic weeds and exotic wetland species that are increasingly sold through nurseries and specialist aquatic plant suppliers. Many of these plants have the potential to become serious problems so a precautionary approach is desirable. NIWA (National Institute of Water and Atmospheric Research) operates the National Centre for Aquatic Biodiversity and Biosecurity (NCABB) which is accessible from www.niwa.cri.nz/ncabb/rc/freshwater .

Part Three: Enhancing biodiversity in the home garden[19]

We have covered the hydrological and ecological service functions of plants at landscape scale and in relation to treatment trains and suggested indigenous species that can be used for these roles. These often involve utilitarian groupings of species and plant signatures to convey a sense of naturalness (Footnote 2, p 4). Here we consider the intrinsic values of biodiversity, why we should promote it and how we can integrate it into the urban context. In particular we focus on opportunities presented by the urban matrix of private gardens, public parks and neglected spaces (Meurk 2005, Meurk & Swaffield 2007). There is a valid place for novel, synthetic associations and plant signatures for gardens and landscaping. It is also desirable to consider naturalistic communities of plants and animals. Faithful copies of such natural communities contain more information, are likely to be more integrated and sustainable, and have their own natural beauty.

Box 2 What is biodiversity all about?

Biodiversity is about variety of species, genetic expression, and ecosystems[20]. Biodiversity is a global concept that refers to the number of indigenous species within a local area or region. It is distinct from **species richness** – the sum total of both native and introduced species. Biodiversity is thus specifically a measure of the variety of the special or unique biota and habitats found naturally in an area (**indigenous**) or nowhere else in the world (**endemic**). It is that area's particular contribution to world biodiversity.

In New Zealand we have about 2500 native vascular plants (ferns, conifers and flowering plants). European settlers began importing familiar productive or amenity plants from their continental homelands less than 200 years ago. Now we have in excess of 20 000 introduced plant species – a tenth of which have escaped into the wild. Many of these exotic species are still spreading and about 13 more become naturalised every year. This is a major threat to our native flora, which is continually pushed back to inaccessible hinterlands. The same is true of animals. New Zealand had no native land mammals until Polynesians brought the rat (kiore) and dog (kuri) here in the last thousand years or so. These, and the many other browsers and predators introduced by Europeans, have taken their toll on our vegetation and wildlife.

Our biodiversity, measured in terms of native species number, is relatively small on the world stage, typical of remote islands. But its importance is disproportionately large as many of the long-isolated species are ancient lineages that have no close relatives elsewhere in the world, or are regarded as ancestral to more common groups. Therefore our biodiversity has an evolutionary and biogeographic significance far greater than its numbers suggest. New Zealand is classified as one of the World's biodiversity 'hotspots' (www.biodiversityhotspots.org). Accordingly, if we were to eventually displace all our native species with exotics then total species richness would be greater than in primordial New Zealand (>20 000 plants versus about 2500). But world biodiversity will have declined by 2500 very important species. Thus **packing in more species doesn't increase biodiversity –** it merely spreads globally common species to more places and constricts the local gene pool.

[19] Expands Principle 3.4 and associated methods in van Roon & van Roon (2005)

[20] interacting associations of microbes, plants, animals and their physical environment within a defined space or catchment.

Why we should protect and enhance our biodiversity[21]
Reclaiming our rich and unique natural heritage is an international, legal and moral duty. We are the guardians of this treasure. Our unique flora and fauna has been shaped by long isolation, evolution within a virtual 'Garden of Eden', climatic 'ups and downs', especially in the past million years, and only in the most recent 'blink of an eye' by exposure to the most competitive plants and animals from the temperate world.

Our local species were completely ill-equipped for the onslaught that accompanied human arrival. New Zealand-Aotearoa was the last major temperate land mass to be colonised by people. But we followed the same pattern that other colonisations around the world have delivered – burning of forest and hunting the megafauna to extinction. By the time Europeans arrived they had perfected more powerful technologies than existed when Europe or even the Americas received their first human footprint. So the resultant transformation – bolstered by the industrial revolution – was extremely rapid here. Moreover the impact was exacerbated by the ecological naiveté of the native plants and animals – that had never 'seen' a land mammal before in millions of years of evolution. So they were ill-equipped to deal with the ferocity of the grazing, predation and competition from the thousands of introduced organisms that poured into the country over the ensuing two centuries. Now we have an opportunity to slow or reverse some of these trends. The most effective place to make a difference is close to home – where it is visible to the urban community.

Conservation priorities and restoration processes[22]
If we still had the luxury of substantial remnants of original (primary) habitat across the lowland countryside, it would be hugely more economical to protect these systems. The true market cost of establishing a stand of 5-year old plants is up to $100,000 per hectare. It is the primary remnants (even if degraded) that preserve the history of the land, but we can only guess at the embodied complexity – of plants, soils and their subterranean fauna, fungi and other microbes, and the myriad of above ground insects. These are benchmarks and seed sources for lost habitat. Nevertheless, **eco-restoration** and planting are valuable now when we have lost so much. We can repair damaged habitat by creating buffer zones around protected remnants and removing pests. But creating lost habitat from scratch really only 'starts the ball rolling' by establishing pioneer species – as has been done during rural residential development at Owhanake on Waiheke Island (Figure 47). These shade-casting, nursery plants suppress exotic grasses (which otherwise prevent natural bush regeneration), provide initial native seed sources and perching places for birds and lizards that will bring in seed from far afield, and create sheltered, bare soil surfaces that enable germination – the first steps in rebuilding fully functional ecosystems. So **restoration is about kick-starting ecosystem processes rather than recreating some snapshot of the past**. We know not what the original componentry was 150 to 1500 years ago. Species have become extinct, exotic species have been introduced and the environment is changed. We can accelerate succession, control invasive pests; otherwise nature will take its course and inevitably result in new synthetic biological communities of coexisting native and some benign exotic species. This applies no more so than in urban environments.

In cities, with increased human and economic resources we can sometimes leapfrog past pioneer species and create secondary habitat in small areas – at huge expense – by transplanting large trees and epiphytes or microcosms of intact ecosystems; e.g. the Te Papa encapsulations of New Zealand's habitats in Wellington, and direct translocation of whole vegetation-soil profiles on West Coast mine sites (Simcock et al. 1999).

---

[21]Expands on methods 3.4.1 to 3.4.15 in van Roon & van Roon (2005)

[22]Expands method 3.4.8 to 3.4.11 in van Roon & van Roon (2005)

Figure 47: *Previously bare pasture blocks that were revegetated during rural residential subdivision at Owhanake, Waiheke Island, New Zealand. Photo: Marjorie van Roon*

Cultural values and uses
Prior to European settlement, tangata whenua initially utilised the natural resources of the land as they found them – with the exception of imported kumara, taro, yams, dog and rat as sources of carbohydrate and protein. Initially exploitation resulted in extinctions of the lumbering and slowly reproducing wildlife, but over time a new balance was achieved and sustainable harvesting of resources was practiced. From this nexus arose classical Māori culture. Most plants and animals of Aotearoa-New Zealand had been given names, and their attributes for food, fibre, building material, and rongoa (medicinal plants) were well known. As such they were taonga or treasures essential for survival. For instance, raupo pollen was collected and used to make a protein-rich, sweet cake, while the foliage and stalks were bundled together to make thatching and temporary rafts.

All native, and some exotic plants, have cultural significance to Māori and were revered as members of the family or whanau. So, wider use of these species, learning about the stories behind them and protecting them, is fundamental to sustaining spiritual connections between tangata whenua and the land (whenua), while at the same time creating mutual respect between Māori and Pakeha for their common waka (canoe) or country.

Plants are powerful symbols of history, identity or sense of place. They often provide the context for our culture, so what plants we have around us takes on a wider significance. They act as mnemonics for stories in the land and they create an authenticity for visitors. Being able to take part in the re-creation of lost heritage, watching plants and ecosystems grow and regenerate, and seeing the linkages reconnect is a rewarding experience. It comes from community participation reaching for common aspirations, reviving personal spirit (wairua) and environmental life forces (mauri), as well as or because of seeing the tangible fruits of one's labour.

Exotic species are part of our heritage too!
While the focus here is unashamedly on our special indigenous plants and wildlife, it is not forgotten that our economy and much of our quality of life is dependent on exotic species. These plants are the basis of our food and timber production, amenity (shade, shelter and aesthetics) and landscape structure. However, many imports have become pests so we have to deal with the 'bad' while nurturing the 'good'. The goal here is, therefore, not to indiscriminately replace exotic 'nature' with native nature, but rather to raise the profile of the indigenous, welcome the useful, beautiful but safe immigrant organisms, and endeavour to eliminate or control the biosecurity risks. Some exotic plants provide valuable food resources for native birds. For example, Australian gums and proteas and South African red hot pokers produce copious nectar for our honey-eaters, often in autumn and early winter when other food is in short supply.

On the other hand, kereru love holly and ivy berries but these (also cotoneasters, cherry laurel, yew and plums) get transported into native forest, germinate and, because they happen to be shade-tolerant and sometimes evergreen, grow up through the understorey and threaten the integrity of the bush. So we need to be selective and intelligent about how we handle the threats. For instance, if holly is the only food for kereru in a part of the city, it would be counter-productive to suddenly fell these trees. Rather we should have a transitional strategy to establish native or safe alternatives and then progressively eliminate the baddies. Invasive, weedy species to definitely avoid or remove include sycamore, silver birch and plane trees (both with allergenic pollen), rhododendrons (poison nectar that affects honey), ivy, holly, yew, tradescantia, aluminium plant, periwinkle, stinking iris, plums, black locust, barberry, cotoneaster, Mexican daisy and honeysuckle. In northern parts of New Zealand there are many more seriously invasive species including wild ginger, exotic palms, woolly nightshade, monkey apple, privets, agapanthus, pampas grass, moth plant, mist flower and so it goes on. Each regional council has a list of their pest organisms.

Criteria for safe exotic species are: they can coexist rather than displace native species (anywhere); they are not widely spread by wind or birds; they are not shade-tolerant; they provide additional resources for native wildlife; and/or they provide some production or amenity value not otherwise present in the native flora.

There is a similar debate about the role of domestic cats in urban environments. While there are rats, stoats and mice on the loose it may be that cats are a net benefit for native wildlife by constraining these more voracious predators. Wild cats are a different story altogether. But the jury is still out on this one and keeping the moggy indoors during the hunting hours and having some cat-free suburbs are still valid and probably desirable options.

Stepping forward to sustainability and biodiversity

The key is to **integrate the productive and economic potential of the land** along with a sustainable **purpose**. Preserving history is fundamental to most cultures. So there is purpose in preserving and promoting the regional history, quality of life and health or sustainability of the environment. Some districts, such as the Waipara wine-growing area in North Canterbury, are committed to walking the ‘clean and green’ talk and using this as a marketing tool.

Matching the tangata whenua concept of *mauri* is the landscape concept of *legibility* – the ability to read the land like a book; to see, interpret and identify with the revealed layers of history. Now the challenge is to restore that lost heritage – maybe to create a rural scene reminiscent of the idyllic English countryside with familiar structural elements – hedgerows, field borders, road verges and riparian strips, *but* distinctively composed of indigenous species. Even mown or grazed pastures and lawns may emulate the English meadow by accommodating native forbs.

There are many opportunities to incorporate indigenous species and new habitats within the standard structural and amenity elements of farm and town. There are plenty of species that will perform the same function as standard, conventional exotic plants. The only difference is that the native species may not grow quite as fast as the best exotic performers. But good things take time!

It is important too to ensure that some of these native plantings are visible – and not relegated to the backblocks where nobody will see them, or confined to the impoverished soils that are useless for anything else. Likely as not they will be fairly useless for native trees as well! Rather, they should be celebrated and placed boldly in prominent locations, and not hidden behind rows of exotic trees (see Meurk & Swaffield 2007). This is where the urban environment has a big role to play.

3.1 What plants go where in the urban matrix[23]

Successful planting of both local and introduced species needs to reflect the natural land patterns – matching plants to the district’s landforms and soils. These integrate the primary requirements of plant

[23]Expands method 3.2.35, 3.4.3 and 3.4.4 in van Roon & van Roon (2005)

growth: moisture holding capacity and status, droughtiness, fertility, frostiness and exposure. The other factor that will determine success and failure is presence and activity of browsing mammals. Moisture limitations can be overcome to some extent by irrigation, but this should be used sparingly and ideally only during establishment, or the natural patterns will be obscured.

The main soil types and their environmental and historical context for each district are to be outlined in lift-out sections (see end piece). This is relevant to all major restoration projects and bush gardens where the original soils, landforms and stream-sides form the substrate.

In addition, there are some exclusively garden situations we may be planting for, such as rock gardens, lawns, herbaceous borders, green roofs and walls (Figures 48 and 49), but they all have their natural equivalents.

Figure 48 (left): *Green wall for private house at Liffey Spring Subdivision, Lincoln, New Zealand. Design: Jason Collett, 2007*

Figure 49 (below): *Green wall at the Pacific Museum, Paris. Photo: Robyn Simcock*

3.2 Urban public spaces

Street trees, avenues and parklands

Our city portals, parks, streets and traffic islands project strong messages to citizens and visitors. To reflect heritage there should be a strong presence of native, noble trees and striking hardy shrubs. Suggested formal street trees are: lowland ribbonwood (deciduous), narrow-leaved lacebark (white blossoms in midsummer), kanuka (white blossoms at Christmas time), cabbage trees, kowhai (use local provenance[24] – has yellow blossoms in late winter-early spring important as sources of nectar for honey-eating birds), totara[22], broadleaf, pokaka and kahikatea (on wet soils), lemonwood (lemon-fragrant blossoms in spring), lancewood (need protection from vandalism at early stage), kauri and karo (in the north), black beech or red beech. In addition are the frost-tender hinau, titoki, karaka, titoki, tarairi, tanekaha and rewarewa.

- These might be interspersed with exotic species and/or used at street corners, traffic islands, road narrowings and other focal points. Red-flowering gums and some hardy proteas and myrtles will also provide food for honey eating birds.

- Entranceways and traffic islands (Figures 50 and 51), apart from noble trees, could feature cabbage trees, lacebark, lancewood, fierce lancewood, kanuka, kowhai, totara (or matai, cedar or kahikatea depending on drainage) and kaikomako. Shrubs may include *Coprosma propinqua*, *C. virescens*, *C. crassifolia*, weeping mapau, *Olearia bullata*, *O. fragrantissima*, *O. lineata*, koromiko, tauhinu, *Teucridium parvifolium*, korokio, shrub pohuehue, scrambling pohuehue, whau, prostrate kowhai, shining karamu, houpara, rohutu, ramarama, *Pomaderris* spp., snow totara, porcupine shrub, bush lily, NZ flax, oioi, *Chionochloa conspicua* and inkberry.

- It has become fashionable to plant large tracts of silver tussock or wind grass in traffic islands, road verges and other grand landscape features. The problem is that they are successional species, usually growing in a forest environment. So they are vulnerable to being swamped with taller, dense exotic grasses or shrub weeds; and they get clogged with dead leaf material and lose their attractive clean shape (Fig. 55) within a few years (see inside back cover). They must therefore be assiduously weeded like flower gardens, or in larger enclosed areas they can be grazed with sheep which maintains their discrete form by continual removal of leaf litter and inter-tussock grasses. Otherwise, they should be treated as temporary nursery plants amongst which divaricating shrubs like coprosmas, korokio and pohuehue can be established. These will be more enduring and valuable to lizards and involve less maintenance.

- Note that exotic deciduous trees shed large quantities of foliage in winter creating problems for drainage and gutterings. Sporadic or clustered evergreen trees will create continuous shade and they can be preferentially placed on north sides of roads so private sections are not shaded.

---

[24] It is preferable to **use local genetic sources** or wild types of native plant species that have natural local populations (such as lacebark or kowhai). This preserves the genetic integrity of the regional biodiversity. Wild types of local plants are generally more vigorous and better competitors than cultivars or mountain varieties and therefore require less maintenance such as releasing from tall grasses and weeds. Some cultivars may be sterile and therefore won't produce fruit or nectar for native birds and lizards (e.g. golden totara). Planting species outside their natural range, where there are no local relatives, poses no genetic issues (e.g. kauri in the South Island); although some may feel they intrude on local character or point of difference. This may nevertheless be preferable to species from another country!

Figure 50 (a) and (b): *Native trees in downtown Auckland landscaping – a stand of kauri near Britomart (left) and cabbage trees at the Viaduct Harbour (right). Photos: Robyn Simcock*

Figure 51: *Native plants for traffic islands. Wellington, New Zealand. Photo: Maria Ignatieva*

3.3 Home gardens

Trees (over 2.5 m tall) suitable for limited sheltered space

Kanuka, cabbage tree (Figure 52), akeake, golden akeake, lancewood (Figure 53), fierce lancewood, kowhai, five-finger, rohutu, kaikomako, turepo, pepperwood, tree fuchsia (needs shelter), wineberry, titoki (needs shelter), marble leaf, *Coprosma areolata, C. rotundifolia*, *C. linariifolia*, *C. robusta*, lacebark, pigeonwood (needs shelter), mahoe, red mapau, *Olearia fragrantissima*, lowland ribbonwood (Figure 53), kohuhu, NZ cedar, ramarama, toro, wharangi and whau (all variously frost-tender, so need to use locally sourced material).

Figure 52*: Small native trees for suburban garden – kohuhu, cabbage tree and five-finger, Christchurch, New Zealand. Photo: Colin Meurk*

Figure 53 (a) and (b): *Two superb native trees for small spaces: ribbonwood in Christchurch (left) and lancewood in Nelson (right). Photos: Robyn Simcock*

Shrubs (woody plants less than 2.5 m tall) and vines
Coprosmas, olearias, koromiko (*Hebe* spp.), korokio, shrub pohuehue, mountain wineberry, prostrate kowhai, *Cyathodes juniperina*, *Leucopogon fasciculatus*, niniao, *Melicytus micranthus*, weeping mapau, poataniwha, *Pomaderris ericifolia*.

Hedges
Many New Zealand trees, shrubs and vines take to hedging like ducks to water. The following have been seen to work in hedges or shelterbelts: Kohuhu (Figure 54), lemonwood and other small-leaved divaricating *Pittosporum* spp., broadleaf, divaricating small-leaved coprosmas, shrub pohuehue, scrambling pohuehue, golden akeake, *Olearia dartonii* and other *Olearia* species, rangiora, totara (inside front cover), rohutu, weeping mapau, climbing broom, korokio, niniao, *Helichrysum dimorphum*, *Brachyglottis sciadophilus* and in warmer climes – red mapau, akeake, and taupata. The vines bush lawyer, NZ jasmine, *Clematis* spp. and passion vine (in the north) will add texture to hedges and also be suitable for trellises and pergolas.

Figure 54: *Hedge of kohuhu and koromiko. Lincoln, Canterbury. Photo: Maria Ignatieva*

Rock and scree gardens (Figure 55) with dry soils
The species size and vigour should be in keeping with the scale of the garden. If rock gardens are close enough to neighbouring gardens then genetic interchange is possible (see Box 3). This can apply to plant pollen as well as insects and lizards. Many mainly herbaceous species are common to green roofs, but more dwarf shrubs are possible here because of the generally deeper soil. To reduce competition from exotic species, the environment needs to be as harsh as possible by reducing soil depth and using only coarse-textured substrates, especially in wetter climates. You will have to experiment to see which species combinations work best in your environment. Lowland to montane coastal, riverbed, scree and rock ledge species will perform better and persist longer than alpine species in gardens because the latter will generally suffer from heat stress or drying winds.

Short tussocks and graminoids
Carex comans, *C. breviculmis*, *C. resectans*, silver tussock, blue tussock, *Festuca actae*, *F. coxii*, wheat grasses, danthonias, *Poa imbecilla*, *P. lindsayi*, *Zoysia minima*, onion-leaved orchid, sun orchid, NZ iris, rice grass, *Lachnagrostis* spp., plume grass, *Deyeuxia avenoides*, wood rushes (*Luzula ulophylla*, *L. celata*, *L. banksiana*) and *Arthropodium candidum*.

Forbs or broad-leaved herbs and ferns
Aciphylla subflabellata, *Geranium sessiliflorum*, *G. retrorsum*, NZ St John's wort, cotulas, *Brachyglottis bellidioides*, *B. lagopus*, *Pratia* spp., harebell, NZ groundsels, NZ linen flax, *Craspedia* spp., field daisy and related Northland *Celmisia* spp., *Celmisia mackaui*, *C. hookeri*, *Brachyscome pinnata*, *Lagenifera cuneata*, *L. strangulata*, *Viola cunninghamii*, NZ aniseed, *Anisotome aromatica*, willowherbs, forget-me-nots, NZ buttercup (*Ranunculus multiscapus*), cloak ferns, chain fern, dwarf kiokio, button fern, *Pyrrosia eleagnifolia*.

Dwarf shrubs, subshrubs, mats and cushions
Scleranthus uniflorus, *Parahebe* spp., *Leucopogon fraseri*, mat coprosmas (*Coprosma petriei*, *Coprosma atropurpurea*), NZ daphne, *Raoulia* spp. (scabweeds), *Einadia* spp., dwarf brooms (*Carmichaelia uniflora*, *C. corrugata*, *C. monroi*, *C. vexillata*), mat pohuehue, leafless pohuehue, *Acaena buchananii* and other biddibids, fuzz weed (*Vittadinia australis*), *Helichrysum* spp., *Leonohebe* spp. and *Pomaderris ericifolia*. Porcupine shrub, Marlborough rock daisy, prostrate kowhai, tree brooms, and matagouri are only suitable for large/deep rock or scree gardens.

Figure 55: *Rock garden. The Bush City, Te Papa, Wellington. See also inside back cover. Photo: Maria Ignatieva*

Box 3 What is a meta-population?

Communities of interbreeding organisms form populations that may seem to be isolated from others of the same species, but which occasionally 'communicate' with nearby populations. The sustainability of small populations will generally depend on migration and contact between these separate populations to ensure out-breeding and replenishment if a population goes extinct. This collection of interdependent populations is called a meta-population (Figure 56). How does this apply to the urban environment and to gardens?

Many grassland and riverbed species are being squeezed between agricultural or urban intensification, on the one hand, and competition from dense swards of exotic grasses, forbs and shrubs in rough field or road borders, on the other. Some have retreated to environmentally stressed rock ledges, but this is not enough for their long-term survival (as they will inevitably be followed by shrub and succulent weeds) and so there is a conservation opportunity in the urban context. Rock gardens and lawns, scattered like islands through a neighbourhood, could harbour some of these now rare herbaceous species – as can wastelands like gravel pits and demolished industrial sites. The seeds and insects (and possibly even lizards) that feed on the plants might travel between these small habitat islands thereby connecting them as a meta-population. For the lizards to make the journey safely through a gauntlet of cats and rodents, corridors of rocks or divaricating shrubs might be created. Some plants for rock garden microhabitats are listed here in section 3.3[25].

[25] See also www.bush.org.nz/planterguide

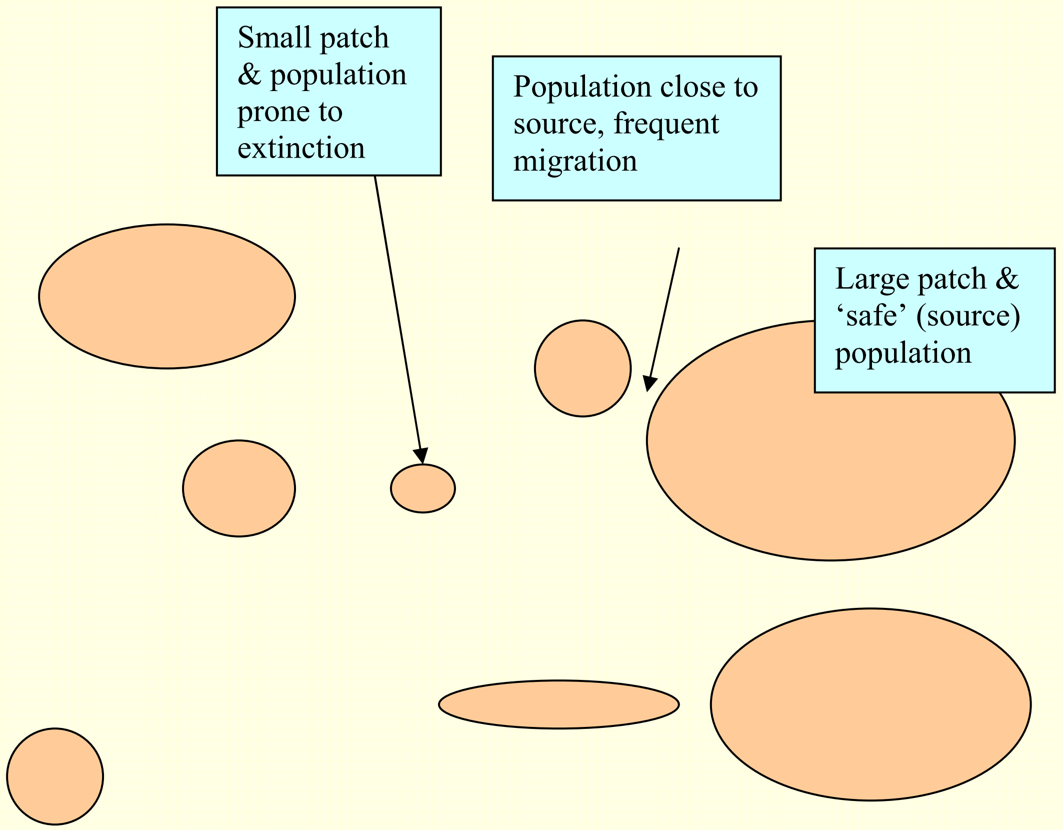


Figure 56: *A cluster of populations of various sizes and degrees of isolation and therefore interpatch migration. Together these comprise a meta-population as they are all part of an interbreeding group even though some component populations will share genes more frequently than others.*

Figure 57: *Native groundcover (grasses, lilies, sedges, biddibids and dwarf koromiko) in display gardens at Ellerslie International Flower Show, 1996 and 1998. Photos: Robyn Simcock*

Forbs and ferns for shady public parks and private gardens (herbaceous borders)

Rengarenga, *Arthropodium candidum*, Chatham Island forget-me-not, puha, *Jovellana*, sea spurge, *Parietaria debilis*, *Scutellaria novae-zelandiae*, inkberry, NZ iris, bush rice grass, holy grass, mountain flax, Māori onion (in open), *Chionochloa flavicans*, *Brachyglottis lagopus*, mountain and field daisies, *Parahebe* large spp., NZ spinach, creeping fuchsia and bush lilies and ferns including shield ferns, tree ferns, hounds tongue fern, kiokio, dwarf kiokio, maidenhair fern, pig fern and spleenworts. New Zealand has many attractive native ferns and herbs with coloured foliage and fruits rather than flowers (Figures 57-59). Pictorial meadows (inside back cover) are assembled from continental annuals. They *are* pretty, but not very New Zealand; and many are weeds that displace native plants and insects.

Figure 58 (left): *Riparian fernery in Christchurch garden – tree ferns and swamp kiokio. Photo: Kelvin MacMillan*

Figure 59 (right): *Herbaceous border of inkberry, NZ iris, Pratia, biddibid, wind grass and pennywort in a town house complex, Christchurch, New Zealand. Photo: Colin Meurk*

Native lawns

Lawns can require a lot of time and expense, and associated activities such as top-dressing, herbiciding, watering and disposing of clippings are not so good for the environment. However, lawns provide great functional places to relax, play sport, and undertake household chores and projects. Visually they provide a wonderful smooth surface to provide contrast in the garden and open up longer views.

By avoiding excessively large areas of lawn and introducing native grasses and ground-hugging species, we can create areas that are as visually pleasing and functional as traditional lawns while providing a safer, less wasteful, and more biodiverse environment for both ourselves and our native fauna. Locally sourced native species are particularly adapted to our environment and should require little or no fertiliser, water and mowing once established.

Many lawns already include native species such as *Hydrocotyle* and *Leptinella*. Therefore a quick and easy way to increase biodiversity is to plant other native species such as *Pratia*, *Dichondra* and biddibid (Figure 60) straight into your existing lawn. Remember that the barbed biddibids may not be a pleasant recreational lawn if allowed to go to seed. Allowing fertility to decline and some moderate shade will encourage ‘meadow species’ such as the native rice grass and various forbs (flatweeds).

Plants for native lawns

Moist

Pennyworts, *Leptinella dioica*, *Pratia angulata*, *Centella*, Māori onion (taller lawn), *Juncus planifolius*, *J. caespiticius*, bristle sedges, spike sedge, *Mazus* spp. (Figure 60b), <u>*Gunnera*</u> spp., *Cotula* *coronopifolia*, *Plantago triandra*, *Gnaphalium* spp. (Figure 61), *Nertera* spp., *Selliera radicans*, biddibids (Figure 60a), silverweed, NZ mint (*Mentha cunninghamii*) and willowherbs.

Dry
Pennyworts, *Dichondra repens*, *Gnaphalium* spp., biddibids (taller lawns, Figure 60a), *Leptinella* spp., *Cotula australis*, *Oxalis exilis* and *Zoysia minima*.

Figure 60 (a) and (b) (above): *Native lawn with biddibid. Photo: Maria Ignatieva; Rare* Mazus novaezeelandiae *in mown turf at Spencer Park, Christchurch. Photo: Colin Meurk*

Figure 61 (left): Gnaphalium audax *in a Christchurch lawn. Photo: Colin Meurk*

Plants for walls

Even inhospitable looking rocks and walls can be substrates for a specialised group of plants. These may otherwise find no place to live in the wild as development spreads, intensifies and weeds encroach. These lists could be expanded to include all rock ledge species for high or low rainfall sites, but this is something to start with. Note, one should never raid wild sources and remove whole plants. Get a specialist to collect seed or, when there are no other sources, cuttings. Here lists for high rainfall and dry walls are separated.

Moist
Chain fern, cloak ferns, button fern, *Psilotum nudum*, *Pyrrosia eleagnifolia* (Figure 62), hounds tongue fern, button fern, *Crassula sieberiana*, NZ iceplant, danthonia grass, *Earina autumnalis* (Easter orchid, Figure 62), NZ linen flax, mat pohuehue and scrambling pohuehue.

Dry
Cloak fern, button fern, *Crassula sieberiana*, *Calystegia tuguriorum*, *Convolvulus verecundus*, NZ iceplant, NZ linen flax, danthonia, NZ groundsel, *Stellaria gracilenta*, *Poa imbecilla*, leafless pohuehue, mat pohuehue and scrambling pohuehue.

Figure 62: *Native* Earina *orchids and* Pyrrosia *ferns grow on a shady scoria wall, Cornwall Park, Auckland. Photo: Robyn Simcock*

3.4 Tips for successful habitat restoration and other larger-scale planting

Planting in even semi-wild situations, where maintenance and irrigation are difficult and infrequent, requires quite a different approach to protected and nurtured gardens.

See the Department of Conservation (DOC) restoration handbook (Davis & Meurk 2001) and other restoration manuals (e.g. Society for Ecological Restoration website, www.ser.org) for the basics; and the NZERN website (www.bush.org.nz) for first-line restoration species for throughout lowland New Zealand organized by Ecological Region and Soil Order (broad soil type).

A summary of key steps for successful extensive (restoration) planting is as follows:

Visioning
Have an idea of where you are going and what you want it to look like. Find natural or planted models that represent this vision do some sketches. Anticipate and plan for changes, growth and full size of plants.

Planning
Area, resources (soils, drainage, money, labour), permissions, security, time of site preparation and planting (e.g. autumn/spring for moist sites; summer for wet sites, spring for frost tender plants).

Ordering plants
It is important to do this early (preferably a year out) so that appropriate, locally sourced plant material can be collected and propagated ready for your planting times.

Site preparation
Weed control, soil ripping or watering and preliminary animal pest control.

Planting

Make sure everyone knows the proper techniques (see brochures and website links for details) – plant deep in dry sites; rootball soil protruding above surface of very wet sites especially for woody plants.

Mulching, watering, pest control

Ensure plants are adequately watered throughout the first summer, but planting properly and mulching will help retain moisture and suppress weeds. Rigorously keep long grass under control for best growth; stake each plant if there is doubt about likely weeding frequency and loss of plants in grass.

Management and long-term maintenance

As much needs to be budgeted for this as for planting! This will be spread over 3-5 years depending on the environment and pest levels.

Infilling or blanking

There will be inevitable mortality and in public places vandalism or theft. Infilling needs to be included in the budget and carried out as soon as practicable.

Monitoring

This will ensure the project is on track to realise the vision. Adaptive management – evaluating performance and adjusting planting and management accordingly. The simplest form of monitoring is to take (digital) photographs of the site before you start and regularly thereafter. Annotate the pictures (especially the date and where taken) and store them in a secure place for future reference. Survival, growth, fruiting and regeneration are useful measurements that can be made also.

3.5 Epilogue

Every household that removes pest plants and animals from their properties and neighbourhoods, and plants even some of the species suggested in this manual, is making a significant contribution to preserving our natural heritage and landscape character. Wildlife will come for the food and shelter that specifically native plants provide; successional pathways will shift; we and visitors will feel more like we are in an authentic New Zealand-Aotearoa. Those designing and maintaining vegetation in public and high-visibility places also have a huge role to play - especially along roadsides, shelterbelts, streams, coasts and in parks.

There are many more plants for the specialist and many birds, lizards, frogs and insects that have only been touched on here; there are many inspirational design ideas (Gabites & Lucas 1998) and many other sources of information about our natural history and managing our environments – from councils and on book shelves.

These are just some ideas to whet the appetite; you will need to experiment to see what best suits your particular situation and aesthetics – a native wilderness in the backyard or a formal garden with integrated native and conventional horticultural species. All will be vital to New Zealand’s collective, yet diverse sense of self and is relevant to the current debate about nationhood. It might be argued that biodiversity and landscape are just as important to our health and well-being as sustainable energy, water, agriculture and economy. Really, the integration of all these factors and values is the way forward.

Further reading

Auckland Regional Council 2001. Riparian zone management strategy: planting guide. Available at www.arc.govt.nz/arc/library/e14404_2.pdf [accessed 6 December 2007].

Centre for Urban Ecosystem Sustainability 2007. Taupo West structure planning process. Discussed under the Taupo Case Study for the LIUDD Programme at: www.landcareresearch.co.nz/research/built/liudd/casestudies/case_taupo.asp [accessed 6 December 2007].

Davis M, Meurk CD 2001. Protecting and restoring our natural heritage – a practical guide. Department of Conservation, Christchurch. www.doc.govt/upload/documents/conservation/native-plants/motukarara-nursery/restoration-guide-complete.pdf

Dunnett N, Clayden A 2007. *Rain gardens. Managing water sustainability in the garden and designed landscape.* Timber Press.

Dunnett N, Hitchmough J eds 2004. *The dynamic landscape. Design, ecology and management of naturalistic urban planting.* Spon Press, London and New York.

Ecopolis Architects 2007. Christie Walk Available at www.ecopolis.com.au [accessed 6 December 2007].

Environment Canterbury and Isaac Centre for Nature Conservation 2003. *Establishing shelter in Canterbury with nature conservation in mind.* Environment Canterbury, Christchurch.

Gabites I, Lucas R 1998. *The native garden – Design themes from wild New Zealand.* Godwit, Auckland.

Harmsworth, GR 2004. The role of Māori values in Low-impact Urban Design and Development (LIUDD) Discussion paper. Collaborative learning and LIUDD web sites, Landcare Research NZ Ltd. www.landcareresearch.co.nz/research/sustainablesoc/social/indigenous_index.asp

Louv, R 2005. *Last child in the woods – saving our children from nature-deficit disorder.* NC, Chapel Hill.

Lucas Associates, Meurk CD, Lynn I 1998. *Indigenous ecosystems of the Lyttelton Harbour Basin – a guide to native plants, their ecology and planting.* Lucas Associates and Governors Bay Community Association.

Manukau City Council 2004. Flat Bush Structure Plan: www.manukau.govt.nz/default.aspx?id=2818 [accessed: 16 October 2007].

Meurk CD 2005. Cities are cultural and ecological keys to biodiverse futures. In: Dawson MI (ed.). *Greening the city – bringing biodiversity back into the urban environment*. Proceedings of a Conference held by the Royal New Zealand Institute of Horticulture in Christchurch, 21-24 October 2003. Royal New Zealand Institute of Horticulture, Christchurch, Pp 301-310.

Meurk CD, Hall GMJ 2006. Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. *New Zealand Journal of Ecology 30*: 131–146.

Meurk CD, Swaffield SR 2000. A landscape ecological framework for indigenous regeneration in rural New Zealand-Aotearoa. *Landscape and Urban Planning 50*: 129-144.

Meurk CD, Swaffield SR 2007. Cities as complex landscapes: biodiversity opportunities, landscape configurations and design directions. *NZ Garden Journal 10*: 10–20.

Meurk CD, Lucas Associates, Barker R 1997. *Streamside planting guide.* Christchurch City Council.

North Shore City Council 2006. Variation 66 and Plan Change 6 to the North Shore City District Plan. Available at www.northshorecity.govt.nz [accessed 15 October 2007].

North Shore City Council 2007. Long Bay Structure Plan: www.northshorecity.govt.nz/

Robinson N 1993. Place and planting design – plant signatures. *The Landscape 53*: 26-28.

Simcock R, Toft R, Ross C, Flynn S 1999. A case study of the cost and effectiveness of a new technology for accelerating rehabilitation of native ecosystems. Pp 234-251. In: Minerals Council of Australia 24th Annual Environmental Workshop, Townsville

Spellerberg I, Given D 2004. *Going native.* Canterbury University Press, Christchurch.

Stewart GH, Ignatieva ME, Meurk C, Earl RD 2004. The re-emergence of indigenous forest in an urban environment, Christchurch, New Zealand. *Urban Forestry – Urban Greening 2*: 149-158.

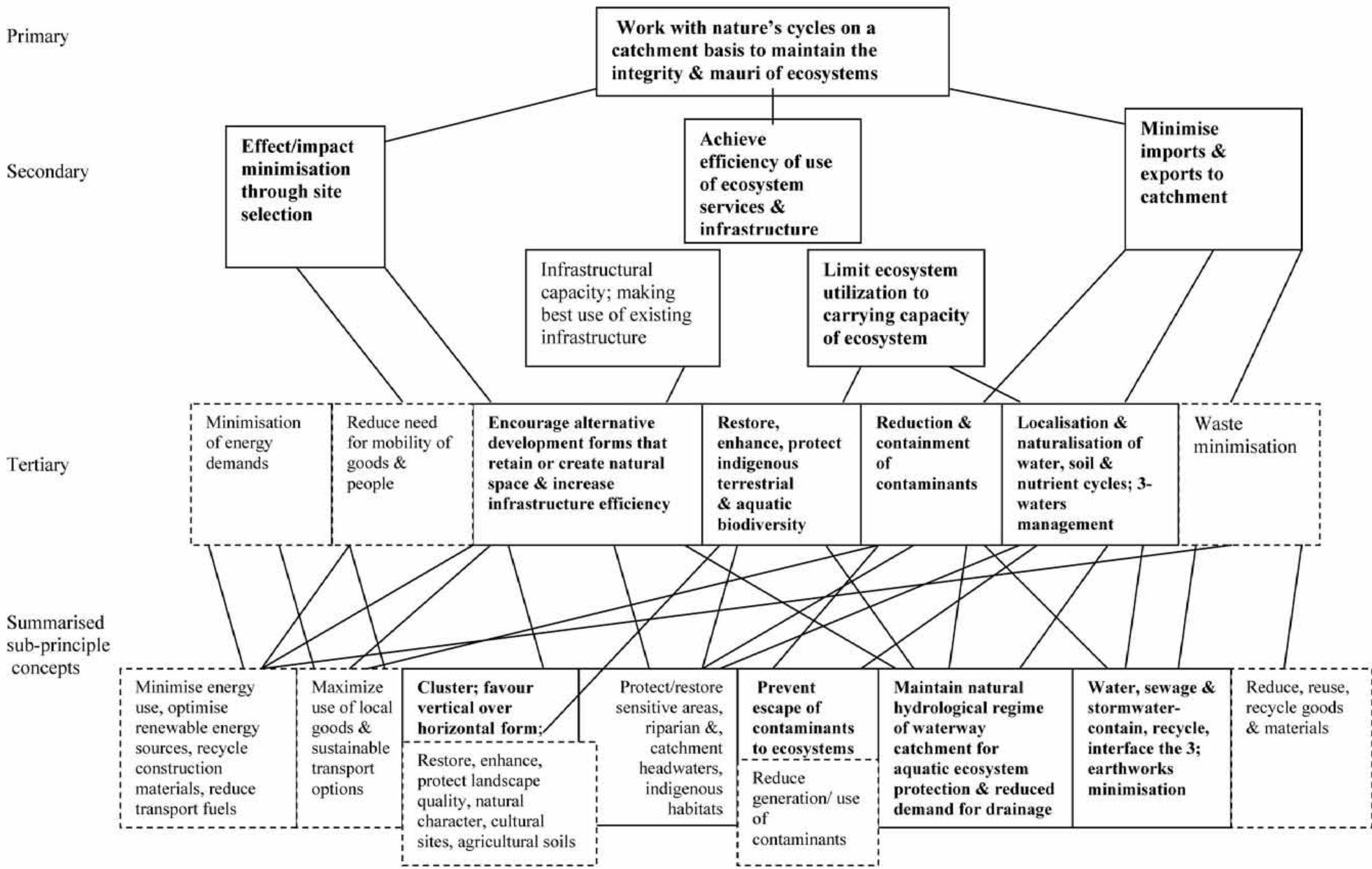
van Roon MR, van Roon HT 2005. Low Impact Urban Design and Development principles for assessment of planning, policy and development outcomes. Working Paper 051, Centre for Urban Ecosystem Sustainability (University of Auckland and Landcare Research) available at www.landcareresearch.co.nz/research/built/liudd [accessed 15 January 2008].

Appendix 1 Links between elements of Low Impact Urban Design and Development (opposite page)

Detailed discussion and description of the principles and a listing of methods of LIUDD are found in van Roon & van Roon (2005), CUES Working Paper 051 – see www.landcareresearch.co.nz/research/built/liudd.

The diagram that follows summarises the principles but the Working Paper (051) provides much more detail enabling the reader of this manual to link methods described here to all of LIUDD.

Figure : Hierarchy of Principles of LIUDD as at 25/5/05. Principles in bold are the dominant focus of this LIUDD, FRST funded, programme. Principles in dashed boxes have minor focus in this programme. Figure 1 is a partial representation of Table 1 (van Roon and van Roon, 2005)



Appendix 2 Common plant names index

Adders tongue fern	*Ophioglossum coriaceum*
Akeake	*Dodonaea viscosa*
Bamboo spike sedge	*Eleocharis sphacelata*
Baumea spp.	*Baumea articulata, B. juncea, B. rubiginosa*
Beech	*Nothofagus* spp.
Biddibid	*Acaena* spp.
Blue tussock	*Poa colensoi*
Blue wheat grass	*Elymus* spp.
Bristle sedge	*Isolepis* spp.
Broadleaf	*Griselinia littoralis*
Bush flax	*Astelia fragrans*
Bush lawyer	*Rubus cissoides, R. schmidelioides*
Bush rice grass	*Microlaena avenacea*
Button fern	*Pellaea* spp.
Cabbage tree	*Cordyline australis*
Cedar	*Libocedrus* spp.
Chain fern	*Asplenium flabellifolium*
Chatham island forget-me-not	*Myosotidium hortense*
Climbing broom	*Carmichaelia kirkii*
Cloak fern	*Cheilanthes* spp.
Cotula	*Leptinella* and *Cotula* spp.
Creeping fuchsia	*Fuchsia procumbens*
Danthonia	*Rytidosperma* spp.
Dwarf kiokio	*Blechnum penna-marina*
Elaeocarps	*pokaka* and *hinau*
Field daisy	*Celmisia gracilenta*
Fierce lancewood	*Pseudopanax ferox*
Five-finger	*Pseudopanax arboreus*
Golden akeake	*Olearia paniculata*
Harebell	*Wahlenbergia* spp.
Houpara	*Pseudopanax lessonii* (and *P. discolor*)
Hinau	*Elaeocarpus dentatus*
Holy grass	*Hierochloe* spp.
Hounds tongue fern	*Microsorum pustulatus*
Hunangamoho	*Chionochloa conspicua*
Ink berry/turutu	*Dianella nigra*
Kahikatea	*Dacrycarpus dacrydioides*
Kaikomako	*Pennantia corymbosa*
Kanuka	*Kunzea ericoides*
Karamu	*Coprosma robusta*
Karo	*Pittosporum crassifolium*
Kauri	*Agathis australis*
Kiokio	*Blechnum novae-zelandiae*
Knobby clubrush	*Isolepis nodosa*
Kohuhu/black mapau	*Pittosporum tenuifolium*
Korokio	*Corokia cotoneaster* (South Island), *C. buddleoides* (North Island)
Koromiko	*Hebe salicifolia/stricta* and spp.
Kowhai	*Sophora microphylla* (southern), *S. tetraptera* (northern)
Lacebark/houhere	narrow-leaved (*Hoheria angustifolia*), North Island (*H. populnea/sextylosa*)

Lake clubrush	*Schoenoplectus tabernaemontani*
Lancewood	*Pseudopanax crassifolius*
Leafless lawyer	*Rubus squarrosus*
Leafless pohuehue	*Muehlenbeckia ephedroides*
Lemonwood/tarata	*Pittosporum eugenioides*
Lowland ribbonwood/manatu	*Plagianthus regius*
Mahoe	*Melicytus ramiflorus*
Maidenhair fern	*Adiantum* spp.
Māori onion	*Bulbinella* spp.
Manuka	*Leptospermum scoparium*
Mapau	*Myrsine australis*
Marbleleaf/putaputaweta	*Carpodetus serratus*
Marlborough rock daisy	*Pachystegia* spp.
Marsh ribbonwood	*Plagianthus divaricatus*
Matai	*Prumnopitys taxifolia*
Mat pohuehue	*Muehlenbeckia axillaris*
Mikimiki	small-leaved coprosmas (*C. crassifolia, C. propinqua, C. rubra, C. virescens*, and others)
Milfoil	*Myriophyllum* spp.
Mountain and field daisies	*Celmisia* spp.
Mountain flax/wharariki	*Phormium cookianum*
Mountain wineberry	*Aristotelia fruticosa*
Niniao	*Helichrysum lanceolatum*
NZ aniseed	*Gingidia montana*
NZ daphne	*Pimelea* spp.
NZ dock	*Rumex flexuosus*
NZ flax/harakeke	*Phormium tenax*
NZ groundsel	*Senecio* spp. (*S. glomeratus*, *S. minimus*, *S. quadridentatus*)
NZ iceplant	*Disphyma australe*
NZ iris	*Libertia* spp.
NZ jasmine	*Parsonsia* spp.
NZ linen flax	*Linum monogynum*
NZ spinach	*Tetragonia trigyna*
NZ St John's wort	*Hypericum gramineum*
Oioi	*Apodasmia similis* (formerly *Leptocarpus*)
Onion-leaved orchid	*Microtis* spp.
Passion vine	*Passiflora tetrandra*
Pennywort	*Hydrocotyle* spp.
Pepperwood	*Pseudowintera colorata*
Pigeonwood	*Hedycarya arborea*
Plume grass	*Dichelachne crinita*
Poataniwha	*Melicope simplex*
Pohutukawa	*Metrosideros excelsum*
Pokaka	*Elaeocarpus hookerianus*
Pond weed	*Potamogeton cheesemanii*, *P. ochreatus*, *P. pectinatus*, *P. suboblongus*
Porcupine shrub	*Melicytus alpinus, M. crassifolius*
Prostrate kowhai	*Sophora prostrata*
Puha	*Sonchus kirkii*
Puka	*Griselinia lucida*
Pukatea	*Laurelia novae-zelandiae*
Pukio	tussock sedges (*Carex secta, C. virgata*)

Purei	turf or short tussock sedges (*Carex comans, C. flagellifera, C. buchananii, C. geminata*)
Puriri	*Vitex lucens*
Ramarama	*Myrtus bullata*
Rangiora	*Brachyglottis repanda*
Red mapau	*Myrsine australis*
Red tussock	*Chionochloa rubra*
Rengarenga	*Arthropodium cirratum*
Rewarewa	*Knightia excelsa*
Rice grass	*Microlaena stipoides*
Rimu	*Dacrydium cupressinum*
Rohutu	*Lophomyrtus obcordata*
Rushes	*Juncus australis, J. distegus, J. gregiflorus, J. pallidus, J. sarophorus*
Sand convolvulus	*Calystegia soldanella*
Sand coprosma	*Coprosma acerosa*
Sea spurge	*Euphorbia glauca*
Sedges	*Carex comans, C. geminata*
Scrambling pohuehue	*Muehlenbeckia complexa*
Shield fern	*Polystichum* spp.
Shining karamu	*Coprosma lucida*
Short tussock sedges (see purei)	*Carex buchananii*, *C. lambertiana*, *C. lessoniana*, *C. petriei*, *C. solandri*, *C. sinclairii*
Shrub pohuehue	*Muehlenbeckia astonii*
Silver tussock	*Poa cita*
Silverweed	*Potentilla anserinoides*
Snow totara	*Podocarpus nivalis*
Spike sedge	*Eleocharis acuta*
Spleenwort	*Asplenium* spp.
Sun orchid	*Thelymitra* spp.
Swamp kiokio	*Blechnum minus*
Swamp willow weed	*Polygonum salicifolium*
Tanekaha	*Phyllocladus trichomanoides*
Taraire	*Beilschmiedia tarairi*
Tauhinu	*Ozothamnus leptophyllus* (formerly *Cassinia*)
Taupata	*Coprosma repens*
Titoki	*Alectryon excelsus*
Toro	*Myrsine salicina*
Tuhara	*Machaerina sinclairii*
Turepo	*Streblus heterophyllus*
Toetoe	*Cortaderia richardii, C. toetoe, C. fulvida, C. splendens*
Totara	*Podocarpus totara*
Tree fuchsia	*Fuchsia excorticata*
Tussock sedges	*Carex secta, C. virgata*
Umbrella sedge	*Cyperus ustulatus*
Weeping mapau	*Myrsine divaricata*
Whararangi	*Melicope ternata*
Whau	*Entelea arborescens*
Wheat grass	*Elymus* spp.
Willowherb	*Epilobium* spp.
Wind grass	*Anemanthele lessoniana*
Wineberry/makomako	*Aristotelia serrata*
Woodrush	*Luzula* spp.

LIFTOUT SECTION CUSTOMISED TO EACH DISTRICT

Every region is different in terms of geology, topography, climate, soils, social conditions and potential vegetation. So, while this manual has endeavoured to provide generic information that is more or less applicable throughout New Zealand–Aotearoa, there are some specifics that are better handled on a regional basis. It is therefore intended that local informants are engaged to provide customised material under the following headings.

Geological, topographical, soil and biological history of the area

Pre-Māori native vegetation and flora

Current status of the local vegetation and flora

Plant suitability and availability

Authors and contact details

Maria Ignatieva[1, 5], Colin Meurk[2], Marjorie van Roon[3], Robyn Simcock[4] and Glenn Stewart[5]

1 Lincoln University, PO Box 84, Lincoln 7675
Email: ignatiem@lincoln.ac.nz

2 Landcare Research, PO Box 40, Lincoln 7640
Email: meurkc@landcareresearch.co.nz

3 School of Architecture and Planning,
University of Auckland, Private Bag 92019,
Auckland Email: m.vanroon@auckland.ac.nz

4 Landcare Research, Private Bag 92170,
Auckland Mail Centre 1142, Auckland
Email: simcockr@landcareresearch.co.nz

5 New Zealand Research Centre for Urban Ecology,
178 Days Rd, Springston RD4, Christchurch 7674
Email: glenn01@xtra.co.nz

Acknowledgements

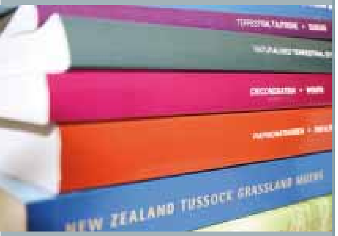
We thank the Foundation for Research, Science and Technology for funding the LIUDD Research Programme. The Lincoln Envirotown Trust (Sue Jarvis), David Hobbs (Broadfield Estates), Mark Hostetler (University of Florida, USA) and Sue McGaw (Hortweb Landscape) contributed ideas and practical perspectives as did Lincoln University Landscape Architecture students (Ecological Design Studio, 2005, 2006 and 2007 – Lucas Adam, Frazer Baggaley, Jason Collett, Simon Moultrie and James Rea who provided figures 2, 3, 6, 13 and 43), and Graduate Landscape Students (Meg Gaddum, Luke McKinlay and Janic Slupski). Stephen Moore, Clare Feeney and Garth Harmsworth provided some constructive suggestions and references. Christine Bezar edited the text. We especially thank Cissy Pan for assisting us with the report formatting and design.

Glenn Stewart and Maria Ignatieva inspecting an extensive green roof in Sheffield, England where this will soon be a requirement for new commercial buildings. Photo: Colin Meurk

Planted silver tussock after a year or two, retaining discrete attractive form, Janet Stewart Reserve, Christchurch. Photo: Colin Meurk

Silver tussock after year three being displaced by tall exotic grasses despite frequent intensive maintenance, Halswell, Christchurch. Photo: Colin Meurk

Pictorial meadow, a concept developed by Nigel Dunnett (left) in Sheffield, England to bridge the gap between manicured and untidy. Although it uses non-invasive, non-local species and cultivars the habitat is utilised by native pollinators and other insects. We have to be very careful with exotic flowers in New Zealand. Photo: Colin Meurk



Manaaki Whenua PRESS

www.mwpress.co.nz