Cities as complex landscapes: Biodiversity opportunities, landscape configurations and design directions

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Introduction

A major feature of urban theory over recent decades has been a sustained challenge to the historical dualities between town and country, between culture and nature, and between buildings and landscape. In their place new urban models and planning paradigms have emerged in which the city is re-conceived as a complex mosaic of conditions, activities, values and experiences – an urban field that is in continual, open ended, and uncertain change (Graham and Marvin, 2001). A key dimension of the emergence of this new 'landscape urbanism' (Waldheim, 2006) has been renewed attention to the landscape ecology of cities and city regions (Stewart and Ignatieva, 2000), and in this paper we explore some of the design opportunities and challenges that arise when considering the conservation and enhancement of indigenous biodiversity in New Zealand cities.

Fig. 1 Indoor fernery under a stairwell featuring maidenhair ferns.

In essence, the same biophysical landscape ecological processes operate in urban and cultural landscapes as in natural environments (Hough, 2004).

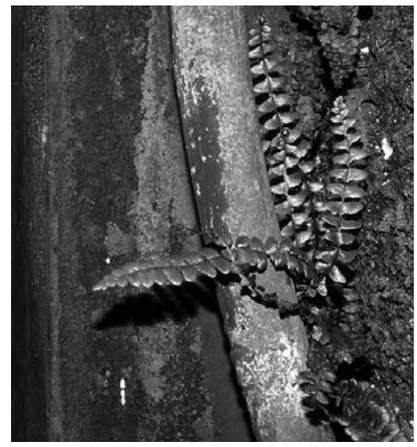

Fig. 2 A broken pipe provides an intermittent cascade sufficient to support the native fern *Blechnum penna-marina* in an otherwise dry 'gorge' of inner city Christchurch. Photo: Kelvin McMillan, Christchurch City Council.

However some of the stresses and disturbances are more extreme than would normally be found in natural ecosystems. There are also patterns that are distinctively different. Patch scale for example is often finer in cultural landscapes, because of the localised intensity of human disturbance (Forman, 1995). Likewise, patch boundaries and configurations are affected by fragmentation associated with human and institutional activity rather than natural environmental gradients. Design and management is typically dominated by social and cultural priorities and one consequence of this cultural transformation of ecological process and pattern is that urban ecology becomes 'de-naturalised' and is more difficult to decipher (Wrede and Adams, 1991). The perceptual and conceptual distancing of urban populations from underlying ecological processes in their surrounding environment (Louv, 2005) means that many people are increasingly influenced by the surface appearance of 'nature' (and by artificial simulacra) rather than a deeper understanding of natural systems.

Fig. 3 Green roofs are a way of reducing impacts of rapid stormwater runoff from urban impervious surfaces.

Despite this de-coupling of culture and nature in the modern industrial world, mature cities in situations where the native biota has remained predominant have often achieved some accommodation with 'wildness'. There are many urban habitats that mimic, albeit extreme, natural lowland habitats – riverbeds, sand dunes, salt marshes, crags and gorges – and an increasing range of indigenous species are becoming 'urbanised' (Spirn, 1984). There is a long established intellectual and design tradition that promotes and privileges 'Nature in Cities' (Laurie, 1979), and much urban ecological restoration in Europe and North America is based upon creating space and opportunity for ecological processes to regenerate spontaneously. Indigenous nature, from surrounding rural and wilderness areas, quietly reinvades urban habitat, supplemented by human agency, creating a new 'Granite Garden' (Spirn, 1984).

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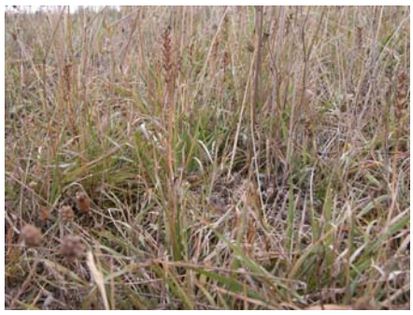

Fig. 4 Green roofs provide another option for biodiversity. Spontaneous indigenous lichens, mosses and the onion orchid (*Microtis*) occur on the roof of this South Canterbury home. Photo: Robyn Simcock, Landcare Research.

In contrast, in the urban areas of Australia and New Zealand that were created as the result of European colonial settlement during the past 200 years, the after-effects of both cultural and ecological imperialism are still very evident (Crosby, 2004). Indigenous nature may be under severe stress from introduced species and human disturbance, whilst urban society itself frequently assigns pre-eminence to introduced cultural forms and species. This creates significant tensions and challenges in developing policy and design strategies to conserve and enhance indigenous urban biodiversity (Swaffield, 2005).

Fig. 5 Natural basalt rock ledge with the Banks Peninsula endemic *Brachyglottis lagopus*.

This paper starts from the proposition outlined in our earlier papers (Meurk and Swaffield, 2000; Swaffield, 2003; Swaffield, 2005), that while access to all types of nature has positive effects on human wellbeing, indigenous nature in particular is an important element in identity and sense of place (Hough, 1990). We analyse typical New Zealand urban form as types of ecological opportunity and examine some urban biotopes and species from similar wild habitats that could be promoted in the urban context. We also examine the opportunities to use knowledge of landscape dynamics to design urban landscape configurations that provide both ecological sustainability (at a metapopulation scale) and sustainability of the human experience of nature.

Fig. 6 Basalt rock wall in Auckland harbouring indigenous species – an *Earina* orchid, the leather fern *Pyrrosia*, *Crassula*, mosses and lichens.

In this analysis we identify three spatio-cultural scales in cities where such experience can be usefully promoted: first, in the 'deep' structure of natural features, hydrological corridors, extensive parks and reserves; second, in the frequently unseen (but crucial) matrix of private land, ranging from gardens to industrial wasteland; third, in the highly visible public realm of streets, access points, edges and nodes, that play a large part in defining the way in which cities see and present themselves.

Fig. 7 Locally rare fern ally *Psilotum nudum* growing in a basalt rock crevice at Rangitoto Island – a potential for population conservation on urban walls in Auckland.

In each of these settings we explore the significance of appropriate and legible design in urban environments, and provide some principles for achieving good design that recognises the potential role of indigenous nature within cultural green space. The basic argument is similar to our previous propositions regarding rural landscapes (Meurk and Swaffield, 2000; Meurk and Hall, 2006). Finally we identify some research needs to further these strategies.

Fig. 8 Bracken fern (*Pteridium esculentum*) fringing ballast along the main trunk railway line in Canterbury.

Design for Urban (Bio)Diversity

In all diverse and plural communities there are competing ideas about how the cityscape should be designed, maintained or managed. Tradition or habit is generally entrenched politically and in public institutions, and in cities still steeped in their colonial origins, this has a persistent influence over environmental decisions. In the case of Christchurch, New Zealand, parks management was for perhaps a century largely shaped by a European horticultural tradition, which typically placed little emphasis upon the celebration of the unique biogeography and ecology of New Zealand and propagation of the indigenous species. The earlier managers also had little comprehension of the biosecurity risks that were being promulgated by importation of numerous exotic species (through Acclimatisation Societies).

Fig. 9 A native sedge *Carex inversa* growing in a footpath crack in the Auckland central business district.

During this first century or so of settlement, therefore, colonial and Victorian values prevailed in urban planting (Strongman, 1999; Leach, 2002). Trees and other productive or amenity plants, initially from Europe, Australia and North America, proved to have phenomenal growth rates and were generally favoured over the

less familiar indigenous species, although even in these early phases there were sometimes intense debates and advocates for indigenous planting within urban parks. Practical considerations (relative growth rates in the presence of exotic animals and grass competition), nostalgia for 'home', and a sense of horticultural aesthetics derived from Europe all played their part in these early decisions.

Fig. 10 An endemic grass *Poa imbecilla* growing on a footpath edge in a Christchurch suburb.

In recent decades, urban communities in New Zealand have become more pluralistic and other values have emerged, and re-emerged (King, 2004). This is recognised in rising cultural diversity and local content in arts, literature, food, and gardening, and in the renaissance of indigenous Maori values and plant knowledge. Intellectually, there is increasing recognition of multiple conceptions of 'nature' and acknowledgement that nature is indeed living, dynamic, diverse and embedded in cities (Barnett, 2006). While nature is now an extension of human decisions and culture, it also acts as a feedback to that culture and an instrumental attitude to nature is giving way to a conception of people being a part of nature rather than divorced from it (McHarg, 1969). In broader terms, experience of life processes (reproduction, dispersal, succession) may be essential to understanding, evaluating and decision-making (personal or political) with respect to sustainability of natural habitat, and (by extension) the greater human environment. If people do not understand how nature works then it is unlikely they will make astute decisions about their behaviour on the land or in the ballot box (Nassauer, 1997).

Fig. 11 Classic wasteland in Sheffield, England with succession from sparse herbfield, dense grassland, invading shrubs and woodland.

We therefore offer below several principles of design for urban biodiversity that seek to mediate between these different pressures and sets of values.

Fig. 12 Herbaceous border in a formal native garden setting featuring a pink cultivar of mountain flax (*Phormium*), red sedges (*Carex*) and scarlet flowering pohutukawa (*Metrosideros*), Port Hills, Christchurch.

Generic principles

- **Regenerative design (Lyle, 1986)**
  The American landscape scholar J.T. Lyle argued that all landscape design interventions, whether dominantly exotic or native species, should contain within them the potential for self sustaining regeneration. His conception of 'design for human ecosystems' drew upon Odum's ecosystem models (Odum, 1968) and extended them into a design programme that treated 'human' and 'natural' elements as part of a single system, for which we should adopt a goal of self regulation and regeneration without the need for external subsidy of materials or energy. This in turn requires adherence to the next principle of management through concepts of stress-disturbance, and to the adoption of realistic management expectations for maintaining successional vegetation (Meurk, 2004).

Fig. 13 Highly structured indigenous herbaceous border featuring green *Scleranthus* cushions, spear grass (*Aciphylla*), purple biddibiddi (*Acaena*), ochre-coloured whipcord hebe, lancewood (*Pseudopanax*), rengarenga (*Arthropodium*), and tussock grasses – suburban Christchurch.

- **Designing and Managing plant communities via a Stress-Disturbance model**
  Grime's stress-disturbance matrix provides a valuable framework for understanding and utilising urban spaces and structures for biodiversity enhancement (Meurk and Hall, 2000; Meurk, 2004). It usefully encapsulates the principle forces operating in human environments. In essence, the model proposes that sustainable design and management of vegetation (and species populations) must take account of the balance of constraints due to stress and disturbance on the one hand and competition in unconstrained environments (largely due to exotic species) on the other. Species are fitted to the environment rather than changing the environment to fit the species.

Fig. 14 Christchurch hills rock garden with mountain flax cultivar (*Phormium*), biddibiddi (*Acaena*), dwarf toetoe (*Cortaderia*), sedge (*Carex*), and cabbage trees (*Cordyline*).

In the generally mesic climates of cities, stress is generally manifest through substrates that may be very shallow and porous, and therefore drought-prone, and/or nutrient rich or toxic. Disturbance of varying intensity, duration and frequency accompanies much human activity. Removal or burial of substrate to varying depths and at various frequencies, or removal of topsoil and vegetation are typical of development.

Fig. 15 Native pūhā or sow thistle (*Sonchus oleraceus*) planted adjacent to a carpark.

- **Transformative design**

  Cities are not only complex landscapes, but also complex systems of symbols. They physically represent the values embodied within urban society and culture, both past and present (Rossi, 1982) and these messages are 'read' by the inhabitants and by visitors. City leaders have recognised this from the dawn of urbanism, and consciously shaped city form to reinforce values which they seek to maintain or impose. Inevitably this effort is focused upon the public realm – the shared spaces of the city, such as streets and parks, and the public buildings. In the late modern New Zealand city this realm is largely owned by the territorial local authority – the city council. Hence the decisions made about the design and management of these areas are central to the evolution of public values concerning indigenous biodiversity. The design and operational policies adopted and practised by city street works units, parks departments and other infrastructure managers are therefore critical to the acceptance and promotion of indigenous biodiversity in cities.

  Perhaps the best New Zealand example is the implementation of the asset management strategy for wetlands and waterways in Christchurch. In little more than a decade, remnant 'left over spaces' such as the old Travis Swamp, have been reinvented as integral parts of new green and blue networks, now Travis Wetland Nature Heritage Park, signalled with appropriate cues for care. In new subdivisions, storm water retention basins are designated lakes and ponds, lined with flax, sedges and raupo. Hence public actions can become transformative, with the potential to stimulate actions on adjoining private land, further reinforcing a deepening public awareness and understanding of nature and natural processes.

Fig. 16 Native aniseed (*Gingidia montana*) in a Christchurch rock garden; once common in lowland and mountain native grasslands but so palatable that it is now confined to inaccessible rocky ledges.

- **Legibility**

  To be effective in transforming values, the public realm must be legible. The 'linguistic turn' in late modern culture has highlighted the need for an understanding of the way meaning is communicated within cities. Lynch crystallised this notion in first articulating the need for a spatial language by which to understand the 'Image of the City' (Lynch 1960), and in then proposing that 'Managing the sense of a region' (Lynch 1976) should become a key tenet of urban planning. Hence urban ecosystems need to be legible in order to be read. Furthermore, the reading must be subtle and nuanced, to recognise the plural values and multiple natures that reflect different stages of history and different dimensions of contemporary society and urban systems.

Fig. 17 The native daisy cotula (*Leptinella dioica*) and waxweed (*Hydrocotyle heteromeria*) growing with moss in a shady lawn, Christchurch.

'Eco-Revelatory' design (Brown, 1999) refers to the way in which design and artistic interventions can 'reveal' underlying ecological processes that is both didactic and uplifting. One of the main challenges facing the promotion of indigenous biodiversity in New Zealand cities is the development of a recognisable design language and indeed an enunciation of the layers of history to be acknowledged in design. This packaging of history must be able to mediate between the inherited cultural norms of urban vegetation (discussed earlier) and the very different forms and structures of indigenous plant communities and ecosystems.

Fig. 18 The nationally rare *Mazus novaezeelandiae* growing in a lawn at the coastal Spencer Park near Christchurch.

In our previous work on rural landscapes we have argued for the use of indigenous plants within established (agri) cultural forms and patterns, and here we suggest a similar line of experimentation in urban settings, with a reverse logic – exploring how earlier forms of ecological system might be

creatively integrated within the contemporary urban condition A preliminary framework/model for New Zealand might draw particular species assemblages (plant signatures) or landscape forms from the following epochs (partly drawn from Pawson and Brooking, 2002): *Archaic* or primordial (ancient geology and quasi-Gondwanic biota), *Mesozoic* drift biota (Malayo-Pacific) and *Holocene* (glacial/post glacial with tectonic uplift and alpine biotic radiation). There are also distinctive assemblages from what might be described as the *Anthropocene* (that is, the post human settlement era), which includes the effects of cultural practices upon indigenous plant ecology; for example, burning during the early Polynesian settlement (described often as Moa-hunter), plant selection and cultivation during the classic Maori period, the effects of exotic species including stock and pests during the colonial period, post-colonial/modern periods of pastoralism, agriculture and urbanisation, and finally the refocus upon indigenous species as part of a late 20th Century pluralism and Polynesian renaissance – within the context of an emerging New Zealand/Aotearoa synthesis.

Fig. 19 A stormwater swale with hebes, mountain flax, and deciduous exotic tree.

- **Cues for Care**
  Wild nature has its own order and pattern, but early stages of succession or edges of habitats can look untidy and weedy, which may be threatening to people who have grown up in a controlled and ordered environment. Change from artificial (high maintenance) to more natural self-sustaining systems involves appreciation of the natural ecology of plants and animals that inhabit urban landscapes Nassauer (1997). This might be seen as a positive feedback loop in which setting up nature in cities leads to greater knowledge and appreciation of nature and therefore a desire to maintain it. Nassauer's (1995) 'cues for care' approach involves using familiar structural elements or foreground tidy strips in the landscape (e.g., hedgerows or lawns) while incorporating indigenous species in order to provide a local flavour and more natural character (Meurk and Swaffield, 2000). Wild nature, if it is to coexist in human living spaces, must fit the cultural norm of 'care' yet can be a cue to deeper historical meaning in the landscape.

Fig. 20 Cascade of detention ponds on Port Hills, Christchurch with indigenous rushes, sedges, raupo (filter), tussock grasses, shrubs and trees.

- **Integrated policy agendas**
  Design and planning for urban biodiversity can address multiple policy goals. The Biodiversity agenda is well formed and acknowledged, but as yet is focused primarily upon the conservation estate. There are suggestions for its extension into productive landscapes, and the 2006 Plants as Infrastructure conference extends the agenda still further into urban settings. Here, it can also address other goals. There is a growing consensus that wildness in people's lives is beneficial to health and well-being (Harrison et al., 1995; Box and Harrison, 1993). Louv (2005) has put up a compelling case for the importance of nature experience for children during their formative years, and there is a growing body of international literature that links physical and mental health indicators with accessibility to green space. The past few years have seen a rapid increase in the priority accorded to sustainability – initially in terms of the health of underlying ecosystems, but now increasingly focused upon the function of human ecosystems, and their impacts on global systems, such as climate change. At the same time, economic globalization intensifies competition between cities, which must establish a point of difference in attracting tourists and businesses, leading to increasing investment in urban entrepreneurialism and the way cities re-invent and re-present themselves. Together these provide an imperative to incorporate innovative, ecologically based design for sustainability and social acceptability on the one hand, and indigenous species for international biodiversity obligations, sense of place and distinctive identity on the other.

Fig. 21 ANZAC Drive, Christchurch, with Australian gum trees on the roadside that will overwhelm the native shrubs and bushes along the border fence.

Multi-scale strategy
We propose a three layered approach to implement these principles.

1. Strategic interventions to create a resilient deep landscape structure

The blue and green patches and linkages or corridors of the city form a deep ecological structure (Hough, 2004). Elements of this structure include natural features, hydrological corridors, and reserves/sanctuaries of remnant or restored habitat, as well as cultural features such as parks. Elsewhere (Meurk and Hall, 2006; Renard and Meurk,

2005) we have proposed goals, visions or targets that apply to deep structure patch configurations that promote biodiversity conservation. Meurk and Hall (2006) suggest nested triangular arrangements of different patch sizes, within contiguous hexagons, as the ideal configuration. Several specific configurations of distance and area have been experimented with and this represents the current synthesis:

6.25 ha core sanctuaries	@ 5 km spacings	= 0.29% cover
1.56 ha habitat patches	@ 1 km spacings	= 1.8% cover
0.01 ha noble tree[3] groves	@ 0.2 km spacings	= 0.29% cover
		Cumulative Cover = 2.38%

This is a key element to both ecological and cultural sustainability of indigenous nature as these configurations provide not only wildlife connectivity but a high degree of visibility of nature to citizens and the potential for transformative effect.

The first element of a coordinated approach to urban biodiversity is therefore to extend and further develop a spatial biodiversity strategy for each city that incorporates existing remnants of the deep landscape structure, culturally modified infrastructure of parks and artificial waterways, and new strategic elements which have been located to achieve metric landscape ecological goals.

Fig. 22 The Timaru District northern portal reflecting natural character with hebes, silver tussock (*Poa cita*), small-leaved coprosma, cabbage trees (*Phormium*), and kowhai (*Sophora*). This represents tamed wilderness or 'cues for care'.

Fig. 23 A plant signature approach to landscaping the front entrance to the Environment Canterbury (Regional Council) office in Christchurch. They have effectively used the striking vertical elements of the rocky knoll-inhabiting fierce lancewood (*Pseudopanax ferox*) in keeping with the facade of the building with the contrasting sand coprosma shrub (*Coprosma acerosa*) as ground cover. This represents important and rare habitats of the region.

2. Targeted public design interventions to enhance the indigenous legibility of focal public spaces

City access points, entrances, portals, nodes, perceptual edges, boundaries, streets, and avenues are highly visible and speak of the image that is intentionally or inadvertently being projected of the city and its inhabitants (e.g., solid, conservative, colonial, vibrant, diverse, historically aware, bicultural, creative, sophisticated, multi-dimensional, and so forth). This is one of the key components of legibility (Lynch, 1960).

The second part of an integrated strategy is therefore to develop and implement strategic and operational policies across all the activities of City Councils, which implement and maintain a progressive increase in the visibility of indigenous plants within the public realm. The strategy must be incremental, adopting best practice design strategies that mediate a balance between traditional styles and forms and newly emerging forms of representation.

3. Planning policies and educational programmes to cultivate the residential/industrial matrix

The private spaces of a city create much of its character and constitute the majority of its area, yet are often unseen or taken for granted. They are a critical element in sustaining interpatch dynamics and supporting fine scale metapopulations of species that need high levels of management. They are the home of the culturally-induced biotope including gardens and their component elements such as rockeries or lawns.

The following table provides examples of indigenous substitution for fine scale predominantly herbaceous urban biotopes. For woody species there are numerous additional references (e.g., Lucas et al., 1996–1997; Meurk and Swaffield, 2000; Meurk et al., 2005). There are also extensive lists of indigenous species for lawns and rock gardens on the New Zealand Ecological Restoration Network (NZERN) website (at www.bush.org.nz/planterguide). The following table is divided into the biotope or substrate, some typical examples of exotic plants used in these contexts and some spontaneous or proposed indigenous substitutes. Figures 1–26 illustrate most of the biotopes and indigenous opportunities tabulated overleaf[4].

Fig. 24 New Zealand jasmine (*Parsonsia*) climbing a pergola at Lincoln, Canterbury.

[3] 'Noble trees' in the Christchurch and wider southern New Zealand context are totara, matai, kahikatea, pokaka, hinau, kowhai, broadleaf, kanuka, cabbage tree, narrow-leaved lacebark, lowland ribbonwood (semi-deciduous) and southern beech. For northern New Zealand, kauri, taraire, puriri, titoki, rewarewa, maire and rimu should be added.

[4] The illustrations were taken by Colin Meurk unless otherwise stated.

Biotopes **Urban / *Wild model***	**Typical exotic plants**	**Indigenous opportunities**
Indoor pot & bedding plants (e.g., Britomart) / *Caves*	Tropical herbs, rubber tree	King & other ferns, rice grass, *Arthropodium*, *Acaena juvenca*, kawakawa, broadleaf, miro
Wall seepage, cascade / *Wet rock faces, waterfalls*	Male fern, miner's lettuce	Moss, hepatic, *Blechnum penna-marina*, *B. fluviatile*, *B. minus*, *Histiopteris*, filmy ferns, *Montia*, *Juncus planifolius*, *Bulbinella*, *Luzula*, *Pratia*, *Nertera*
Green roofs / *Canopy epiphytes, dry rocks, ledges*	Stonecrop, brown top, sweet vernal, bromes, storksbill, sheeps sorrel	Lichen, moss, danthonia, orchids, knobby clubrush, *Elymus*, *Dichelachne*, *Festuca actae*, *Muehlenbeckia axilaris*, *M. ephedroides*, *Dichondra*, *Acaena*, *Leucopogon*, *Scleranthus*, *Calystegia soldanella*, *Libertia*, *Disphyma*, *Linum*, *Carex pumila*, *Carex resectans*
External Building structures / *Ledges*	Wall lettuce, nipplewort	*Leptinella minor*, *Asplenium flabellifolium*, *Dichondra*, *Einadia*, hot rock ferns – *Cheilanthes*, *Pyrrosia*, *Pellaea*, *Pleurosorus*
Wall crevices / *Cliffs, gorges*	Ivy-leaved toadflax, wall lettuce, mullein, purple linaria, male fern	Lichen, moss, bracken, hot rock ferns, *Psilotum*, *Phymatosorus*, *Festuca actae*, *Linum monogynum*, *Oxalis exilis*
Ballast / *Riverbed, dune*	Hemlock, fennel, nightshades, buddleja, couch	Bracken, silver tussock, *Acaena*, *Epilobium*, *Geranium*, *Euphorbia*, *Spinifex*, *Muehlenbeckia ephedroides*, *M. complexa*, leafless lawyer, cabbage tree, poroporo
Pavement cracks, gutters / *Shattered rock*	Moss, pearlwort, fleabane, sowthistle	*Cotula australis*, *Poa breviglumis*, *Oxalis exilis*, *Cotula coronopifolia*, *Epilobium*, *Hydrocotyle*, *Geranium*, *Deyeuxia*
Wasteland / *Slips, wind blown debris, dunes*	Prairie grass, couch, sheep's sorrel, clover, meddick, hemlock, mallow, convolvulus, pampas grass, dock	*Lachnagrostis, Cotula australis*, *Acaena*, *Muehlenbeckia*, *Linum*, *Dichelachne*, *Wahlenbergia*, *Pseudognaphalium*, *Dichondra*, *Epilobium*, toetoe, silver tussock, cabbage tree
Gardens, parks / *Controlled disturbance sites*	See below	See below

Garden herbaceous Biotopes **Urban / *Wild model***	**Typical exotic plants**	**Indigenous opportunities**
Herbaceous borders / *Stressed sites*	Hollyhock, *Petunia*, *Agapanthus*, *Begonia*, *Bergenia*, *Primula*, *Acanthus*, *Pulmonaria*, lily, iris, daisies, poppies	*Myosotidium*, *Aciphylla*, *Anisotome*, *Gingidia*, *Arthropodium*, *Euphorbia*, *Libertia*, *Dianella*, *Fuchsia procumbens*, *Parahebe*, *Jovellana*, *Pratia physaloides*, *Apodasmia*, NZ flax, puha, bush lily, snow tussock, sedges, ferns, small hebes
Rock garden / *Alpine scree, riverbed*	*Dianthus*, *Crocus*, succulents, *Armeria*	*Raoulia*, *Leptinella*, *Hypericum*, *Aciphylla*, *Muehlenbeckia*, *Celmisia*, *Brachyscome*, *Dichondra*, *Epilobium*, *Gingidia*, *Isotoma*, *Blechnum penna-marina*, *Paesia*, *Carmichaelia* cushion/turfs, hot rock ferns, short tussocks – *Festuca*, *Carex*
Lawns / *Meadows, herbfields*	Red fescue, perennial ryegrass, clover, common daisy, pennyroyal	*Hydrocotyle*, *Cotula*, *Leptinella*, *Dichondra*, *Pratia*, *Plantago*, *Isotoma*, *Mazus*, *Gnaphalium*, *Centella*, *Oxalis exilis*, *Gunnera*
Swales, rain gardens / *Dry river flood channels*	Rushes, grasses	NZ rushes, sedges, reeds, NZ flax, toetoe, cabbage tree, lawn species above, *Bulbinella*, *Selliera*

Garden woody Biotopes **Urban / *Wild model***	**Typical exotic plants**	**Indigenous opportunities**
Dense barrier planting / *Bush*	Sycamore, birch, willow, poplar, pine, elderberry, holly, yew	Based on kauri, podocarp, beech or other canopy hardwoods, with understorey & ground cover according to property area
Parkland & streets (the 'noble' trees) / *Fire modified forest edge*	Oak, elm, redwood, magnolia, cherry blossom, daffodil, lilies, hyacinth	Kauri, podocarps, beech, hinau, rata, pohutukawa, ribbonwood, lacebark, kowhai, broadleaf, titoki, lemonwood
Trees for narrow inner city spaces / *Woodland*	Birch, yew, mayten, wattle, gum, banksia, cypress, azara, silk tree, palms, fruit trees	Kanuka, cabbage tree, lancewoods, narrow-leaved lacebark, myrtles, wineberry, ribbonwood, kowhai, tree fern, kaka beak, mapau, weeping mapau, tree brooms, kaikomako, wharangi, toro, maire, *Coprosma virescens*, *C. crassifolia*, *C. areolata*, *Olearia fragrantissima*
Pergolas / *Tree canopy*	Clematis, wisteria, ivy begonia, virginian creeper, honeysuckle, jasmine, sweet pea	Clematis, parsonsia, lawyer, passionvine, supplejack
Hedge, shrubbery / *Open exposed scrub*	*Tecomaria*, box, privet, holly	*Muehlenbeckia complexa*, *Helichrysum dimorphum*, *Brachyglottis sciadiophilus*, small-leaved coprosmas, vines (above), myrtles, broadleaf, pittosporum, olearia, hebe

The third part of the strategy is thus to provide public educational resources that highlight the opportunities for incorporation of indigenous plant communities within the everyday private landscape of gardens, school grounds, and so on.

Fig. 25 A native bush garden in Addington, Christchurch. It is collective space donated by the surrounding properties planted out in locally sourced native species. Mike Peters in the bush was the architect of the project and also developed the New Zealand Ecological Restoration Network website.

Animals in the ecosystem

We have emphasized plants in our discussion, but this is in a matter of practical intent rather than ideological bias. Vegetation is the substrate for wildlife; hence sustainable urban vegetation is part of a living ecosystem rather than an artificial façade which might otherwise be plastic trees and 'astroturf'. For instance in New Zealand ecosystems there are up to 10 invertebrate species for every vascular plant species. Butterflies utilise flowers and foliage of *Muehlenbeckia* species. Wetas and huhu beetles are found in rotting wood, demonstrating the importance of leaf litter and other natural detritus. Stick insects are often found in hedges. Native skinks are found in stones, rocks, wood piles and long grass. Geckos can occupy rock piles, walls, ledges and trees or hedges. The commonest exotic birds in cities the world over are rock pigeons, house sparrows, starlings and mynas. White-eyes, grey warblers and fantails are increasingly common in New Zealand urban shrubberies and hedges and can glean insects equally off native or exotic plants. Welcome swallows are also frequently seen swooping through urban air space taking insects on the wing. There seems little reason why in the future falcons and rock wrens could not inhabit ledges in built canyons as well as they do in the wild. Rock wrens in particular will be an endangered species of the future in the mountains whereas cities can paradoxically offer greater options for critical predator control. The honey-eaters and kereru that presently occupy urban woodlands will continue to inhabit natural bush fringing the cities, but also parkland and hedges funnelling into the urban habitats. While indigenous wildlife may utilise exotic plant species, the co-adaptation between this wildlife and indigenous plants, particularly in relation to fruit and nectar supply (Burrows, 1994), and the biosecurity risks of many exotic species, reinforces the notion that increased indigenous vegetation will be beneficial to not only natural character but to ecosystem integrity.

Research needs

There are a number of research needs that must be pursued to achieve these strategic goals. A number are already under way as part of urban ecological research programmes across New Zealand. Others are not, and require champions and support:

- Improving understanding of the dynamics and demography of aesthetic preference and values concerning indigenous species in cities and their interaction with exotic species and established design conventions.
- Developing and testing design solutions that can mediate between conflicting values and avoid subjugating one set of values by another.
- Identifying management and maintenance options for regenerating ecosystems, and improving the connection between design intent and subsequent maintenance.
- Identifying a more comprehensive list of suitable indigenous species for particular habitats across a range of climates.
- Finding improved and socially acceptable ways to manage exotic pests and weeds in urban environments.

Policy implications and priorities

There are also a number of policy implications and priorities. These include:

- Integration of biodiversity goals into other policy agendas such as Long Term Community and Council Plans (LTCCP) and the Urban Design Protocols.
- Setting metric (numerical) targets for urban biodiversity, such as areas and proximity of reserves, and their incorporation into statutory and operational management systems (such as the LTCCP and City Plan).
- Developing strategic landscape and urban design policies that provide long term visions for the expansion and integration of urban greenspace whilst accommodating shorter term variation and contingency (Swaffield and Primdahl, 2006).
- Demonstration projects (e.g., a native garden demonstration in the Christchurch Botanic Gardens is planned for the end of 2007).
- Better links between theory, policy, design and maintenance within asset management processes (for example, policies that prevent profligate use of high quality water resources and persistent or mobile chemicals in park management).

Fig. 26 Templeton Golf Course with remnant prostrate kowhai, tree kowhai, hybrids kowhais, native grasses, forbs and mat plants including dwarf broom, leafless pohuehue (*Muehlenbeckia ephedroides*), and dwarf mingimingi (*Leucopogon fraseri*).

Conclusions

Cities are complex landscapes comprising diverse physical, ecological and social gradients. Contemporary urban greenspace planning and design for biodiversity must accommodate precedents (the pre-existing infrastructure), as

well as new knowledge or ideals and policy directions. These two dimensions are subject to ideological, ecological and aesthetic tensions in postcolonial cities (Given and Meurk, 2000) – as exemplified in Christchurch, New Zealand. It will be difficult to resolve these conflicts, but if one accepts the (constitutional and moral) imperatives for improved ecological integrity, sustainability, biodiversity, and landscape legibility, and that these are essential ingredients to identity, self knowledge and quality of life, then it will be important to continue providing the means and methods by which these new states will be achieved.

Cities are keys to biodiverse futures for New Zealand–Aotearoa, as they are the primary home of the majority of the population, and the gateway for visitors (Meurk, 2005). An urban biodiversity strategy must operate at all levels – the home garden, incorporating maintenance crews' values and potentials into the strategy, city-wide projects such as heritage trails, up to long term strategic commitments within regional and city policy and asset management. While it is clear that new cultural representations of nature cannot simply be forced on even a partially unwilling public, neither should a conservative vision of urban history, as reflected in landscape ideals of the 'City Beautiful', be sustained against the increasingly plural values of current communities and the needs of future generations. For all generations rue the loss of previous nature.

It is axiomatic that a change from artificial (high maintenance) to more sustainable urban systems involves appreciation of the natural ecology of plants and animals that inhabit urban landscapes. Managers, planners, operators on the ground and plant nurseries all need new knowledge about indigenous species, their propagation and maintenance requirements. This must then be incorporated within innovative design concepts. At some point a positive feedback loop is likely to emerge in which more visible expressions of indigenous nature in cities reinforces greater knowledge and appreciation of nature and in turn a desire to sustain it. As Meurk and Swaffield (2000) have pointed out, the initial change may be problematic, but a 'cues for care' approach eases the tension and the transition. Nor is it supposed that one form of landscape dominance and subjugation is replaced by another equally monocultural view. The essence of a 'new garden city', for instance, is to incorporate well presented examples of *all* the historic layers, with varying degrees of control depending on the genre being locally represented.

Meurk and Hall (2006) and Renard and Meurk (2005) have proposed goals, visions or targets that can apply to the deep structure of the city (patch configurations). Without these targets there is a danger of drifting, stagnating, or capture by other agendas. The forces of economic globalisation and new technologies can change whole streetscapes and neighbourhoods within very short time frames. It is essential therefore to maintain a clear long term strategic biodiversity programme against which new development proposals are evaluated, and opportunities tested and adopted.

Within the matrix of private and public spaces in the city, regenerative design opportunities involve matching ecological understanding with cultural archetypes. For example, woodlands and parklands should eventually be self sustaining and have biodiversity elements (Stewart et al., 2004), yet not harbour biosecurity risks. Species also need to be ecologically matched to soil or substrate types (Lucas et al., 1996–1997). Except for specialist displays, planting design, whether dominantly exotic or native species, should reflect the environmental capabilities of the site. The basis for such a matching is inventory and mapping of both natural and artificial patterns (the spatial configuration of habitat patches, corridors, matrices, and mosaics in relation to substrate or landform / soil conditions). Patches may be remnants, spontaneous or synthetic habitats (equated with biotopes), or planted stands.

Our proposal is therefore to shape urban biodiversity to reveal all layers of ecological history, and ensure it is able to regenerate and evolve, and be integrated with the increasing diversity of cultural and aesthetic needs of urban dwellers. Concepts and strategies to achieve this must operate at a range of scales in time and space.

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