Low Impact Urban Design and Development (LIUDD): matching urban design and urban ecology

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This paper outlines the roles that ecological concepts and the practice of landscape design have in achieving sustainable and healthy cities of the future. This approach is embodied in the Low Impact Urban Design and Development (LIUDD) movement. We describe studio exercises conducted for the students at Lincoln University in the Landscape Architecture Group to illustrate the evolution of thinking and implementation of LIUDD principles in some complementary case studies from Christchurch City and Lincoln Village. We review the theory, experience and justification for integrating biodiversity into urban environments.

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THEORETICAL BACKGROUND

Landscape architecture professionals are becoming involved to a greater degree in ecological reviews, sustainable urban design and ecological restoration. Landscape and urban ecology are young disciplines in New Zealand, despite them often being an integral part of courses overseas. New Zealand has not had a history of underpinning design with ecology and biodiversity concerns.

The FRST-funded Low Impact Urban Design and Development Programme (LIUDD) is one of the current New Zealand sustainable cities research efforts focussing on the cities of Auckland, Taupo and Christchurch with links to Melbourne (Australia) and Vancouver (Canada). The Low Impact Development (LID) strategy is a growing approach in western North America, for example in Seattle (Washington), Portland (Oregon), Vancouver (Canada), Midwest (Chicago) and on the east coast in Massachusetts (Eason 2003). New Zealand LIUDD and North American LID are mostly oriented to finding environmentally sensitive approaches to managing urban stormwater (introducing rain-gardens, green roofs, open swales, detention ponds and using ecologically friendly pervious surfaces). LID and LIUDD programmes call for alternative, cost-effective urban design and development that involves designing and working with nature - creating community environments that respect, conserve and enhance natural processes.

Compared to many countries, New Zealand's LIUDD programme has additional imperatives because in the last 150 years New Zealand's landscape has been dramatically modified. Thousands of species of plants and animals have been introduced into the pristine environment.[1] Exotic trees, shrubs and herbaceous species from Europe, Australia, North and South America, South Africa and Asia have been traditionally favoured over the unfamiliar and less productive indigenous

1 > 2500 species of naturalised exotic plants and 2500 native plants in the New Zealand flora.

REPORT

species. The reasons for this 'bias' were practical and reinforced by nostalgia for the European plants of 'home' (Meurk and Swaffield, 2007). New Zealand has become host for more exotic organisms than anywhere else on earth because of a temperate climate, broad indigenous species niches and freedom from natural control agents. Today the protection and restoration of native biodiversity is task number one. That is why one of the key goals of the New Zealand LIUDD programme is to protect and enhance native urban biodiversity (Eason, Dixon and van Roon, 2003). Many naturalised species are now becoming noxious weeds; the use of even a few traditional Northern Hemisphere plants makes LIUDD practices difficult. For example, in the Northern Hemisphere, *Sedum* is one of the essential genera for green roofs. In New Zealand *Sedum* is a weed so the choice of species for green roofs in New Zealand has to be approached carefully. Guidelines for creating swales, rain-gardens, green roofs and using street trees need new research that addresses this particular New Zealand problem and is directed to practical field establishment of suitable native plants in the applications of LIUDD.

New Zealand's version of LID (LIUDD) therefore is associated with specifically employing native plants and attracting native species of birds. The clichés 'living in harmony with nature' or 'appreciation of nature' in New Zealand have to mean 'native flora and fauna' if the country is to live up to its obligations under the Convention on Biological Diversity, especially now that the convention is turning attention to urban environments.

'PLANT SIGNATURE' APPROACH

At present there are several approaches to enhancing native biodiversity in the Northern Hemisphere. In Germany with its long traditions in urban ecology and sustainable design, a recent development has been the concept of 'spontaneous vegetation'. This signifies a new aesthetic value being attached to 'urban wildlife' which reflects the local environmental conditions and demonstrates a sustainable, economical way of garden maintenance (Kuhn, 2006). For the first time in planting design practice, weedy vegetation has been recommended for ornamental purposes. 'Spontaneous vegetation', in the German sense, means vegetation that appears on the site by accident (from the existing site seed bank or natural dispersal) and without conscious design intent. Spontaneous vegetation has a very special status in German and Dutch literature, where the concept of ecological parks first took hold. The idea is to use spontaneous plant communities for 'landscape architectural purposes'. In other words, the Germans have tried to develop a new aesthetically acceptable vision of wastelands. After the major landscape destruction Germany experienced in the Second World War, the citizens looked closely at what existed in the cities and saw value in even minor appearances of nature. Wastelands with colonising species were abundant in Germany and it is not surprising that botanists used them as a major source of study. With later movement of biodiversity protection and nature restoration in Europe, Germany led in the observation, evaluation and later 'improvement' of spontaneous plant communities. This consideration of 'spontaneous vegetation' gave rise to a natural typology of native plant communities

– woodlands, pioneer and ruderal meadows, and perennial grass communities.

In the United Kingdom, 'Go Wild', a similar movement, has developed in the last 10 years where traditional monocultural lawns are replaced or just 'left alone' to favour the development of diverse wildflower meadows that attract wildlife[1] (Lickorish, Luscombe and Scott, 1997; Kingsbury, 2004).

The United States has considerable experience in research of increasing biodiversity and working with natural processes. One example being Joan Nassauer's 'messy ecosystems' approach, where an important role is given to the introduction of native prairie and wet meadow plants for Midwest urban neighbourhoods (Nassauer, 1995; 1997). At present, the United States is very active in initiatives dealing with improving the ecological health of cities and introducing native biodiversity to front and back yards, buildings, streets and highways. Examples can be found in the Midwest (Chicago's City Hall roof with prairie plants) and on the east and west coasts, such as the 'wildlife habitats in your backyard' project and the creation of the Lady Bird Johnson Wildflower Center.[2]

For several decades, New Zealand has been developing its own 'Going Native' strategy with an emphasis on increasing the planting or revegetation of indigenous plants (Spellerberg and Given, 2004). Since the 1990s, 'plant signatures' have been very popular in New Zealand planting design. The plant signature concept was developed by Robinson; it is 'an abstraction from the actual place or plant community, but it is a composition that offers some essence of the place' (Robinson. 1993). It reflects natural habitats reminiscent of a place and symbolises that place, or captures the essence of its natural history – a prerequisite of legibility.

In our LIUDD project we are working with palettes of native plants that can provide a memorable expression of each particular place in the country. Our vision of the plant signature concept is based on research on existing spontaneous and artificial native plant communities and on identifying their aesthetic as well as their ecological features. The plant signature concept does not mean just a simple mimicking of natural plant communities and their fragments. It is a creative interpretation and use of the ecological and decorative essence of plant combinations, a bit like an abstract depiction of a literal subject. These plant signatures must increasingly provide new 'ecological' solutions for design at a detailed level – for example, for front and back yards of private gardens, street/road planting, public gardens, pervious parking spaces, swale filters and ponds – to promote multiple values when space is in short supply.

An Ecological Design Studio has been run by the Landscape Architecture Group, Environment, Society and Design Division at Lincoln University for the last three years. As part of the LIUDD programme, landscape architecture students were provided an opportunity to explore different practical solutions related to design with nature.

The main objective of this studio was to teach students to 'read' ecological landscape patterns and processes as a basis for later ecological design. Students were asked to examine and compare the diverse theoretical sources of landscape and urban ecology and their practical outcomes at a range of field sites in Christchurch.

The case study sites used for the Ecological Design Studio were Aidanfield subdivision, one of the newest Christchurch suburbs, and Lincoln Village, with both established and new subdivisions.

The Studio reinforced the value of urban ecology, the formation of wildlife habitats, economic development through the improvement of neighbourhood property values, the improvement of neighbourhood social interaction and aesthetic enhancement leading to a positive local sense of place. This project was intended to offer a replicable model of how to analyse and employ the role of urban ecology in urban design.

SITE SELECTION

Christchurch City was founded around 1850 by English settlers. It is one of 'the most English cities outside of England' according to promotional brochures. During settlement and the subsequent drainage of the extensive wetlands, native vegetation was almost completely destroyed and replaced by fast-growing exotic plants. Now, a major concern in Christchurch is the loss of native biodiversity, the loss of connectivity between fragments of native vegetation and a lack of authentic local identity.

Aidanfield subdivision is one of the newest and most expensive in Christchurch. Aidanfield was chosen because some of the concepts of LIUDD practice were implemented in its original design, for example, simple swales and detention ponds with native plantings. Nevertheless, there are a lot of incongruous conventional features that make this subdivision ecologically unfriendly, such as large impervious paved car parking areas, or garden planting that is not linked to the character of the swales or, in some cases, represents weed risk.

Our second ecological design site was located in Lincoln Village, 10 kilometres from the edge of urban Christchurch. One chosen subdivision was conventional, for example the new Lincoln Palms or Roblyn Place. The second subdivision was also new, but showed some elements of LIUDD (for example, Ryelands). Comparisons were also made with older conventional subdivisions in Lincoln. One of the main tasks of this studio was to propose scenarios for retrofitting a conventional subdivision using LIUDD principles.

A third Studio site (Liffey Stream subdivision) was also located in Lincoln Village. This particular example was chosen because a progressive developer, David Hobbs, was very keen to implement ecological principles into his new subdivision design.

GOALS AND OBJECTIVES

The goal of this studio project was to analyse subdivisions, and identify opportunities and problems with current conditions in terms of natural, cultural and design features, then propose a new design vision that addressed requirements of the LIUDD concept. These new visions are seen as navigation guides for creating new generations of subdivisions in New Zealand using principles of ecological design.

The approach was to investigate the hinterland at a broad landscape scale: forming the catchment context of the subdivision, the subdivision itself and an individual property at a detailed level. Another task was to explore possible connections, such as green corridors or stepping stones, between subdivisions and surrounding ecosystems. Corridors, both continuous and discontinuous, provide pathways for the dispersal of plants and animals and they retain other ecological and landscape values. Corridors are habitats or a system of habitats for native flora and fauna (Dawson, 1994). They form a distinctive 'natural' reflection of local landscape boundaries – creating natural character and identity and establishing a framework for further ecological restoration.

At the detailed level of an individual property or streetscape, the Studio's objective was to propose appropriate plant signatures. These plantings were to provide new 'ecological' solutions and substrates for fine-scale garden elements and LIUDD stormwater devices (front and back yards of private gardens, street planting, road and swale planting, rain gardens, green roofs, public gardens and car parks).

METHODS OF ANALYSIS

The green corridors analysis used maps of existing river and stream corridors, shelterbelts, street planting and stepping stones of existing fragments of green areas (native or exotic vegetation or mixed) on a district-wide scale. Site analysis of the subdivision focused on existing hydrological patterns, traffic circulation, vegetation character, and typical house size and orientation. The site analysis of subdivisions was also contrasted with adjacent, older conventional subdivisions in which LIUDD principles had not been applied. Cross-sections and sketches were actively used in all stages of the project.

Fine scale analysis focussed on ecological features of individual residential houses, gardens and surrounding areas and aimed to explore opportunities to use LIUDD practices. Aerial photos and maps, photo archives from the Christchurch City Council and Selwyn District Council, and field observation were actively used in the project. The theory of landscape ecology dynamics was also consulted.

Regarding green corridors, in the case of Aidanfield, the most important option was to connect remnant vegetation or ecological patches (Wigram Detention Basin, Canterbury Agricultural Park, Carrs Reserve, Hoon Hay Park, Halswell School and Halswell Quarry) with native vegetation of the Port Hills. This virtual corridor or network of habitat patch stepping stones is ideally configured as in Meurk and Hall's (2006) schema which optimises patch size, density and connectivity for ecological integrity and social experience of nature. The proposed system of green corridors would require the use of land inside the Aidanfield site (creating green areas with native plants, swale system and detention basins) and outside, across Hendersons Basin, aiming to complete a sustainable stormwater management system (Figure 1).

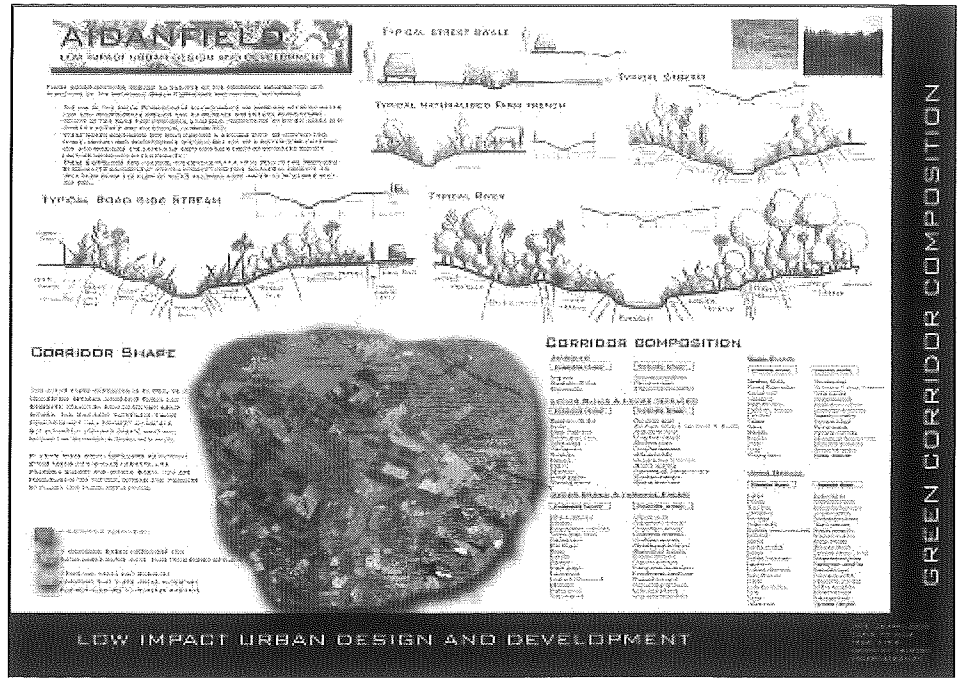

Figure 1. The proposed system of green corridors for Aidanfield site (Christchurch). Design: F Baggaley

In the case of Lincoln Village, the most important connections were considered to be corridors to Te Waihora – Lake Ellesmere and the Port Hills (Figure 2). It is important to provide connectivity between patches, while recognising that many birds can use discontinuous stepping stones. Thus 'connectivity' does not necessarily mean physical continuity. It is a concept that is species specific and depends on the vagility and territorial behaviour of the organisms concerned. Walking, cycling and horse-riding trails can parallel these green corridors and bring people and nature together. The proposed Christchurch Perimeter Walkway provides such a route through the southwest Christchurch growth area and recapitulates the ancient Māori pathway between the Heathcote and Halswell catchments. This continuity can be achieved visually and recreationally as well as by vegetation, for example, using hedges (to separate individual properties) with native plants instead of walls or fences. Even small patches with native plants in back or front yards or in roundabouts could provide valuable stepping stones for native birds or insects.

The following types of corridors (their structure and composition) were suggested:

1. Bush corridors (without a waterway or storm water management feature) running adjacent to existing main roads.

2. Small-scale corridors within subdivisions, including swales, buffer zones and wetland habitats.

3. Corridors that surround minor stormwater systems outside subdivisions, including roadside swales, farm ditches and seasonal streams and creeks.

4. Larger riparian and green corridors running alongside permanent streams and rivers such as Cashmere Stream and Heathcote River.

5. Crop and field margin corridors – hedgerows and shelterbelts.

6. Power lines, or utilities, and railway corridors (see Figure 3).

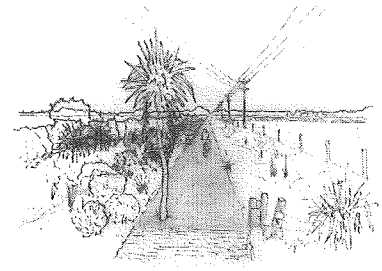

Figure 3. Proposed power line corridor. Design: J Rea, 2006

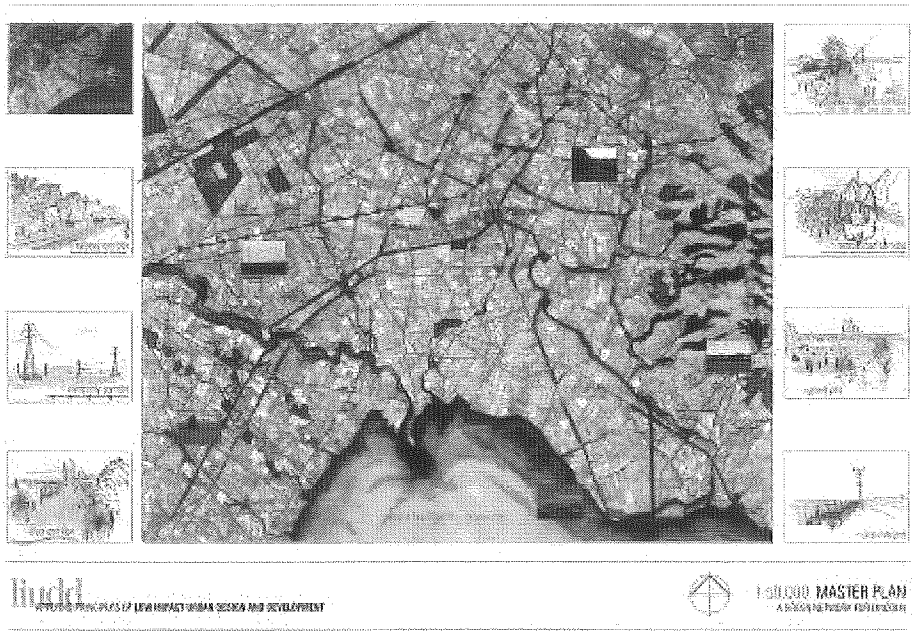

Figure 2. Proposed green corridors for Lincoln Village. Design: J Rea, 2006

STREET LAYOUT

Recommendations on street subdivision layout strongly favoured integration with the topography and hydrology pattern which complemented the natural water regime. This involves the least amount of earthworks and therefore saltation of waterways. Circulation fluency, community spirit and perceived safety all had high priority. The street layouts were designed to create a pedestrian-orientated community. The development of common space gives an opportunity for social interaction within the neighbourhood (Figure 4). Overall, the retention of underlying landforms, soils and drainage patterns preserves the history of the land. This, together with interpretive cues, signals and flags, signs and sculptures, provides legibility.

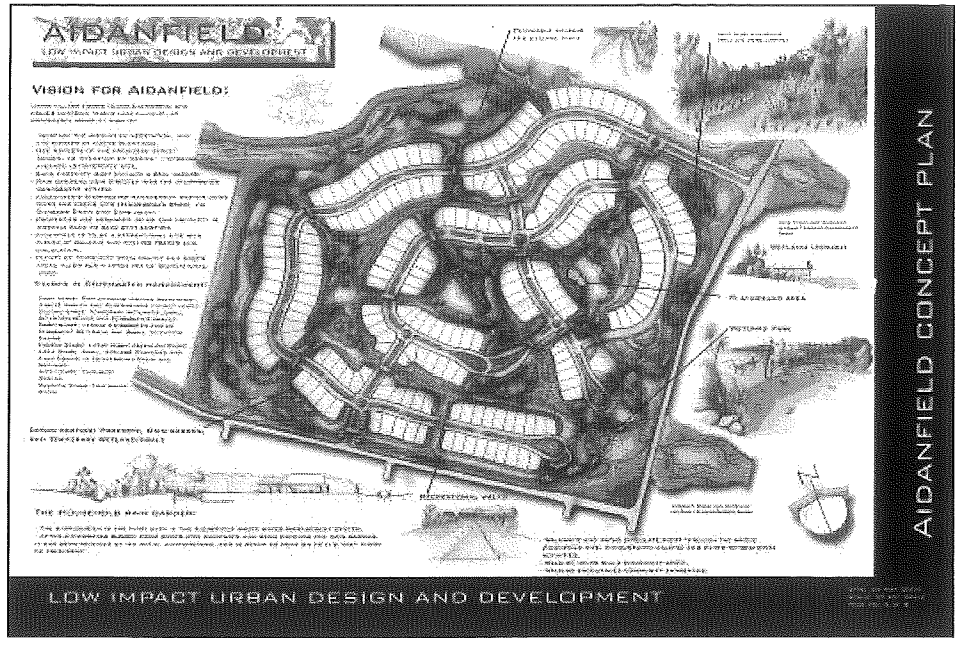

Figure 4. Proposed design for Aidanfield subdivision. Design: F Baggaley, 2006

STREET TREES

The Ecological Design Studio suggested a range of indigenous trees along with some non-invasive but wildlife friendly exotic trees, suitable for streets, portals and parklands. These larger structural or striking iconic species may be called 'noble' trees in the European sense, such as oak, elm, linden. The following species are relevant to the eastern South Island:

- Lowland ribbonwood (*Plagianthus regius*, deciduous);
- Narrow-leaved lacebark (*Hoheria angustifolia*, white blossoms in mid summer);
- Kanuka (*Kunzea ericoides*, white blossoms at Christmas time);
- Cabbage trees (*Cordyline australis*);
- Kowhai (South Island *Sophora microphylla*, yellow blossoms in late winter – early spring);
- Totara (*Podocarpus totara*, not golden totara as these are sterile and provide no value to wildlife);
- Broadleaf (*Griselinia littoralis*);
- Pokaka (*Elaeocarpus hookerianus*, on wet soils);
- Lemonwood (*Pittosporum eugenioides*, lemon fragrant blossoms in spring);

- Lancewood (*Pseudopanax crassifolius*, need protection from vandalism at early stages);
- Black beech or red beech (*Nothofagus solandri* or *N.fusca*).

These might be interspersed with exotic species and/or used at street corners, traffic islands, road narrowings and other focal points. Red gums, some hardy proteas and myrtles are non-invasive exotic species that provide nectar for honey-eating birds.

PLOT AND HOUSE LAYOUT

The concept suggests an increase in average size of the private lots, although this might be effected through greater emphasis on community and communal space and a reduction in hard boundaries (fences) between properties. Green hedges with native species were suggested instead of fences. All sections or lots were designed to allow greater solar efficiency: north-facing houses receive maximum sun in the Southern Hemisphere.

WATER MANAGEMENT

Each property is recommended to have a green roof, comprising a small rain garden which will join with other individual rain gardens so that water flow can be directed into the storm management system which then leads into a larger basin. The following stages in stormwater management are proposed:

Private property level: roof-garden, water cistern, rain garden, reduction of non-permeable surfaces and connection to nearest street swales;

Neighbourhood level: stormwater swales, temporary wetlands and small retention ponds;

Subdivision scales: larger stormwater swales, permanent wetlands and small to average size detention basins;

Regional scale: ponds, streams and large-scale basins and wetlands.

PLANT SIGNATURES

Plants were selected on the premise that they were indicative of species originally found in south-west Christchurch and Lincoln Village (pre-European settlement). However, for some particular effects, design characteristics such as form, colour and texture were deemed important, in some cases, native plant cultivars were selected (for example, *Phormium tenax*, 'Chocolate Fingers', instead of the natural green form).

Another important criterion for plant selection was an ability to enhance water and soil quality by filtration, for example, *Typha orientalis, Schoenoplectus tabernaemontani* and for their ability to attract and provide habitats for native birds, for example, *Sophora microphylla, Cordyline australis, Podocarpus totara, Phormium tenax, Pittosporum tenuifolium, Coprosma* spp., *Pseudopanax arboreus* and *Pseudopanax crassifolius*.

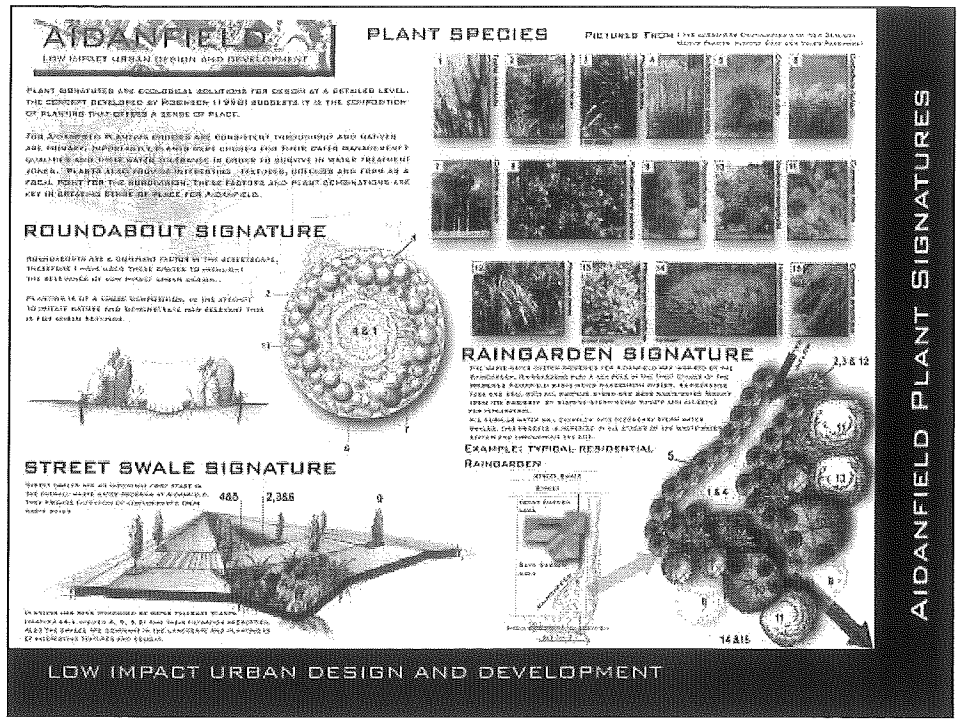

Figure 5. Plant signature for roundabout, street swale and rain garden in Aidanfield subdivision. Design: F Baggaley, 2006

There were seven major types of plant signatures suggested for Aidanfield and Lincoln Village:

1. Roundabout signature (dominant feature of streetscapes)

Plants were chosen for their tolerance to drought and air pollution, while at the same time reflecting design characteristics such as texture, colour and form. One of the crucial points for roundabout plant signature was the height of plants (to provide clear visibility). Plant species selected were *Chionochloa rubra*, *Cortaderia richardii*, *Coprosma propinqua*, *Pittosporum tenuifolium* (low growing cultivars) and *Phormium tenax*. However, clean-stemmed taller species such as lancewood, narrow-leaved lacebark and cabbage tree can be used without danger (Figure 5).

2. Street swale signature (provide filtration of contaminants from wastewater)

Plants were chosen for their water and contaminant absorption capacities and water management qualities. Plant species included *Chionochloa rubra*, *Cortaderia richardii*, *Phormium tenax*, *Carex* spp., *Juncus* spp. and *Cordyline australis* (Figure 5).

3. Rain garden plant signature (the first step on the fine scale of a residential house water management system)

Plants were chosen based on their capacity to tolerate conditions of surplus stormwater and some wastewater runoff from adjacent properties. Rain gardens

should also have high aesthetic qualities. Suitable plant species for larger sites (> 100 m2) include: *Typha orientalis*, *Phormium tenax*, *Chionochloa rubra*, *Astelia fragrans*, *Pseudowintera colorata*, *Apodasmia similis*, and *Leptospermum scoparium*. For small-scale sites the following species are better: *Juncus* spp., shorter tussock sedges such as *Carex flagellifera* and *C. buchananii*, *Dianella nigra*, and *Isolepis nodosa* (Figure 5).

4. Entrances to subdivision plant signature

Formal use of native trees at portals or entranceways and along the internal streets reinforce natural character (springs, for example), so that we face the one element of our landscape that is unique to New Zealand and Canterbury: the local plant species and disinctive growth forms. For example, for Roblyn Place in Lincoln Village, the main idea of this entranceway plant signature was to celebrate the ecological peculiarities of the Canterbury Plains and surrounding Port Hills. A sculpture using local rocks that reinforces local traditions can be an especially important part of portal plant signatures. Species included *Dacrycarpus dacrydioides*, *Nothofagus solandri*, *Sophora microphylla*, *Griselinia littoralis*, divaricating shrubs such as *Pseudopanax arboreus*, *Corokia cotoneaster*, *Hebe* spp. and *Phormium tenax*.

Entranceways can feature cabbage trees, narrow-leaved lacebark, totara (or matai or kahikatea, depending on drainage) and shrubs such as *Coprosma propinqua*, *Coprosma virescens*, *Olearia bullata*, *Olearia fragrantissima*, *Hebe* spp, *Teucridium parvifolium* and New Zealand flax.

5. Native boundary plant signature

This plant signature is designed for use as a property boundary within subdivisions as an alternative to fences. This signature is based on native plants which can be easily clipped and at the same time provide a food source for native birds. Species such *Griselinia littoralis*, *Pittosporum eugenioides*, *Pittosporum tenuifolium*, *Corokia cotoneaster*, *Lophomyrtus obcordata*, small-leaved *Coprosma* spp., and vines such as *Parsonsia* spp., *Muehlenbeckia complexa* and *Clematis* spp. will be most appropriate for the native boundary in Christchurch conditions.

6. Green roof plant signature

A green roof is a roof partially or fully covered by plants. Thin-layered green roofs feature drought tolerant plants growing in 5 to 15cm of lightweight soil. Green roof plant signatures are based on an assemblage of plants from grassland and dry rocky environments and include some coastal plants. Examples are *Leptinella* spp., *Epilobium* spp., *Geranium sessiliflorum*, *Raoulia* spp., *Poa* spp. and *Rhytidosperma* spp.

7. Native lawn plant signature

This signature is based on creating environmentally friendly, biodiverse lawns using native plant species from ephemeral wetland, lakeshore and grassland turfs. Species need to match the natural moisture conditions with *Pratia*, *Leptinella*, *Hydrocotyle*, *Plantago triandra*, *Mazus* and *Dichondra* being suitable.

DISCUSSION AND CONCLUSIONS

As with any applied project, it is important to reflect on the outcomes and to use these as a way forward, to pause and to ask 'Where to from here?' At present, the immediate possibilities are quite apparent. The Christchurch City Council, for example, is a potential beneficiary of these ideas as a means of addressing the various shortfalls in biodiversity protection and enhancement. The City Plan, Planting Strategy and Biodiversity Strategy all point to the need for greater integration of biodiversity into the urban framework. The integration of biodiversity is also a direction of the Convention on Biological Diversity that New Zealand is a signatory to. The council, in conjunction with developers, needs to introduce measures that ensure more sustainable design features such as stormwater management practices and enhanced indigenous biodiversity being incorporated into new subdivisions. Local neighbourhood organizations such as Lincoln Envirotown are assisting the local community with sustainable living by drawing on the results of this research through neighbourhood meetings, field days, and displays. Hopefully residents will then incorporate aspects of our design concepts into their own neighbourhoods and individual properties.

It is one thing for researchers and students to have theoretical knowledge, for local government staff or decision makers to be given information and for homeowners to see a brochure, but, it is quite another matter for best practice and theoretical optimal design to be taken up and implemented. Change is always uncomfortable and costly. Other research in the LIUDD programme investigates barriers to dissemination, uptake and implementation of LIUDD principles. This does not assume a 'right' path or 'holier than thou' attitude, but rather how to engage the community, and decision-makers, in a dialogue that leads to a mutually agreed sustainable and healthy environment, biodiversity and living conditions that transcends sense of place.

The information presented here represents a synthesis of theory, teaching material, student uptake and innovation, moderated by our experience of LIUDD. The floristic information reflects the region of New Zealand where the case studies were situated. Some basic LIUDD principles were enunciated by the students. These relate to:

- using natural vegetation in a hydro-train to ameliorate stormwater flow;
- siting buildings for maximum energy efficiency;
- configuring streets, pathways and parks to enhance the human experience;
- defining plant signatures for various urban elements and, as devices that celebrate local natural heritage; and
- establishing landscape connectivity to create sustainable nature and cultural connection with nature.

NOTES

1. http://www.kew.org/gowild/index.html
2. http://www.wildflower.org

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