LIVING ROOF GUIDE

PUKAPUKA TĀTAKI KI TE MATAORA TUANUI

GUIDE TO LIVING ROOFS, WALLS AND FACADES IN WHĀNGĀREI, NEW ZEALAND

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LIVING urbanism

WHANGAREI DISTRICT COUNCIL

DOCUMENT INFORMATION AND QUALITY CONTROL

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Document Name :	Living Roof Guide v5.0	**Version History:**	v5.0	March 2019

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Preface

Living roofs, walls and facades are becoming increasingly common in cities throughout the world. The purpose of this guide is to highlight the multitude of economic, social and environmental benefits that these living systems can provide to Whāngārei - improving outcomes for its people, land, water, nature and visitors.

Whāngārei, like many other cities in the world, faces continued pressure from advancing urbanisation. 70% of the world's population is estimated to be living in urban environments by 2050. Population growth, urban development and sprawl have altered once natural environments, creating increased built form, more hard surfaces, less green space and less permeability.

This is a living guide that will grow, change and develop with time to provide locally relevant information for anyone embarking on a living roof, wall or facade project in the Whāngārei District.

New Zealand Alpine Daisy
Photo Renée Davies

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INTRODUCTION

KUPU ARĀTAKI

INTRODUCTION

Manaaki whenua, manaaki tangata, haere whakamua
Care for the land, care for people, go forward

This guide highlights all of the benefits that can be realised from incorporating living roofs, walls and facades into the existing and future fabric of our cities.

Whāngārei has the incredible opportunity to build the very last Hundertwasser building in the world, showcasing living roofs as an asset to urban environments. This iconic building will be a new landmark for Whāngārei – an inspiration and catclyst for the community to promote and foster better understanding and use of living roofs, walls and facades locally.

Living roofs and walls provide numerous social, environmental and cultural benefits that can contribute to making Whāngārei a more resilient, liveable, and loved city. The purpose of this guide is to increase knowledge, understanding and promotion of the installation of living roofs, walls and facades in Whāngārei.

"When one creates green roofs the houses themselves become part of the landscape"

-Freidensreich Hundertwasser (1928-2000)

Figure 1: Negative Impacts from Urban Built Form

The principles of Living Urbanism will be described to maximise the available benefits when designing a living roof. Practical information is detailed to explain the considerations needed for your own project.

A New Zealand (NZ) and Whāngārei specific perspective on practical advice for living roof design is provided alongside inspirational case studies from around the globe.

Why Living Roofs?

Amid concerns about climate change, energy conservation, food production and sustainable development, there is a growing need to pursue solutions that present real economic, environmental and social benefits within our built environments.

Living roofs offer an opportunity to shape how we use ecology in cities by shifting the focus to exploring what our cities would look like if potential benefits were embedded in the design process. We can use functional interventions to shape our cities – a Living Urbanism approach.

Living roofs blend beauty and function, with an aesthetically appealing building technique and material that provides sanctuary for wildlife; detention and slow release of stormwater; reduction of urban heat island effect; and building insulation.

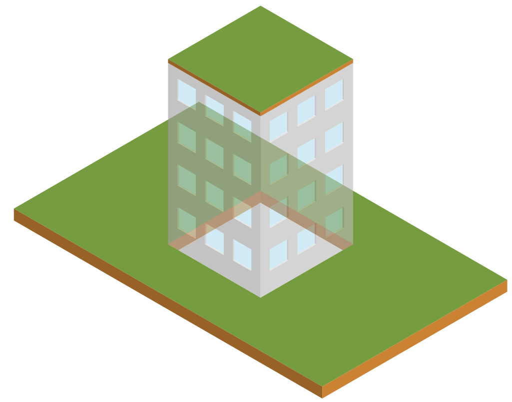


Figure 2: Living roofs concept - to mitigate lost ground plane green space or enhance an environment if there is no loss of green space

Urbanisation

Urbanisation and the issues we face as a result of it require new ways for design-led thinking to make our cities more liveable. Around the world cities are prioritising the promotion, installation and uptake of green infrastructure.

New high energy use urban systems create a number of negative outcomes for people and the environment generating pollution and heat from commerce, industry and transportation. Alongside the retention of the solar energy by buildings and hard surfaces, this creates a warmer city environment.

Globally, living roofs, walls and facades are being used to mitigate the loss of vegetation in our urban environments, provide attractive green spaces, reduce stormwater runoff effects and enhance biodiversity.

Living roofs in Aotearoa are not new - Māori used sod to build whare paruparu (dirt houses) and European settlers commonly constructed sod dwellings.

However, the approach and initiative required to implement living roofs in our modern environment is new and lack of local information and experience has been a barrier to living roof development in NZ.

Due to its geological isolation NZ's plant and animal life has developed down a unique evolutionary path. Our isolated nature and equatorial spread means that our climatic conditions are highly varied, along with our soils and ecosystem types.

NZ is one of the world's worst for biodiversity loss and our status continues to deteriorate. This dire placement in the world biodiversity hierarchy confirms that any and every opportunity for biodiversity and environmental enhancement should be taken.

Green infrastructure projects provide just such an opportunity beyond the more commonplace terrestrial approach, particularly in our fast growing urban environments where space for plants (particularly native plants) at ground level is severely constrained.

Te Kākano, The Seed - Hundertwasser Art Centre
Photo Zoë Avery

INTRODUCTION

Figure 3: Types of Living Roofs and Walls

What is a Living Roof?

Living roofs include ornamental roof gardens, naturally vegetated roofs and also biodiversity roofs. The types of roofs range from the commonly seen extensive (shallow) to intensive (deeper) vegetated roofs.

What is a Living Wall and Facade?

Living walls and facades are intentionally vegetated vertical space that can be internal or external to a building. Living facades can simply have climbing plants growing on them or structures attached to the walls specifically designed to foster species able to thrive in such a condition.

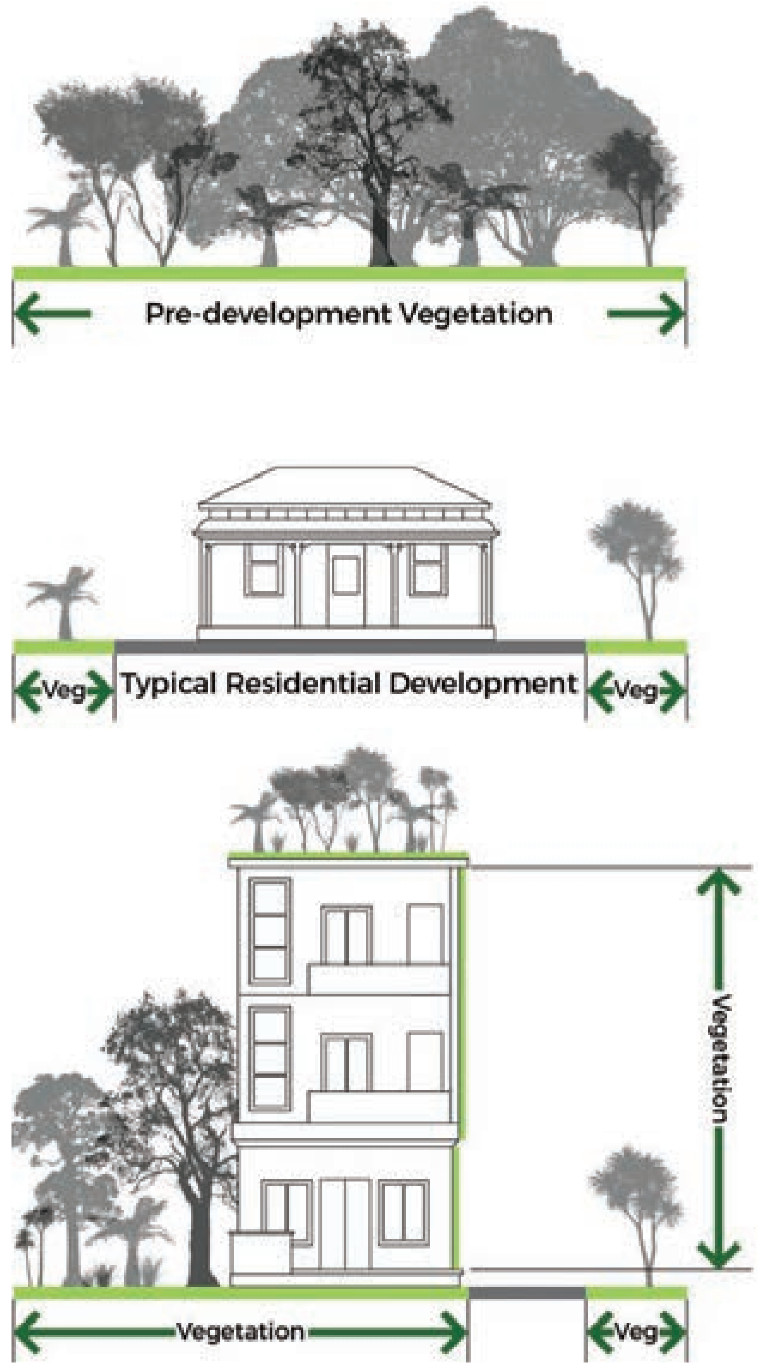


Figure 4: Living roofs, walls and facades protect vegetation cover/green space/biomass

The Highline, New York City
Photo Emma Comrie-Thomson

INTRODUCTION

Choosing your Living Roof type

The appropriate type of living roof is determined by the range of outcomes to be achieved by the roof and any associated design constraints.

Living roofs are categorised into three broad types:

- Intensive
- Semi-intensive
- Extensive

Right: Residential apartment extensive living roof in Copenhagen, Denmark
Photo Zoë Avery

Right below: Allen & Overy Offices semi-intensive living roof in London, UK
Photo Zoë Avery

Below left: ACROS Fukuoka building intensive living roof (Fukuoka, Japan)
Photo Darren Ebbett

Intensive Living Roof

Intensive roofs are essentially roof gardens. They are generally designed for public access, high visual and recreational amenity.

These roofs create public or private open spaces for residents, workers and the community. The vegetation options are limitless, but as such, the cost of these roofs is high.

Structural loading can also be an issue, as these roofs require a higher substrate depth, which in turn requires careful design considerations. Irrigation of intensive green roofs needs to be designed for and maintenance of these roofs requires careful consideration and planning.

Substrate	500mm-1500mm
Vegetation	Trees, shrubs, grasses
Cost	High
Structural Loading	High
Maintenance	High

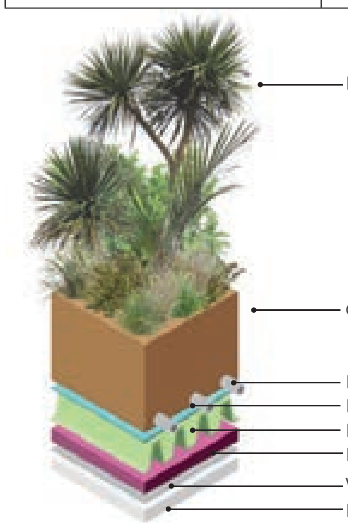


Figure 5: The layers of an intensive living roof

Semi-intensive Living Roof

Semi-intensive green roofs can have varying depths of substrate and generally have elements of both intensive and extensive roof design.

These roofs generally have private access for residents and workers.

Vegetation can comprise shrubs, grasses, sedums or mosses.

Substrate	150mm-500mm
Vegetation	Shrubs, grasses
Cost	Moderate
Structural Loading	Moderate
Maintenance	Moderate

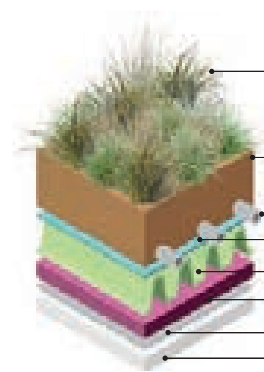


Figure 6: The layers of a semi-intensive living roof

Extensive Living Roof

Extensive green roofs have a shallow substrate and are generally cheapest to install. They have the lightest weight and as such are generally the most favoured option for retrofitting a living roof onto an existing building.

These living roofs are generally installed for no private or public access.

Extensive green roofs are commonly planted with sedums, mosses and grasses that are able to thrive in a shallow substrate and require minimal maintenance and irrigation.

Substrate	50mm-150mm
Vegetation	Grasses, succulents, mosses
Cost	Low
Structural Loading	Light, generally suitable for retrofit
Maintenance	Low

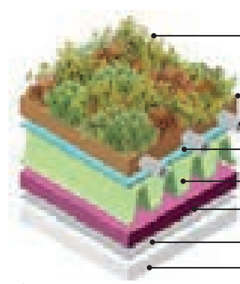


Figure 7: The layers of an extensive living roof

INTRODUCTION

Subsets of these living roof types are:

- Biodiverse
- Biosolar
- Modular

For example, an intensive living roof may also house solar panels, making it an intensive biosolar living roof.

Biodiverse Living Roof

The design and type of living roof installed will dictate the amount of biodiversity achieved.

Biodiversity living roofs typically have differing levels of substrate, creating differing microclimates. They usually incorporate a variety of different substrates, clay, sand, logs and gravel drainage corridors.

The design of these roofs needs to consider the more extreme environment found of a roof, including temperature extremes, sunlight, high winds and access.

Biosolar Living Roof

Biosolar living roofs combine the use of solar panels and vegetation. They are designed to provide stormwater mitigation, biodiversity and produce more electricity by keeping the photovoltaic panels at an ambient temperature thereby increasing the working efficiency of the panels.

The plant species, panel setting and height all needs to be designed to enable light and water to reach the vegetation beneath the photovoltaic panels.

Modular Living Roof

Tray or modular living roof systems are vegetated (usually plastic) trays planted close together on the roof. They are pre-planted and grown off site then brought onto the roof for an instant vegetated cover effect.

These are typically used for extensive living roofs where general access is not available.

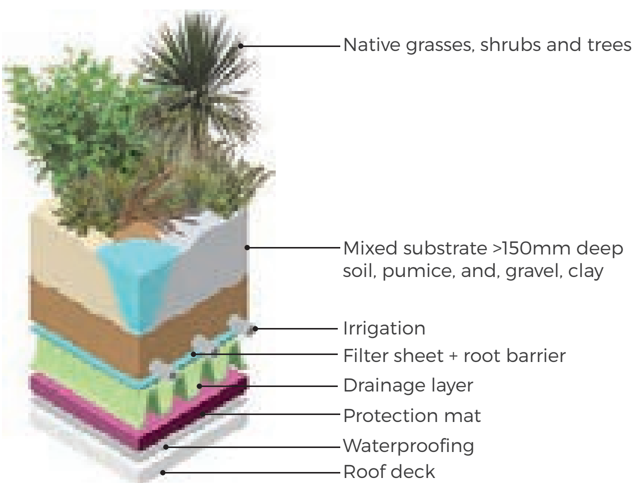


Figure 8: The layers of a biodiverse living roof

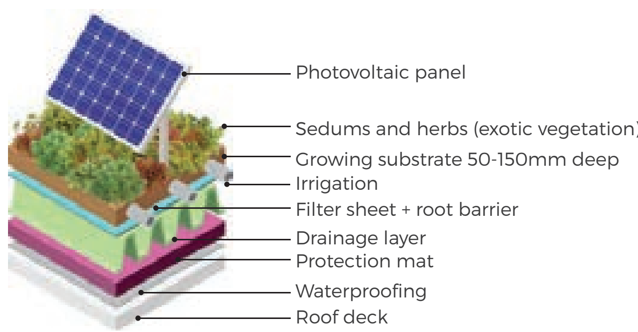


Figure 9: The layers of a biosolar living roof

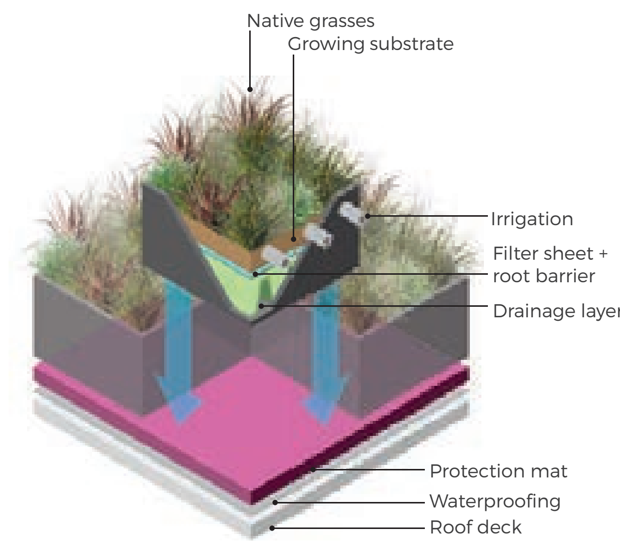


Figure 10: The layers of a modular living roof

Biodiverse living roof in Copenhagen, Denmark
Photo Zoë Avery

Biosolar living roof in Friburg, Germany
Photo Dusty Gedge

Modular living roof at the Viaduct, Auckland
Photo Zoë Avery

INTRODUCTION

Choosing your Living Wall type

Living walls are intentionally vegetated facades that can be internal or external to a building. These green infrastructure systems are categorised into three main groups:

- Living walls
- Living facades
- Hybrid walls

Below: Living facade of *Philodendron cordatum*, NZI building, Auckland. Photo Zoë Avery

Living Walls

Living walls are vegetated structures attached to a wall specifically designed to foster species able to thrive in such conditions, either hydroponically or modularly. Living walls incorporate the plant's roots into a structural support which is fastened to the wall rather than climbers planted in soil at ground level.

Living walls are now created deliberately as a habitat for plants that can sustain an array of species for a variety of benefits. Some designed systems have an irrigation system that provides water and nutrients with dramatic visual effect.

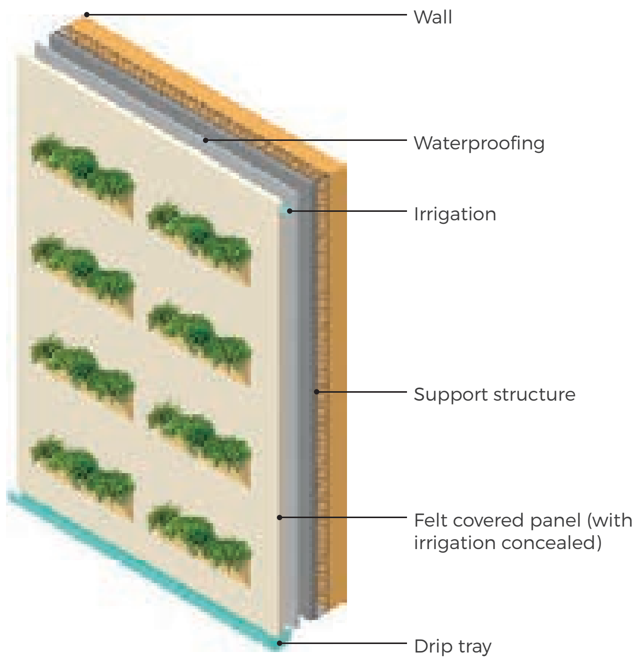


Figure 11: Hydroponic living wall system

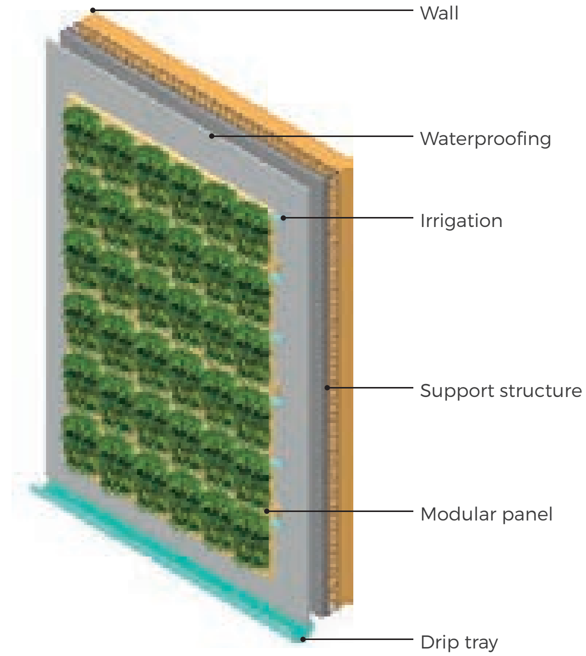


Figure 12: Modular living wall system

Living Facades

Living facades are essentially climbing plants growing along the facade of a building. This is achieved by plants grown in beds at street level or in containers at different levels of the building.

Hybrid Walls

Hybrid walls are made of vertical container systems for interior or exterior walls with plants that grow between each level. The living wall component is placed in front of the spandrel panel and the living facade is placed in between. This allows light and potentially ventilation into the building. Maintenance access can be provided if designed to include terraces.

Hybrid living wall system at One Central Park, Sydney, Australia.
Photo Zoë Avery

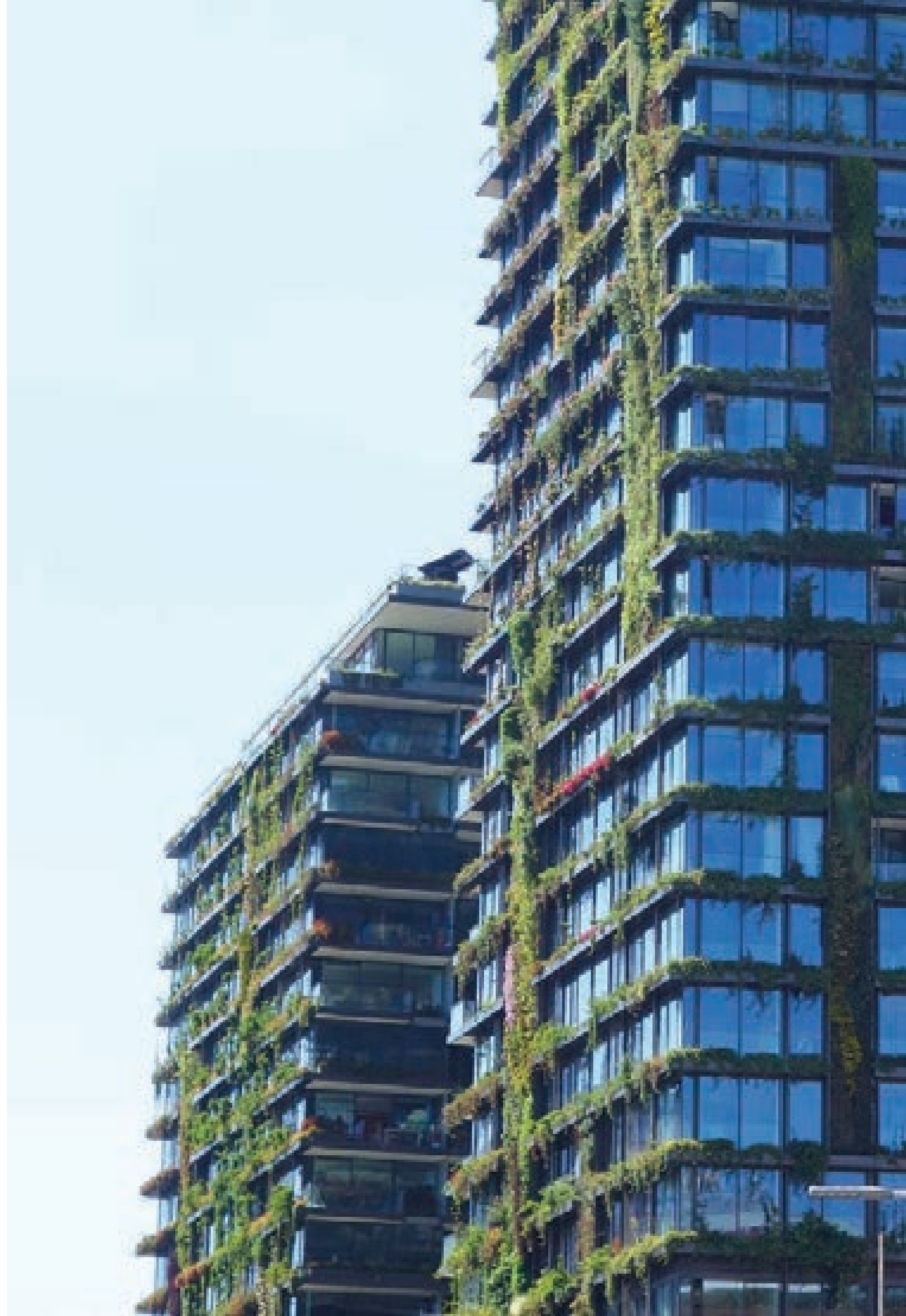
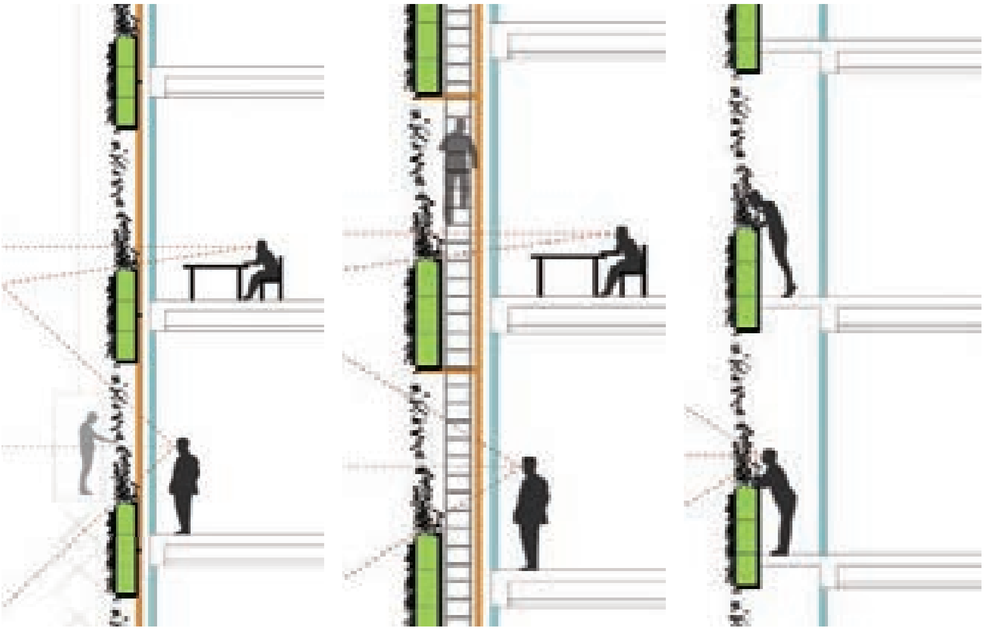


Figure 13: Various hybrid wall systems



Hybrid wall without integrated maintenance

Hybrid wall with integrated maintenance

Hybrid wall with full access

Below: Hydroponic living wall system at The Atrium, Auckland.
Photo Sam Hendrikse

Enhancing biodiversity

The biodiversity of a living roof, both its flora and fauna, is the key catalyst for efficient energy storage, temperature reduction, maintenance of nutrient cycles and assistance with ecosystem functions.

In cities, space for leaf area (the main thermoregulatory mechanism on earth) is reduced due to the requirement for buidling services. The higher the vegetation cover, the cooler the surface temperature and the greater the efficiency in utilising energy. This is an important contribution to a world of changing climate and resource depletion.

In the minimally vegetated environment of the city, living roofs extend these functions.

Bee + Prostrate Mānuka
Urquharts Bay Living Roof, Whāngārei
Photo Zoë Avery

BENEFITS OF LIVING ROOFS, WALLS AND FACADES

TE PAINGA O NGĀ PAETARA, TE KĀINGA KANOHI, KI NGĀ TUANUI KAIAO

BENEFITS

Benefits of Living Roofs, Walls and Facades

Living roofs protect the roof membrane from UV and weather damage, and extend the roof life by as much as three times. They increase property values by providing additional and more marketable living space. Living roofs save a significant amount of energy by reducing heating and cooling bills through insulation on the building. This insulation reduces energy expenditure and associated carbon emissions.

With global temperatures changing, these systems also offer a cheap way of reducing the urban heat island effect. They can reduce noise levels entering and leaving the building by up to 18 decibels (dB) and reflective noise by 3dB or more.

Living roofs are a form of sustainable drainage, replicating natural drainage patterns, reducing stormwater runoff and flash flooding through stormwater attenuation (in many cases around 70%, depending on substrate depth). Stormwater is soaked up by the soil and vegetation then gradually released back into the atmosphere and drainage system.

Living roofs can provide a valuable public amenity for residents and workers, and improved views from surrounding buildings. Importantly for developers, they raise a company's 'green' credentials and are a fantastic way to show corporate social responsibility.

- Increase in Property Values
- Financial Savings/Energy Savings
- Improvements to Onsite Stormwater Management
- Improved Human Health
- Carbon Sequestration
- Aesthetic/Biophilic Improvements
- Noise Attenuation and Sound Improvement
- Improved Biodiversity
- Support of Green Products and Systems
- Urban Heat Island Mitigation
- Shading/Integration with Photovoltaic Panels (Solar Panels)
- Reducing Climate Change Effects
- Improved Air and Water Quality
- Improvements to Building Envelope Longevity
- Food Production
- Support Emerging Manufacture, Design, Installation, Maintenance and New Uses

The benefits are far reaching as shown in the Living Urbanism benefits diagram (Figure 17) on page 56.

Throughout this guide the different interconnected benefits icons shown left will be displayed alongside the values and projects (refer to page 54 for extended benefits).

Increase in Property Values

The provision of a living roof can result in increased property values in a number of ways:

- Providing a more aesthetically appealing building
- Providing more marketable floor space (accessible living roofs)
- Lower building operating costs

It has also being proven that living roofs are beneficial in terms of workplace productivity, recruitment and staff retention. It is becoming well established that the more attractive and environmentally friendly a building is, the more sought after it will be, demanding higher property values and lease rates.

Canadian research estimates that buildings with a recreational living roof achieve an 11% increase in property value, and buildings with views onto living roofs have a 4.5% increase in property value (Smart Cities Research Services, 2010).

At a broader scale, overseas studies show that aesthetics and biodiversity in an urban context appeal to city dwellers, and that green infrastructure will be essential to the long term sustainability of city environments.

Financial Savings/ Improved Building Performance

Energy Savings
Living roofs can reduce heating and cooling costs by insulating the building. These systems act as a natural insulator helping to keep heat out and reducing the need for air conditioning in summer. Planting further reduces energy costs by providing shade and relief from summer heat. Vegetation and substrate naturally lose water through evaporation and transpiration, further cooling buildings during summer. In winter living roofs provide another insulation layer, helping to keep the warmth in the building which reduces heating demand and costs.

Research undertaken in Toronto estimated that there could be a $21 million energy saving from the implementation of a citywide living roofing scheme, based on annual energy savings of 4.15 kWh/m^2 (Ryerson University, 2005). Studies in Germany and the United States also suggest that cities can have significant energy savings from the introduction of living roofs.

Environment Canada have undertaken research which has shown that the upper floor of a building with a living roof is likely to save 20% of its energy demand through reduction in cooling needs. A five storey building or more, in summer would save in the region of 6% and a two storey building in summer, would be between 10-12% (Environment Canada, 2008: Dr Brad Bass). This insulating and cooling of the living roof building reduces energy expenditure and carbon emissions.

Thermal performance
Studies have shown that, due to the insulating properties of living roofs, the membrane temperature beneath a living roof can be significantly lower than when the membrane is exposed.

Temperature fluctuations during spring and summer on a conventional roof were of the order of 45˚C whilst under a living roof the fluctuations were in the order of 6˚C (National Research Council Canada, 2013).

The reduction in membrane temperature fluctuations, in conjunction with protection from sunlight, frost and other weather damage, means that a living roof can extend the life of the membrane by two to three times. This provides further cost savings over the life of the building.

Extended roof life
Living roofs protect the roof membrane from ultraviolet and weather damage which in turn can extend the roof life by two or three times. The installation of a living roof can therefore save money by doubling the life of the waterproof layer. In Germany, the first living roofs were created by covering wet bitumen with 60mm of sand. These roofs subsequently became naturally vegetated.

Sound insulation
Living roofs can act as a significant barrier for sounds. The components of a living roof system, from the soil, vegetation and drainage layers all act to either absorb, reflect or deflect sound waves. Studies in the UK suggest that a living roof can reduce sound by 8dB compared to a standard roof. Urban areas that suffer from high levels of noise pollution, such as, buildings within flight paths could all benefit from the installation of living roofs.

Whole life costs
Living roofs can benefit the whole life cost of the building. Limited research is available on this matter, yet recent research in London has shown a benefit to the whole life cost of a building with the incorporation of a living roof.

Increase Environmental Rating Score
NZ has independent green building rating systems called Green Star NZ and Homestar NZ. Living roofs are the only system that can be introduced which provide a number of points in the Green Star and Homestar NZ rating tools. Living roofs can provide more benefits than living walls and the benefits could be extended, providing more points from energy and ecology to emissions. For example, under 'Homestar V4', living roofs and living walls can contribute up to a higher score in the native ecology (if they are planted with native species) and on-site food production (vegetable gardens and fruit producing plants) credits.

Depending on the type proposed, living roofs can also receive an innovation score. As such they can easily increase the score achieved in the tool.

BENEFITS

Improvements to Stormwater Management

Living roofs are one system used in water sensitive urban design. Stormwater management is a common issue faced in cities. Most of our existing urban drainage systems are currently at capacity, many having been designed so long ago as a system of combined surface water and waste water.

If a sustainable drainage or low impact design approach is taken as part of a development, it ensures the site is not increasing surface water flood risk or polluting the environment.

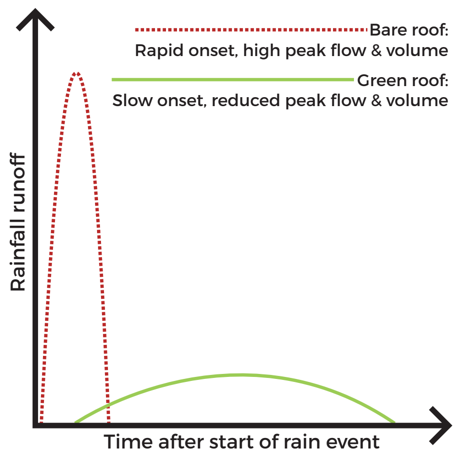


Figure 14: Rainfall event on living roof vs standard roof

There are three key factors in the sustainable drainage approach being:

- Quantity of surface water run off
- Quality of surface water run off
- Amenity benefits

The nature of climate change at a regional level will vary in NZ. Projections of future climate change indicate that there will be more frequent, short-duration, high intensity rain.

NIWA estimates for a mid-range scenario, that a 1 in a 100 year event, could become a 1 in 50 year event by the end of the century (Climate Change Projections for New Zealand, NIWA National Climate Centre, August 2008).

Living Roofs may reduce the water storage requirements and drainage infrastructure on a site.

Human Health & Wellbeing

Biophilia is an innate and genetically determined affinity that human beings have with the natural world. It is widely researched that contact with greenery or vegetation provides benefits to humans. Reduced stress levels and cleaner water and air have been attributed to the provision of green space.

Access to green space can bring about direct reductions in a person's heart rate and blood-pressure, and can aid general well-being. A Texan study of post-surgery recovery in hospitals demonstrated that recovery was quicker and with less chance of relapse if patients could look out onto green space. A number of American hospitals have subsequently been redesigned to bring these benefits to patients, and have been rewarded with greater patient 'throughput'.

A roof on the Kanton Hospital in Basel was redesigned 20 years ago by vegetating it, because it was felt that patients in intensive care would benefit from looking out onto this rather than the grey-space of before. Some community hospitals in the UK are now being designed with a greater consideration of green-space provision, and the good-practice work on hospital design being developed by Commission for Architecture and the Built Environment [CABE] is likely to further this.

The thermal benefits that green roofs provide may also have indirect benefits for people living or working within the buildings. This has not been researched, but anecdotal evidence from Germany in the late 1990s is of interest. In a survey of staff absence from sickness at the Bundepost offices in Stuttgart, it was shown that staff in one building demonstrated significantly lower absences than those in others.

The only change in the 4-year period that could be identified was that one of the buildings was given a green roof; this building supported lower staff sickness levels. It is possible that the green roof reduced the fluctuation of daily mean temperatures within the upper levels of the building, and/or the vegetation helped cool and moisturise in-going air near ventilation ducts." (Living Roofs UK, https://livingroofs.org/health/).

Right: Tram station living roof in Zurich, Switzerland
Photo Zoë Avery

BENEFITS

Green Space, Amenity, Vistas

Our appreciation of an area can be significantly increased by the installation of living roofs. This is apparent when looking over the roofscape of Whāngārei – where the potential for greening of roof environments is huge.

It is important to provide attractive green space for people living, working and visiting Whāngārei. Living roofs can provide visually appealing green space, visually soften the built environment, and help people's mental and physical health. They have an important ecological role, supporting biodiversity, and providing a 'sense of place'.

Within urban centres there is a need for increased residential densities as cities continue to grow in population and expand in area. As residential infill occurs, there is a loss of green space and amenity. Living roofs are a solution to help mitigate these adverse effects.

Whāngārei's rooftops should be seen as an under-utilised asset. Living roofs can provide valuable recreational resource. The Michael Hill Golf Course living roof is an example of where a living roof installation provides significant visual aesthetic mitigation. Recreational green space has been provided on living roofs all over the world, Jubilee Gardens at Canary Wharf Station in London is a prime example.

London's Kensington Roof Gardens, built in 1938, provide gorgeous aesthetic recreational space in the middle of a heavily populated city. Cannon Street station is another example of an intensive roof garden in the heart of London.

Living roofs can significantly improve local vistas. This can be of value when adding extensions to dwellings or commercial buildings and visual mitigation is required at the planning stage.

BENEFITS

Biodiversity & Habitat Creation

Living Roofs can provide significant biodiversity benefits. Many countries use living roofs as mitigation for the loss of habitat. Switzerland has moved towards introducing living roof systems that mimic natural habitats found locally.

Living Roofs can improve biodiversity by providing much needed green space especially in industrial or commercial areas. They create new green links/corridors for species to network and move along. They may also provide a mosaic of habitats for endangered plants, invertebrates and birds. It has been demonstrated that to create an invertebrate rich living roof, consideration of varying substrates, depths, different local plants and incorporation of dry wood or rocks for habitat is required.

Living roofs can provide connections across cities that short-range species would not be able to cross otherwise. This is important in ensuring populations do not become isolated. For Whāngārei, living roofs would connect the forest areas of Parihaka and Pukenui.

"Although gardenesque in character such roofs can provide a significant resource for local biodiversity with good planting schemes. These should include some native and certainly include flowering plants that are of known foraging value for bees. Inclusion of water features, dead logs and nest boxes can increase the potential for such roofs to act as a resource for local wildlife."

(Dusty Gedge, personal communication, July 2017).

Food Production

Living roofs are being considered more and more for food production, with the increasing cost of food transportation and reducing "food miles". Inner city market gardens are being installed in Europe, the US and China. The use of living roofs for hydroponic or container food production is becoming more widespread.

Living walls have been installed for food production but more commonly living facades with fruiting, climbing plants are used.

Living roofs are particularly important for densely populated cities where space is at a premium. Singapore, China and the United States have a number of thriving food producing living roofs. The incorporation of beehives on rooftops is also becoming more common throughout the world to support and enhance the urban bee population.

Urban Air & Water Quality

Vegetation and soil have been proven to help filter pollutants and dust from the air and water. There are a number of factors that affects the ability of vegetation to absorb pollutants from weather conditions to the type of vegetation. Wetlands are being trialled on living roofs in the United Kingdom, which can filter and treat water.

Climate Change Adaption

Urban heat island effect

Although the urban heat island effect is not an issue for Whāngārei city, it is relevant to other large centres in NZ.

Our urban areas have a higher average temperature than rural areas. The urban heat island effect is the term used to describe the difference in these temperatures.

With the effects of climate change taking hold, the number of hot days experienced in our cities will increase along with reliance on air conditioning. Living roofs are a proven technique to help mitigate the urban heat island effect.

The two most recognised methods for reducing the urban heat island effect is to:

- Introduce more vegetation into the urban environment which will provide shading and cooling through evapotranspiration
- Increase the albedo or reflectiveness of roofs to reflect a higher amount of solar radiation back into the sky, thereby producing less heat.

Living roofs are now commonly being used overseas to mitigate the effects of the urban heat island effect.

Right: Bere House, Islington, London
Photo Dusty Gedge


Waitakere Council Building Living Roof
Photo Renée Davies

CASE STUDIES

AKO TAKE

CASE STUDIES

Hundertwasser Wairau Māori Arts Centre

Location:
Dent Street, Town Basin, Whāngārei, NZ

Client:
Whāngārei Art Museum Trust

Concept Design:
Friedensreich Hundertwasser

Design Input & Oversight:
The Hundertwasser Non-Profit Foundation and Springmann Architecture

Living Roof Designers:
Zoë Avery & Renée Davies, 4Sight Consulting

Architect:
Grant Harris, HB Architecture

Project Manager:
Ben Tomason, Griffiths & Associates

Living Roof Type:
Intensive living roof

Development Type:
Commercial, public and educational

Build:
New build

Building Type:
Art museum, art gallery, cafe, sculpture park & education space

Living Roof Brief:
The design brief for the living roof afforestation has been driven by a concept of giving this space back to nature. People should enjoy these spaces as a guest of nature, just like walking through the forest. The aim was to create a forest using New Zealand native, Northland specific plants including offshore island, threatened, endangered or rare species.These local species are integrated with fruiting trees, so one can wander through the forest and discover, pick and eat fruit. This forest is to be set randomly, wild with spontaneous vegetation beneath the trees where new plants can self seed as happens in nature.

The brief was to follow the known and practiced Hundertwasser living roof design practices while respecting New Zealand's endemic plants, animals and building and resource laws. As such, the earth layer (substrate) uses locally sourced pumice (light weight and porous volcanic rock), zeolite and organic matter. Paths are to be permeable and covered in natural materials with no visible edges.

The planting plan has been developed to maximise the amount of roof space dedicated to nature. The proposed plant palette has a diverse mix of exotic fruiting trees and New Zealand natives that are adapted to the local ecological region. Focus has been placed on species that are threatened and found on offshore islands - highlighting the special character and the unique location of the Hundertwasser Art Centre in Whāngārei.

Project Drivers:

- Habitat creation
- Giving space back to nature in Whāngārei city
- Aesthetic green space for community, visitors and workers on landmark building
- Recreation space for sculpture park
- Stormwater management
- Energy conservation - insulation values for galleries below
- Roof longevity

Right: Hundertwasser Living Roof Afforestation perspective and cross section
Drawings by: 4Sight Consulting: Zoë Avery, Renée Davies, Sam Hendrikse
Imagery released courtesy of The Hundertwasser Non-Profit Foundation

CASE STUDIES

Living Roof Design:
Vegetation:

Native Specimen Trees:
- *Alectryon excelsus subsp. Grandis,* Tītoki
- *Alectryon Grandis,* Three Kings Island Tītoki
- *Corynocarpus laevigatus,* Karaka, Kōpī
- *Elingamita johnsonii,* Elingamita
- *Pittosporum fairchildii,* Fairchild's Kohūhū
- *Pittosporum obcordatum,* Heart-leaved Kohūhū
- *Pennantia baylisiana,* Three Kings Kaikōmako
- *Planchonella costata,* Tawāpou
- *Nestegis apetala,* Coastal maire
- *Rhopalostylis sapida 'Chathamica',* Chatham Island Nīkau
- *Sophora chathamica,* Kōwhai
- *Strebulis smithii,* Three Kings Milk tree

Exotic Fruit Trees
- *Pyrus communis,* 'Doyenne du Comice' Pear
- *Pyrus communis,* 'Beurre Bosc' Pear
- *Prunus domestica,* 'Billington' Plum
- *Prunus domestica,* 'Burbank' Plum
- *Malus pumila,* 'Sunrise' Apple
- *Malus pumila,* 'Egremont russet' Apple
- *Malus pumila,* 'Monty's surprise' Apple
- *Prunus persica var. nucipersica,* 'Nani's Nectarine
- *Prunus persica,* 'Caravan peacherine'

New Zealand Native Shrub Planting:
- *Veronica parviflora,* Hebe Parviflora
- *Veronica speciosa var. brevifolia* Cheeseman, Hebe Brevifolia
- *Veronica diosmifolia,* Hebe Diosmifolia
- *Coprosma repens,* 'Poor Knights'
- *Griselinia lucida,* Puka, Akapuka

New Zealand Native Underplanting:
- *Arthropodium* 'Matapōuri Bay'
- *Asplenium oblongifolium*
- *Astelia banksii*
- *Apium prostratum subsp. denticulatum*
- *Blechnum novae-zelandiae*
- *Carex solandri*
- *Carex testacea* - green
- *Chionochloa flavicans*
- *Dianella nigra*
- *Festuca coxii*
- *Lepidium oleraceum*
- *Pimelea arenaria / Pimelea villosa*
- *Pimelea prostrātā subsp. Prostrātā*
- *Samolus repens*
- *Selliera radicans*
- *Xeronema callistemon*
- *Pachystegia insignis*
- *Hibiscus ricardii*
- *Hibiscus richardsonii*
- *Dianella nigra*
- *Selliera radicans*

Substrate Depth:
600-700mm

Substrate Composition:
20% Organic matter, 70% Pumice, 10% Zeolite

Drainage System:
Free-draining drainage system

Waterproof Membrane:
Root resistant waterproofing membrane

Irrigation:
Drippers below surface and pop up irrigation – all controlled

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Reinforced concrete

Slope of Roof:
2-20 degrees

Roof Access:
Permanent access while HAC is open

Climate Evaluation:
Full sun, some areas part shade. Wind can be strong - gusting to over 135km/hour.

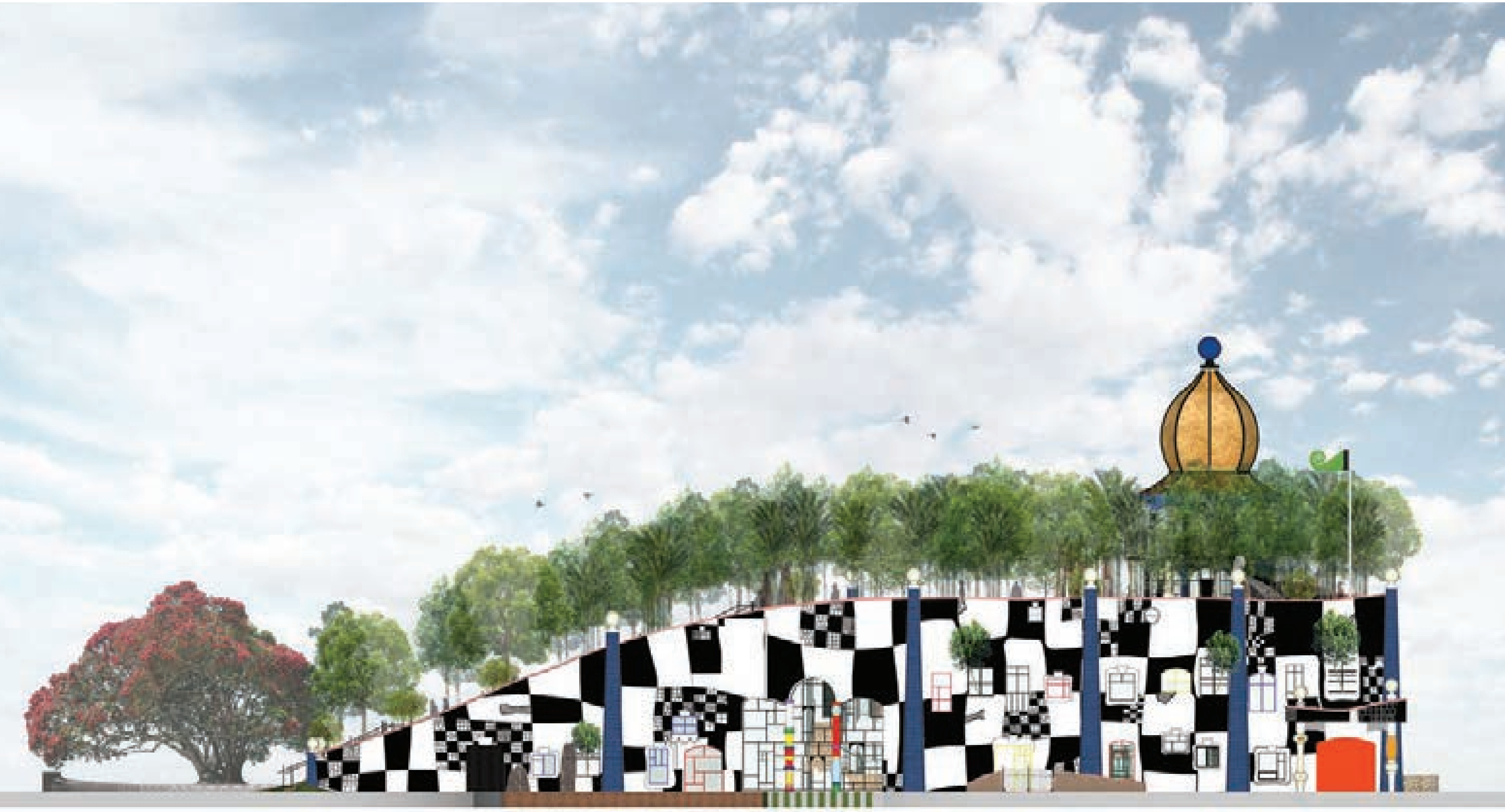
Site Considerations:
Nationally significant build on landmark building which will have public access for sculpture park. Leak dectection system included in design.

Size:
~980m^2

Completion:
Planned completeion date early 2020

Right: Hundertwasser Living Roof Afforestation Elevation
Drawings by: 4Sight Consulting: Zoë Avery, Renée Davies, Sam Hendrikse
Imagery released courtesy of The Hundertwasser Non-Profit Foundation

CASE STUDIES



CASE STUDIES

Urquharts Bay Toilets

Location:
Urquharts Bay Road, Urquharts Bay, Whāngārei Heads

Client:
Whāngārei District Council

Living Roof Designers:
Zoë Avery and Renée Davies

Architect:
Chris Howell, Main 4 Architects

Living Roof Type:
Semi-Intensive

Development Type:
Public

Build:
New Build

Building Type:
Public Toilet Block

Living Roof Brief:
Native living roof with appropriate species for the location, adjoining Bream Head Scenic Reserve.

Project Drivers:

- Aesthetics
- Biodiversity/habitat creation
- Roof longevity.

Living Roof Design:
Vegetation:

- *Sellieria radicans*
- *Coprosma acerosa*
- *Pimelia prostrātā*
- *Muehlenbeckia complexa*
- *Disphyma australe*
- *Apium prostratum*
- *Leptospernun nanum*
- *Arthropodium Cirratum* Matapōuri Bay 'Renga Renga Lily'

Substrate Depth:
250-300mm

Substrate Composition:
20% Organic matter, 70% Pumice, 10% Zeolite

Drainage System:
VersiDrain drainage system

Waterproof Membrane:
Living roof root resistant waterproof membrane

Irrigation:
EcoBlanket capillary living roof irrigation and timer

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Wood

Slope of Roof:
8 degrees

Roof Access:
No access provided, limited for maintenance with clip station for harness

Climate Evaluation:
Full sun, high winds and a coastal location

Size:
36m^2

Completion:
2013

Cost:
Everything above waterproofing ~ \$275/m^2

Right: Living Roof at Urquharts Bay, Whāngārei Heads
Photo Zoë Avery

CASE STUDIES

Buckleton Beach Shed

Location:
Buckleton Beach, Tāwharanui

Client:
G & J Cremer

Living Roof Designer:
Renée Davies

Living Roof/Wall Type:
Semi-Intensive

Development Type:
Private

Build:
New Build

Building Type:
Residential garage/boat shed

Living Roof Brief:
A semi-intensive living roof located on a new boat shed building. Plant selection taking inspiration from its coastal location and from known successful NZ natives that have been used as living roof plants to create a native living roof that has botanical and visual links with the adjacent coastal garden design.

Project Drivers:

- Aesthetics
- Stormwater management

Living Roof Design:
Vegetation

- *Festuca coxii*
- *Coprosma acerosa*
- *Leptospermum flavescens* 'Little bun'
- *Libertia ixioides*
- *Pimelea prostrātā*
- *Leptospermum flavescens* 'Pink beauty'
- *Muehlenbeckia axillaris*
- Area of lawn

Substrate Depth:
200mm

Substrate Composition:
20% Organic matter, 70% Pumice, 10% Zeolite

Drainage System:
Plazadeck drainage system

Waterproof Membrane:
Nuralite living roof waterproof membrane

Irrigation
Above ground dripper irrigation

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Concrete

Slope of Roof
<3 degrees

Roof Access:
Limited for maintenance

Climate Evaluation:
Full sun, high winds and coastal location

Site Considerations:
Views from deck of house down onto the living roof. Client desire for some lawn area.

Size:
45m^2

Completion:
August 2011

Right:
Living roof at Buckleton Beach, Tāwharanui
Photos Renée Davies

CASE STUDIES

NZI Building

Location:
1 Fanshawe Street, Auckland

Client:
IAG

Living Roof Designer:
Greenroofs Ltd

Architect:
Jasmax

Contractor:
Scarbro

Living Roof/Wall Type:
Extensive

Development Type:
Commercial

Build:
New Build

Building Type:
Commercial Office Space

Living Roof Brief:
Roof top garden adjacent to staff outdoor area. Used to reduce stormwater runoff plus any runoff from the roof to be used for flushing toilets. The building achieved a 5 star Green Star rating for sustainable design from the New Zealand Green Building Council.

Project Drivers:

- Aesthetics
- Workplace productivity
- Recreation
- Stormwater management
- Water quality

Living Roof Design:
Vegetation
Exotic Sedum mix (seven species)

Substrate Depth:
50-75mm

Substrate Composition:
20% Organic matter, 70% Pumice, 10% Zeolite

Drainage System:
Standard drainage system

Waterproof Membrane:
Nuralite waterproof membrane

Irrigation:
Below ground dripper irrigation

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Wood

Slope of Roof:
0-5 degrees

Roof Access:
Permanent access by staff and used for entertaining clients.

Climate Evaluation:
Full sun and high wind environment

Size:
350m^2

Completion:
May 2009

Cost:
Everything above waterproofing ~$200/m^2

Right: Living Roof at NZI Centre, Auckland
Photos Will Thorne

CASE STUDIES

Mt Difficulty Winery

Location:
Mt Difficulty Winery, Bannockburn, Central Otago

Client:
Mt Difficulty Wines

Living Roof Designer:
Stormwater360 – Greg Yeoman

Architect:
Red Rooster Design

Project Manager/Contractor:
Stormwater360

Living Roof Type:
Extensive

Development Type:
Commercial

Build:
New Build

Building Type:
Wine Barrel Store

Living Roof Brief:
The brief for the new barrel store in Bannockburn, Cromwell was to create a temperature controlled and environmentally conscious space that would fit into the surrounding Central Otago landscape. The resulting building is an earth-toned, exposed aggregate, pre-cast panel construction buried back into the hillside with a vegetated living roof covering the complete 900m² building footprint. The barrel store is located at the base of the hillside below the restaurant and wine tasting cellar door.

Temperature control is a vital component of wine making and was a key factor in the design. In an effort to keep the temperature at the correct constant temperature, the building is set into the earth hillside at the back sides and a 150mm deep vegetated roof was installed on the insulated roof slab. The resulting energy requirement has been reduced primarily to only requiring energy input to artificially increase or reduce the temperature for the winemaking process.

Process water from the winemaking process is irrigated onto the roof through sprinklers reducing loading on the onsite wastewater plant.

Rocky outcrops were strategically placed onto the living roof to successfully encourage habitat for the local Cromwell geckos.

Project Drivers:

- Aesthetics
- Stormwater management - process water
- Energy conservation
- Roof longevity
- Habitat creation

Living Roof Design:
Vegetation:
Selected locally grown/sourced NZ native grasses including:

- *Poa cita*
- *Festuca coxii*
- *Festuca novae-zelandiae*
- *Carex testacea*
- *Carex buchananii*
- *Thymus vulgaris* (locally sourced Thyme)
- Stonecrop sedum

(Approximately 14,000 plants in total)

Substrate Depth:
150mm

Substrate Composition:
Lightweight pumice based proprietary media

Drainage System:
LiveRoof modules

Waterproof Membrane:
TPO

Irrigation
Spray irrigators using mix of process and fresh water

Living Roof Construction:
Modular tray living roof system

Roof Structure:
Reinforced concrete slab + warmroof

Slope of Roof
~2 degrees

Roof Access:
Walk-on access from hillside, with balustrading at front edges. No heights restraints required.

Climate Evaluation:
Full sun and exposed

Site Considerations:
Rabbit protection required consideration

Size:
900m²

Completion:
March 2012

Cost:
Everything above waterproofing: ~$300/m²

Right: Mt Difficulty Winery Living Roof
Photo Renée Davies

CASE STUDIES

Waitakere Civic Building

Location:
Henderson, Auckland

Client:
Former Waitakere City Council (now Auckland Council)

Living Roof Designer:
Renée Davies & Landcare Research

Architect:
Architectus

Project Manager/ Contractor:
Canam (main contractor) & Greenroofs Ltd (substrate installation and planting)

Living Roof Type:
Extensive

Development Type:
Commercial

Build:
New build

Building Type:
Government office

Living Roof Brief
Waitakere City Council's original vision for the development of the living roof was to:

- Demonstrate the range of sustainable benefits of living roof technology.
- Create a living roof which is specific to the New Zealand situation, and at least in part, reflective of plant species found in the Waitakere environment.
- Create an organic patchwork of plants which will move and change over the years with competition and natural growth styles.
- Provide splashes of colour variation through leaf colour, texture and seasonal flowering.
- Ensure a multitude of outcomes are achieved for stormwater, habitat and amenity.
- Provide a robust, well-researched and documented process for plant selection, including substrate make-up, and monitoring to provide useful and innovative input into living roof technology specific to New Zealand.

Project Drivers

- Aesthetics
- Improved biodiversity
- Improved air and water quality
- Stormwater management
- Support of green products and systems
- Thermal performance
- Urban Heat Island Effect mitiagtion

Living Roof Design:
Vegetation:

- *Acaena microphylla*, NZ bidibid
- *Calystegia soldanella*, Sand convolvulus
- *Coprosma acerosa*, Sand coprosma
- *Dichondra repens* 'piha', Mercury bay weed
- *Disphyma australe*, New Zealand iceplant
- *Festuca coxii*, native tussock
- *Leptostigma setulosa*
- *Libertia peregrinans*, NZ iris
- *Muehlenbeckia axillaris*
- *Muehlenbeckia complexa*
- *Muehlenbeckia ephendroides*
- *Pimelea prostrātā*, NZ daphne
- *Selliera radicans*

Substrate Depth:
50-130mm

Substrate Composition:
20% 4-8mm grade expanded clay (Hydrotech), 30% 4-8mm grade pumice, 20% Perry's garden mix or Living Earth garden mix, 30% 1-3mm or 1-2mm grade pumice

Drainage System:
Rigid drainage boards

Waterproofing:
Standard waterproof membrane

Irrigation:
No irrigation installed initially. Modifications have been undertaken to the design (including installation of ecoblanket irrigation for harsh summer droughts and introduction of mounds).

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Concrete

Slope of Roof:
~2 degrees

Roof Access:
Limited for maintenance

Climate Evaluation:
Full sun and exposed

Site Considerations:
Plants chosen to withstand the harsh conditions of the roof, must be native preferably from the Waitakere Ecological District.

Size:
500m^2

Completion:
August 2006

Right: Waitakere Civic Building extensive living roof.
Far right: Mixture of native species on mounds
Photos by Renée Davies.



Clockwise from top: Side view of the Potter's Children Garden Entrance living roof. Close up vegetation on the living roof. Side angle photo of the living roof.
All photos Jack Hobbs

Potter's Children's Garden Entrance

Location:
102 Hill Road, The Gardens, Auckland

Client/Partner:
Auckland Botanic Gardens

Living Roof Designers:
Jack Hobbs and Ed Snodgrass

Architect:
Adams De La Mere Architects and Landscape Architects

Living Roof Type:
Extensive, timber roof

Development Type:
Public

Build:
New

Building Type:
Public entranceway

Living Roof Brief:
An extensive living roof is located on the entranceway to the Children's Garden at the Auckland Botanic Gardens. The planting on this living roof has been designed for maximum visual impact utilising plants of outstanding form and colour. All of the plants are exotic but are known to thrive on living roofs with shallow substrate.

Project Drivers:

- Aesthetics
- Improved air and water quality

Living Roof Design: Vegetation

- *Aloe aristata*
- *Aloe humilis*
- *Bromeliad neoregelia* 'Night Sky'
- *Echeveria elegans*
- *Gazania sp.*
- *Iris sp.*
- *Lampranthus sp.*
- *Ornithogalum dubium*
- *Senecio serpens*

Substrate Depth
110mm

Substrate Composition
20% v/v Organic matter, 70 % Pumice, 10% Zeolite

Drainage System
Maccaferr Plazadeck/Nuraflow drainage mat

Waterproof Membrane
Nuralite 3PV & 3PG waterproofing membrane system

Irrigation
Conventional above-ground jets

Living Roof Construction
Built-in-place living roof system

Roof Structure
225x50mm tongue & groove 'Lawsons' cypress sarking fixed to beams with 2/100x3.75 FH nails per board.

Roof Access
Limited for maintenance

Site Considerations
As the entrance to a children's garden, the "funky", somewhat outrageous look was desired to draw the attention of children. The roof slopes towards the road and the proximity of viewing platforms (in the form of large, flat boulders) means that the roof is visible from the road and within the children's garden.

Size
12.9m^2

Completion
July 2010

Comments
Following planting, the large *Echeveria* lost their orange flower spikes and were replaced with numerous 'pups'.

The *Echeveria* grew better at the lower, wetter end of the roof while the *Aloe* grew better at the higher, drier end.

The *Ornithogalum* failed to flower in 2012 and the leaf and flower size was a third of the expected size, indicating the low fertility of the living roof substrate.



Far left and top: Front of the toilet block living roof.
Photo Bec Stanley

Right: Tussock on the toilet block living roof.
Photo Jack Hobbs

Potter's Children's Garden Toilet Block

Location
102 Hill Road, The Gardens, Auckland

Client/Partner
Auckland Botanic Gardens

Living Roof Designer
Jack Hobbs and Ed Snodgrass

Architect
Adams De La Mere Architects and Landscape Architects

Living Roof Type
Extensive, timber roof

Development Type
Public

Build
New

Building Type
Public toilet block

Living Roof Brief
An extensive living roof is located on the roof of the Children's Garden toilet block at the Auckland Botanic Gardens. The planting on this green roof has been designed to showcase native plants and complement adjacent native landscaping.

Project Drivers
- Aesthetics
- Improved air and water quality

Living Roof Design: Vegetation
- *Austrofestuca sp*
- *Austrostipa stipoides*
- *Chionochloa rubra*
- *Coprosma acerosa* 'Hawera', *Libertia peregrinans*
- *Muehlenbeckia complexa*
- *Poa cita*
- *Xeronema callistemon.*

Substrate Depth
110mm

Substrate Composition
20%v/v Organic matter, 70 % Pumice, 10% Zeolite

Drainage System
Maccaferr Plazadeck/Nuraflow drainage mat

Waterproof membrane
'Nuralite' 3PV & 3PG waterproofing membrane system for green roof

Irrigation
Conventional above-ground jets

Living Roof Construction
Built-in-place living roof system

Roof Structure
225x50mm tongue & groove 'Lawsons' cypress sarking fixed to beams with 2/100x3.75 FH nails per board

Slope of Roof
15 degrees

Roof Access
Limited for maintenance

Site Considerations
To fit the aesthetic of the surrounding landscape, this living roof was planted with similar and complementary plants.

Size
29.9m^2.

Completion
July 2010

Comments
This living roof forms part of a treatment train; rainfall is discharged to a swale planted with sedges and rush that then drains into a pond.

The tussocks and *Libertia* were immediately visible while the *Muehlenbeckia* and *Coprosma* blended into the substrate. The use of the high visibility plants was imperative for this public site and was achieved through clustering and the contrasting plant colour and texture.

The plants on the native roof required less maintenance than the exotic entrance roof as there were no dead seed heads to be removed.

CASE STUDIES

Wiles Ave Studio

Location:
Wiles Avenue, Auckland

Client:
Robyn Simcock and Stuart Smith

Living Roof Design:
Robyn Simcock

Project Manager/ Contractor:
Stuart Smith

Research:
Dr Robyn Simcock

Living Roof Type:
Extensive (lightweight)

Development Type:
Private

Build:
New build

Building Type:
Studio

Project Brief:
An extensive living roof located on a new studio that occupies sunny garden. The herb garden was shifted to the roof, as this is one of the few sunny places on the section.

The roof is also overlooked by a bedroom and neighbour's decks, so needs to be relatively aesthetically attractive; about one quarter to one third of the roof should be suitable for growing annual crops such as lettuces and coriander.

The studio is a wood workshop with noisy equipment, so the living roof helps suppress noise (it has double glazing and thick insulation). The living roof is at shoulder height for the neighbours, so plants were selected for the boundary that needed very little maintenance, were dense and tidy, and discouraged children from trying to get onto the roof (we used low Bromeliads).

Project Drivers:

- Aesthetics
- Food production
- Sound proofing
- Stormwater management

Living Roof Design:
Vegetation:

- Rosemary
- Thyme varieties (including *T. vulgaris*, and emerald thyme)
- *Oreganum, Bergamont*
- *Calendula*
- Blue *Salvia*
- Chives
- Sage
- Lettuce
- Coriander
- *Dianthus*
- *Geranium*
- Lavender angustifolia (has performed poorly)
- Bromeliads
- *Sedum mexicanum.*

Substrate Composition:
20%v/v Organic matter, 70% Pumice, 10% Zeolite

Drainage System:
ANS Modular drainage system with 20mm deep cup retention cell depth made from recycled HDPE plastic overlaid with 5mm thick bioblanket filter layer (recycled polyethylene and hemp) that promotes even water distribution and water retention. The cups interlock creating a stable platform that stays put (not prone to wind unlike the lightweight rolled products); but the units are relatively heavy and expensive but very strong and effective protection for waterproofing.

Waterproof Membrane:
Standard waterproof membrane

Irrigation:
A small water tank on the adjacent car port collects roof runoff from the two storey dwelling main house. The water tank is connected by a hose and allows hand watering.

Living Roof Construction:
Built-in-place living roof system

Roof Structure:
Wood 190x45mm rafters at a maximum of 480mm centres; extra rafters were added at little additional cost as the spans are short.

Slope of Roof:
5 degrees

Roof Access:
Limited for maintenance

Climate Evaluation:
Morning sun NE aspect, low wind and afternoon light shade from adjacent trees (palms and pittosporum).

Site Considerations:
Planting that discourages people from climbing onto the roof from neighbouring section as roof is at about shoulder height. The roof has areas that are regularly replaced, and some areas with fertiliser added to encourage plant growth so water runoff quality is elevated in nutrients. Runoff is split into a rain chain that feeds a pot plant, and a perforated pipe that runs along a garden with citrus trees.

Size:
22m^2

Completion:
August 2016 but plants are added to over time

Clockwise from top:
View of studio living roof from private open space
Garden beds populated with various herbs
Rosemary thriving in the garden beds
Photos Zoë Avery.

Wiles Ave Carport

Location:
Wiles Avenue, Auckland

Client:
Robyn Simcock and Stuart Smith

Living Roof Designer:
Robyn Simcock

Project Manager/ Contractor:
Stuart Smith

Research:
Dr Robyn Simcock

Living Roof Type:
Extensive (lightweight)

Development Type:
Private

Build:
New build

Building Type:
Residential garage and bike shed

Project Brief:
A roof to test native and non-native plants and demonstrate techniques to manage drought stress and stratify a roof by microclimate.

Left: Living roof provides stormwater mitigation on the carport roof and softens the architectural structure of the carport.
Photo Zoë Avery.

Project Drivers:

- Aesthetics
- Food production
- Sound proofing
- Stormwater management

Living Roof Design:
Vegetation:
Mix of native and exotic species.
Areas with very thin media and afternoon sun are planted with:

- *Sedum ternatum*
- *Sedum reflexum* (syn. *Sedum rupestre*)
- *Sedum spurium*
- *Sedum rubroctintum* 'jellybeans'
- Bromeliads (notably *B. neoregelia* 'Red of Rio')
- *Lampranthus* (iceplant)
- *Kalanchoe.*

Areas with thin substrate but afternoon shade are planted with natives:

- *Xeronema callistemon*, Poor Knight's lily
- *Astelia banksii*
- *Collespermum hastatum*
- *Acaena sp.*
- *Dichondra brevifolia*

Areas with deeper substrate (over the bike shed) are planted with natives:

- *Athropodium bifurcatum* 'Matapouri Bay
- *Coprosma repens* 'Poor Knights'
- Hebe *obtusata*
- *Doodia australis*
- *Acaena*
- *Selliera radicans*
- *Fuschia procumbens.*

Substrate Depth:
20-200mm

Substrate Composition:
20% v/v Organic matter, 70 % Pumice, 10% Zeolite

Drainage System:
ANS Modular drainage system with 20mm deep cup retention cell depth made from recycled HDPE plastic overlaid with 5mm thick bioblanket filter layer (recycled polyethylene and hemp) that promotes even water distribution and water retention. The cups interlock creating a stable platform that stays put (not prone to wind unlike the lightweight rolled products); but the units are relatively heavy and expensive but very strong and effective protection for waterproofing.

Waterproof Membrane:
Standard waterproof membrane

Irrigation:
A small water tank on the roof collects runoff from the two storey dwelling main house and water can be bucketed from this onto parts of the roof. Special native plants on the roof are watered by hand as required in summer.

Living Roof Construction:
Built-in-place living roof system but edges of the roof were grown as modular trays, and these were flipped out to provide instant cover

Roof Structure:
Wood 190x45mm rafters at a maximum of 480mm centres; extra rafters were added and little additional cost as the spans are short.

Slope of Roof:
3 degrees

Roof Access:
Limited for maintenance

Climate Evaluation:
Variable sun due to shading from main house and adjacent buildings at different times of the day; quite protected from wind.

Site Considerations:
Matching plants to shade and substrate depth

Size:
$39m^2$

Completion:
August 2016 but ongoing as the centre of the roof is being transitioned from wildflowers to permanent vegetation

Blending beauty and function

Living roofs are simple in their concept – you need to be able to keep plants and soil on the roof and allow excess water to be drained off. For a new build living roof, the project brief or drivers and aspirations, whether it be vegetation, recreation space, biodiversity or public access, are the key considerations that determine the finished outcome and then inform the type of plants, loading requirements and materials used.

Green wall
Photo Renée Davies.

DESIGN CONSIDERATIONS

KA HURITAO KI NGA HOAHOA

DESIGN CONSIDERATIONS

Living Urbanism

The role of green technology interventions within the built environment in general (such as living roofs and walls) start to redefine the human role in integrating life processes into future city landscapes. In particular exploring how our indigenous flora and fauna can play a part in these life processes – thus protecting and enhancing indigenous biodiversity resilience and sustainability in our cities.

Living Urbanism is the sensory connection of humans with the built environment and nature.

Living roofs blend beauty and function. The multifaceted outcomes delivered by living roofs not only address non-human life within the city, but extend to engagement with human processes. This co-facilitation leads to a more resilient city providing for the inherent adaptability of city residents, both human and non-human in a changing world.

Currently, most living roof designs do not consider the roof space as an extension to the landscape, urban fabric, community

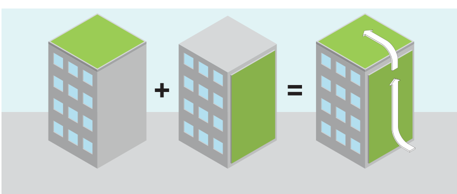


Figure 15: Connection of ground plane to living wall and living roof

and nature. Living urbanism is a concept developed to address this. It is comprised of a set of design principles that reflect the sensory connection of humans with the built environment and nature in order to help design green infrastructure that maximises benefits. It is concerned with creating spaces that connect the urban fabric to people and to nature – creating spaces that are healthy and enjoyable to live, work and play in. In this context, living urbanism is defined as the sensory connection of humans with the built environment and nature.

Living urbanism design-led principles, as illustrated in Figure 16, have been established to help better integrate living roofs into our urban landscapes to maximise benefits. The key principles, drawn from urban design, are permeability, legibility, concentration, diversity, sustainability, identity, accessibility, and robustness.

Identity allows beauty and local stories to be embedded into design for the benefit of the urban dweller.

Permeability is the ability to move unrestricted through a space and provide connection between the living (human and non-human) and non-living.

Legibility of a living roof relates to the layout of the space, how the living roof relates to the built form, surrounding open space, paths, barriers, landmarks, and edges, which all work together to create an understandable 'place'. The design of path locations and connections to the edges of the building can inform how users relate to the wider landscape, and how they connect, at height, to the broader built environment and landscape.

Concentration and dispersal of the living and nonliving link to many realised benefits with living roofs. These include improved health and wellbeing, by enabling activities within walking distance, and protection of a landscape and environmental features, to connect people with nature. Exposure to vegetation is known to have positive e ects on people's feelings of wellbeing, stress levels, health inequalities, anxiety, tension, and postoperative recovery time.

Sustainability benefits are far-reaching, with one benefit being the reduction in heating and cooling bills. Diversity on living roofs relates to a mix of plant species, creating spaces and landscapes that enhance the local areas biodiversity, providing food for insects, birds and humans. This creates benefits for the community with mixed use built forms, providing amenities to live, work and play within walking distance.

Diversity in the green space provided on living roofs achieves this benefit, creating interstitial spaces for food production, recreation, biophilia, and amenity . This principle also relates to the provision of diverse natural elements, incorporation of a mixed species list to avoid monocultures, and use of logs and clay banks for dierent species and habitat creation.
Robustness considerations for a living roof relates to maintenance across changes in building ownership and activity use. As such, designing living roof spaces that provide for a wide range of uses, are resilient, and allow adaptation over time, as things change, is beneficial to the eciency of the living roof.

Accessibility of a living roof is concerned with creating a safe and accessible place for all. This is important when considering universal accessibility, or access to the living roof in the event of a fire. When designing a living roof, the access to and from the roof is important and this translates into plant selection and irrigation when considering the types of plants alongside fire escape paths. Several forms of access to the roof are available, including ramps and stairs.

Identity benefits are extremely important for areas, where living roofs can create of a sense of place and belonging that reflects the character of the space and its inhabitants (both human and non-human), reflecting indigeneity, cultural and natural narratives, which all assist in place-making.

Living Urbanism assists urban designers, architects, planners and developers with creating places where people, nature and the economy thrive. It is a toolkit that helps you explore all of the benefits that could be incorporated into your design.

Below: Living facade in Parnell, Auckland.
Photo Sam Hendrikse

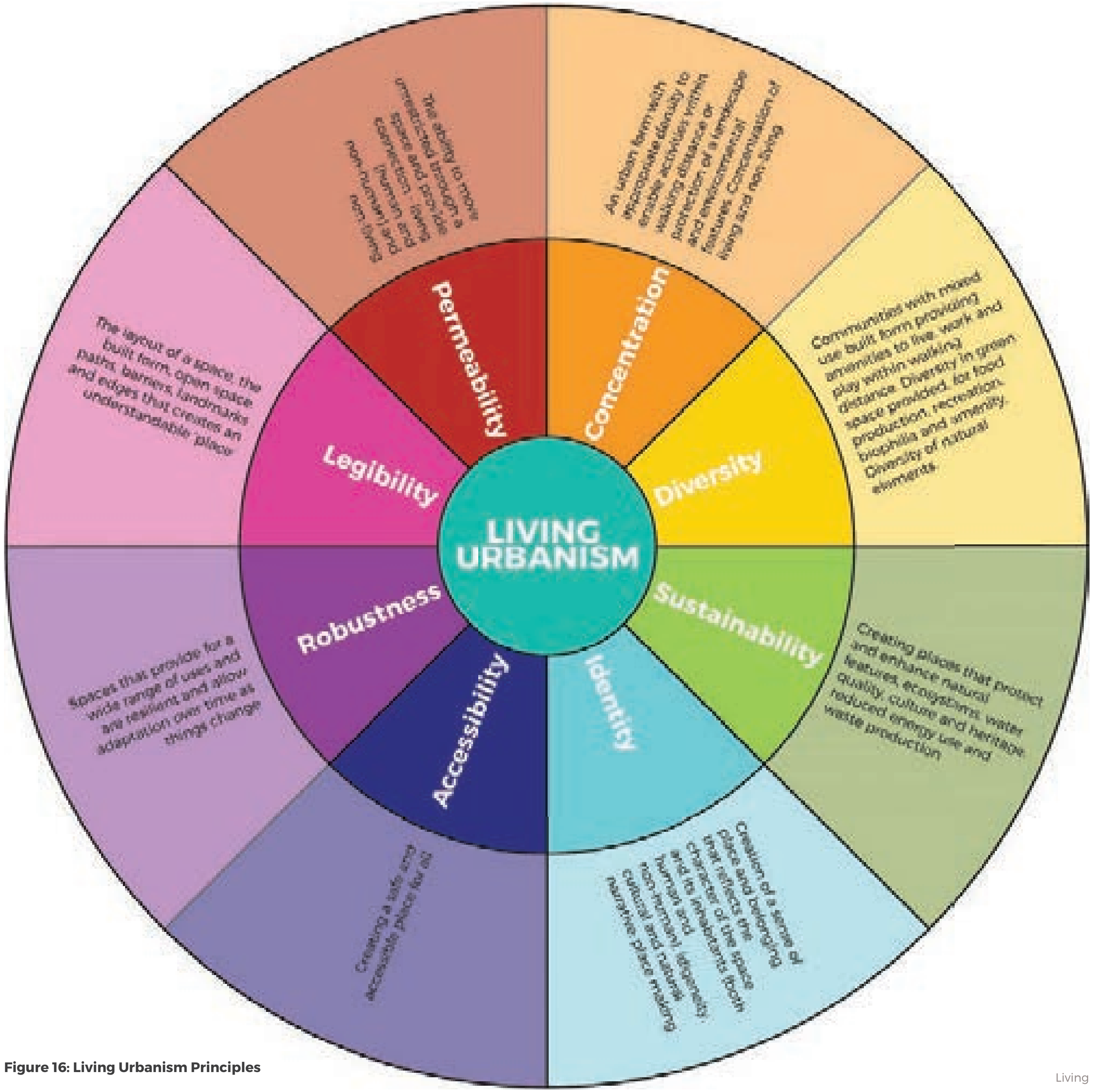


Figure 16: Living Urbanism Principles

Living Urbanism Benefit	Economic	Environmental	Social
Increased employment from local food production	✓		✓
Reduction in transportation of food with associated air pollution, greenhouse gases, traffic, etc	✓	✓	✓
Reduction in the frequency of combined sewer overflow events	✓	✓	✓
Reduction in the frequency of flooding	✓	✓	✓
Reduce stormwater runoff	✓	✓	
Improved markets for recycling plastics - reuse of waste materials	✓	✓	
Improved markets for compost and recycled aggregates - reuse of waste materials	✓	✓	
Lower energy in overall system	✓	✓	
Improved thermal performance - insulatating and cooling	✓		✓
Reduced patient care costs in health facilities	✓		
Replacement cost savings on public buildings	✓		
Increase in life expectancy of pipes and other grey infrastructure	✓		
Reduction in costs of erosion control	✓		
Increase in property values with a corresponding return in property taxes to the city	✓		
Increase in employment from design, manufacture, installation, maintenance and new uses	✓		✓
May assist planning process	✓	✓	✓
Extended roof life	✓		
Improved whole life cost of building	✓	✓	
Complement photovoltaic panels	✓	✓	
Reduction in associated health care costs from improving air quality and reducing heat	✓		
Contribution to savings on power plants and transmission infrastructure	✓		
Energy savings in building and resulting greenhouse gas emission reduction	✓	✓	
Reduce water storage requirements and drainage infrastructure on site	✓		
Increased amenity	✓	✓	✓
Increased recreational space and opportunities, such as bird watching	✓	✓	✓
Improved human health (physical and mental)	✓	✓	✓
Improvements to work environments/workplace productivity	✓		✓

Improved vistas	✓		✓
More liveable environment for citizens and less heat related stress			✓
Sound insulation - less noise entering and leaving buildings	✓		✓
Biophilically satisfying noises (like wind rushing through grass)			✓
Cooler more enjoyable streets and public space			✓
Healthier and more productive population	✓		✓
Less crime and associated policing, judicial and incarceration related expenses	✓		✓
Increasing community cohesion	✓		✓
Increase in walking, cycling, gardening and running			✓
Beautifying unattractive building features			✓
Opportunities for artistic expression			✓
Educational/Urban nature experiences	✓	✓	✓
Improved biophilia and therapeutic value of additional natural space		✓	✓
Greater food security	✓		✓
Improved biodiversity		✓	
Improved water quality		✓	
Receiving waters become more fishable, swimmable, drinkable		✓	✓
Greenhouse gas emission reductions		✓	✓
Less smog formation		✓	✓
Reduction in particulate matter in the air		✓	✓
Plants and growing media can sequester carbon		✓	
Provide a habitat for wildlife		✓	
Contribute to reducing climate change effects	✓	✓	✓
Contribute to reducing Urban Heat Island effect	✓	✓	✓
Reduction in landfill waste	✓	✓	
Pollination by insects, particularly bees		✓	
Increased environmental building rating score	✓	✓	

DESIGN CONSIDERATIONS

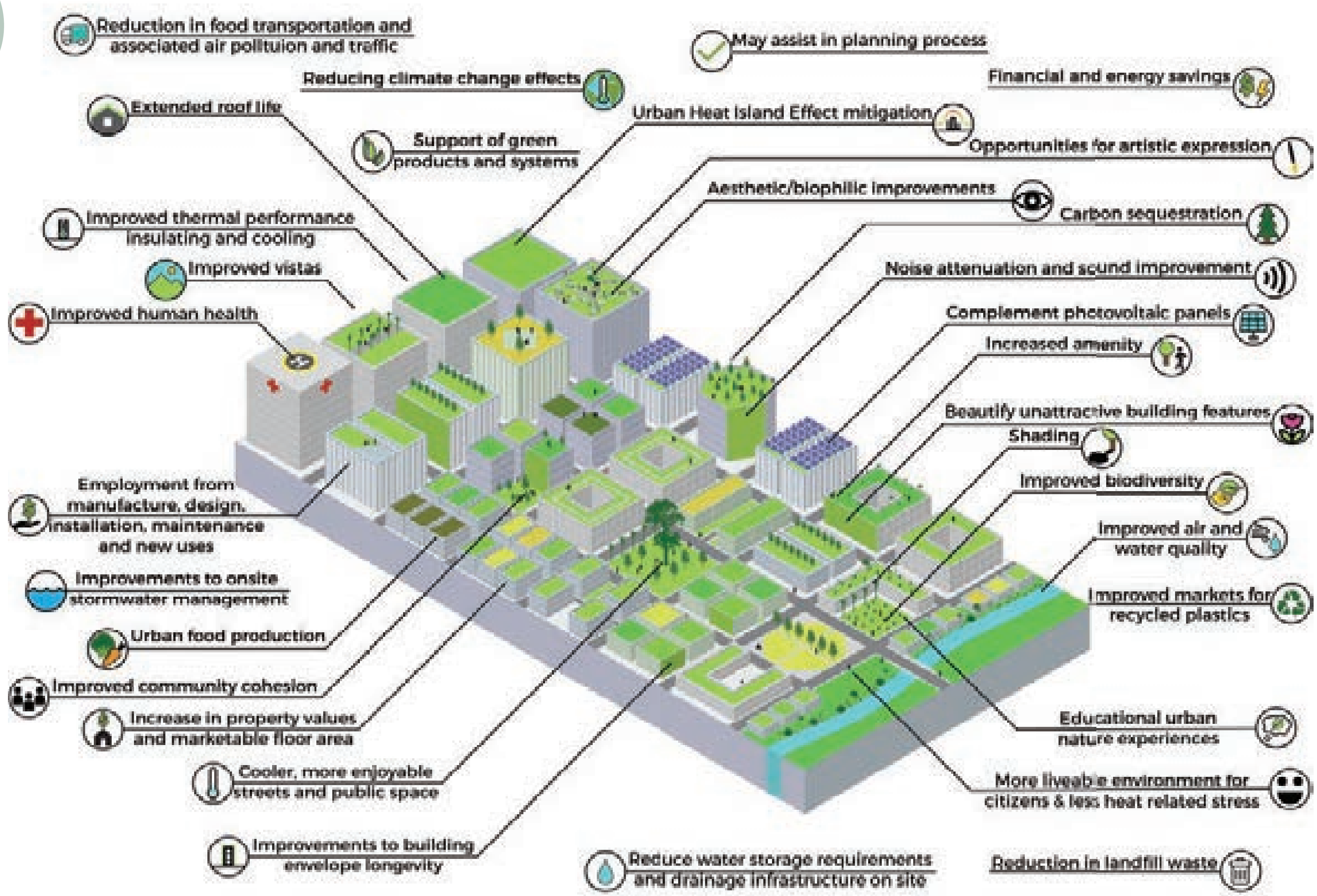


Figure 17: Benefits of the Living Urbanism City

Hundertwasser Museum, Vienna, Austria
Photo Zoë Avery

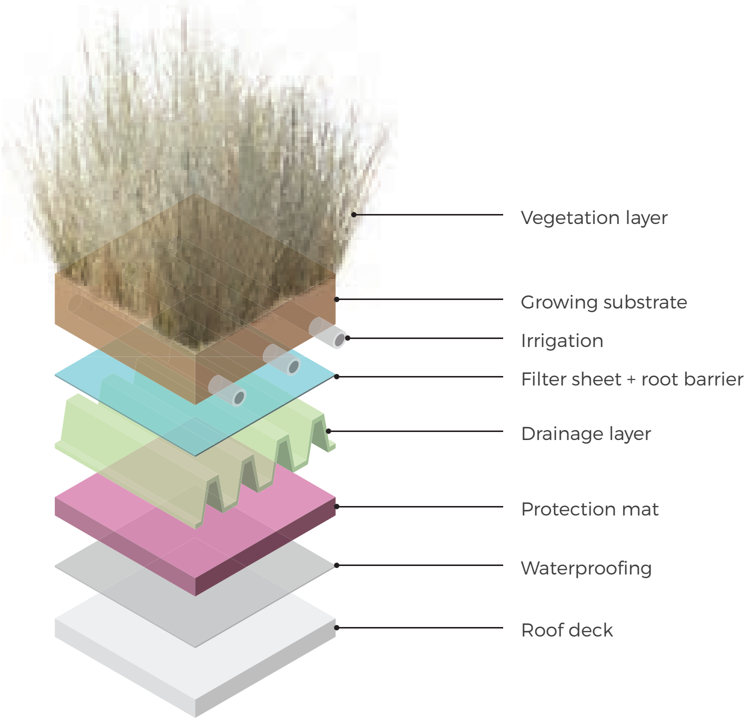
DESIGN CONSIDERATIONS

Living Roof Design

With a retrofit living roof project, the ability of the roof to support the weight of the system components is the first consideration to ensure the structure does not collapse (the level of detail for this is reduced depending on the scale and type of structure on which the living roof is being located). If you have a stronger roof base then you can achieve a deeper substrate and grow a wider variety of plants.

The ideal scenario for a living roof design is to work from an initial design brief, project drivers and aspirations, then undertake a site analysis to determine the most appropriate environmental and social considerations (the living urbanism choices) - then work from this to determine the structural loading and infrastructure components required to support the chosen approach.

Figure 18: The components of a living roof



Right: Lavender thriving on the living roof on the Offices of Allen & Overy LLP, London.
Photo Zoë Avery.

Self seeded orchids a nice surprise

A phenomenon that has been encountered on many NZ living roofs is the natural arrival of a small NZ native perennial grass orchid *Microtis parviflora*. These orchids appear to love the conditions of living roofs and pop up amongst the existing vegetation (both exotic and native). Orchid seeds are microscopic and find their way to the roofs on the wind. Although a common orchid, it is normally hidden from sight – on living roofs it stands out and is quite impressive.

NZ native orchid *Winika cunninghamii* on green a wall
Photo Renée Davies

DESIGN CONSIDERATIONS

Living Urbanism Design

Creating the Design Brief
The principal design objectives, project aspirations or reasons for incorporating a living roof, wall or facade need to be identified at the beginning. The design brief informs the planning, design, construction and ongoing maintenance. The design aesthetic and anticipated benefits need to be understood to deliver a living roof which meets the client's anticipated aspirations.

If a brief is for native vegetation and recreational access, this then informs the plant palette, depth of substrate and access options. This design may not be suitable for a person who wants a low maintenance, low cost, light-weight living roof retrofit.

What are the Design Objectives:

- Increase in Property Values
- Financial Savings/Energy Savings
- Aesthetic/Biophilic Improvements
- Improvements to Building Envelope Longevity
- Shading/Integration with Photovoltaic Panels (solar panels)
- Improvements to Onsite Stormwater Management
- Noise Attenuation and Sound Improvement
- Improved Biodiversity
- Food Production
- Urban Heat Island Mitigation
- Carbon Sequestration
- Reducing Climate Change Effects
- Improved Air and Water Quality
- Improved Human Health
- Support of Green Products and Systems
- Support Emerging Manufacture, Design, Installation, Maintenance and New Uses

When taking a living urbanism approach it is important to note that the living roof, wall or facade will form part of the wider landscape, environment, community and essentially create a 'sense of place' in the built form. As such, it is good to assess surrounding uses, views, aspect, street trees, parks and planting.

Worldwide research continues to confirm that living roofs provide both urban habitat and social benefits alongside a range of ecosystem services within the predominantly hard surfaces of our urban environments.

In New Zealand rooftops are an underutilised asset that can assist with climate change adaptation and improved amenity in our urban and rural areas if the appropriate features are incorporated into the roof design process.

There is a palette of tested design interventions and approaches that provide options to increase the benefits of a living roof. Any combination and mix of the components from this palette can be used depending on the drivers for the project and desired functional and aesthetic outcomes.

DESIGN CONSIDERATIONS

Living Urbanism Palette

Environmental

Clay banks - habitat for native solitary bees

Logs and dead wood – insect habitat

Water and/or boggy areas

Mounds

Rubble mounds

Scree/rock areas

Shell/gravel beds

Bird and bee attracters

Diversity of plant form and shape

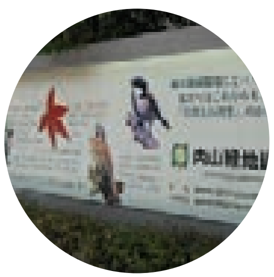
Economic

Photovoltaic panels

Solar hot water panels

Beehives

Social



Interpretive signage/ education

Playgrounds/ recreational space

Permeable walkways

Seating areas

Access over vegetation

Views to roof

DESIGN CONSIDERATIONS

Insect habitat

Invertebrate diversity on a NZ native living roof can provide the required array of prey species for skinks. Invertebrate biodiversity potential on NZ living roofs differs from Europe and America due to our non-flying native invertebrates. Native vegetated living roofs provide temperature variables similar to terrestrial environments. Humidity (and lack of) is the main difference compared with terrestrial situations and therefore the main constraint to biodiversity on a NZ living roof.

Habitat

Living roofs are an artificial environment that allow for manipulation of both the range and type of microtopography, materials, and vegetation diversity in order to transform into an elevated habitat that provides ecosystem services.

Natural analogs of living roofs (such as cliffs, scree slopes, riverbeds, coastal rock outcrops and dunes), provide inspiration and guidance to the types of vegetation communities and natural features that will improve habitat outcomes for a roof.

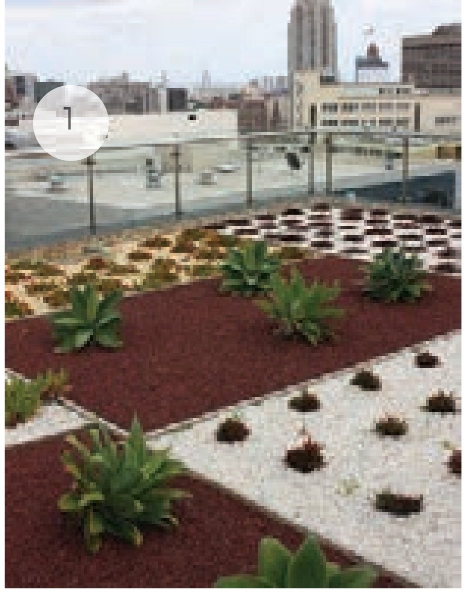
This is particularly relevant to the New Zealand situation, where our environmental and ecological conditions vary considerably from other countries where most living roof research has been carried out.

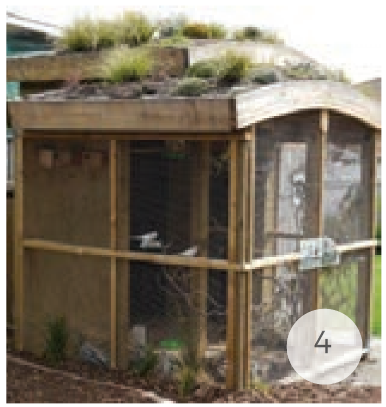
The range of plants found in these ecosystem types are adapted to shallow substrates and extreme temperature and moisture conditions - which are similar characteristics of extensive and intensive living roofs.

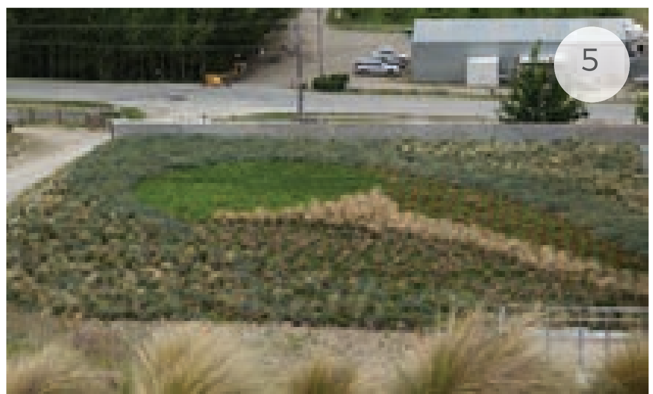
Right: Bere House, Islington, London
Photo Dusty Gedge

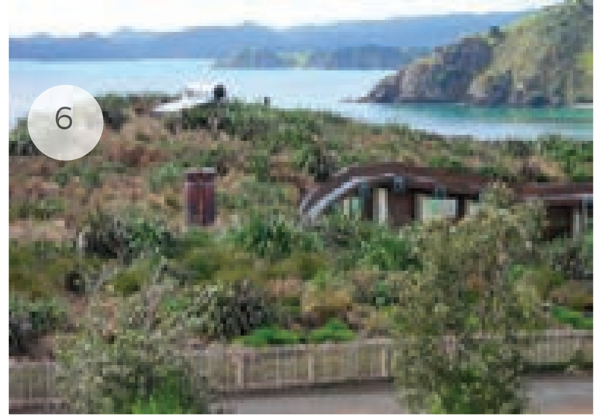
LIVING ROOF INSPIRATION

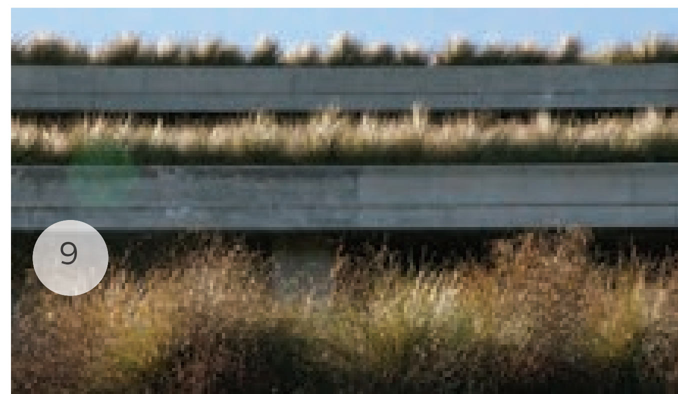
1. Modernist patterns - Sydney
2. Access stairs on steep roof - Copenhagen
3. Quirky approach - Colonia, Uruguay
4. NZ native roof on aviary - Southland
5. Mount Difficulty Vineyard extensive modular living roof - Cromwell
6. NZ native eco-roof - Northland
7. Mass planted *Xeronema* - Auckland Zoo
8. Apartment block - Torino, Italy
9. Mahana Estate Winery - Nelson
10. Buckleton Beach living roof - Matakana











LIVING WALL INSPIRATION

11. Apartment building - Shanghai
12. Restaurant sign - Torino, Italy
13. Commercial plaza - Sydney
14. Public park - Shanghai
15. NZ natural green wall on clay bank
16. Medical centre - Nelson
17. NZ residential - North Auckland
18. Wire facade - Colonia, Uruguay
19. NZ coastal residential - Auckland
20. Commercial cafe - Auckland
21. *Philodendron scandens* living facade at NZI building - Auckland.
22. Climbers on apartments - Copenhagen
23. Wire facade with NZ natives - Auckland

Example of living roof in full shade - that allows for a unique mix of native plants
Photo Zoë Avery

Site Analysis

Site analysis is the preliminary phase of the living roof design process. It includes the study of climatic conditions, structural loading, geographical, access, drainage, irrigation, and infrastructural context of a specific site. Understanding the site characteristics is important for retrofit and new build living roof, wall or facade developments as these elements impact design, cost and outcomes desired.

Climatic Conditions

Climatic conditions vary from site to site depending on the geographic location as well as surrounding topography, aspect, height of building and surrounding buildings. Understanding the high and low temperatures, wind, sun, shade and rainfall will inform the plant selection and design of the living roof or wall.

Sun

When assessing a site for sun it is important to consider the time during the day that the living roof or wall receives sunlight; the sun's path at different times of the day and year; how the living roof or living wall's shape, slope and orientation affect solar access; any obstructions such as parapets, adjacent buildings, trees and landforms will impact on the living roof or wall; and the users' of the space, whether they want to have sun or shade at certain times of the day for maximum enjoyment of the space.

The effect of sun on the living roof or wall is a key factor in determining which plants will be appropriate for the different sites.

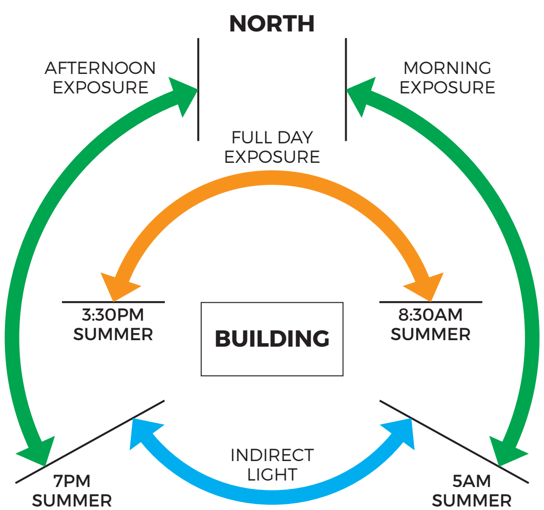


Figure 19: Solar orientation of a living roof

Rainfall
Whāngārei averages 1500mm of rainfall annually. However, Whāngārei's rainfall is generally not sufficient to support a living roof, wall or facade throughout the year and irrigation needs to be considered for hot and drought stricken summer periods.

Irrigation is determined by the type of plants chosen. Consideration of use of water from other areas on site, storage and reuse or whether potable water would be required for irrigation.

Wind
The effect of wind load needs to be considered as it relates to the living roof, wall or facade. Wind speeds are generally higher at roof level than at ground level.

Wind can also be stronger around the building corners. Tall buildings can also cause a downdraft and updraft effect where air hits a building and is pushed up, down and around the sides. Air forced downwards increases wind speed at street level.

The more buildings, the more complex the wind patterns are. The stronger the wind the greater the evaporation (dehydrating) effects will be resulting in higher irrigation requirements.

Temperature
Whāngārei's climate and temperate is fairly warm, with an average annual temperature of 15.7˚C. In the urban environment it is important to note that commonly temperatures increase with elevation from an increase in the thermal mass from the city's built form.

It is important to assess the sites potential temperature range, including taking into account recent extremes. This will not only impact plants chosen, but planting design and locations.

Microclimate
Different spaces on a roof or around a building (i.e. urban canyons) can have their own microclimate where temperatures, humidity and wind can increase. These areas need to be designed with plants and material able to support these local conditions.

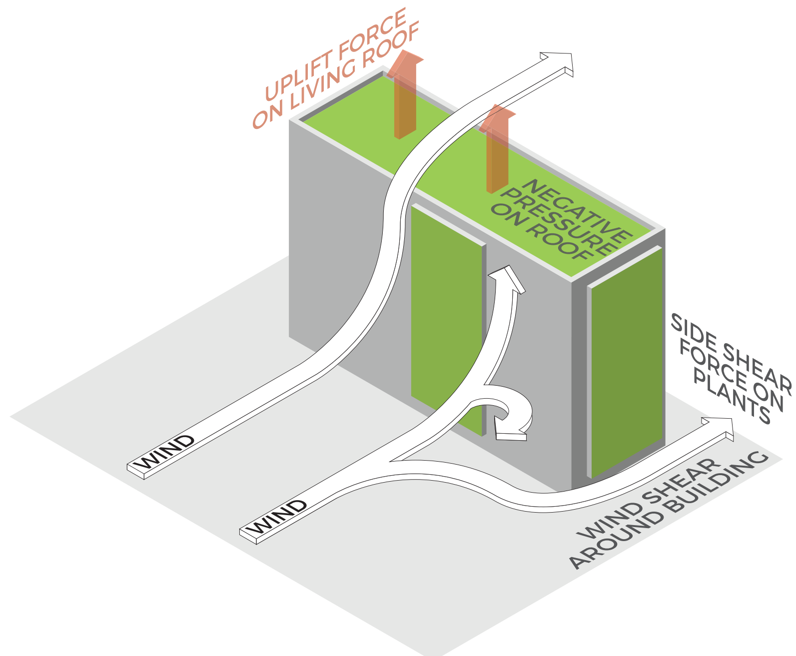


Figure 20: Diagram of wind forces on living buildings

DESIGN CONSIDERATIONS

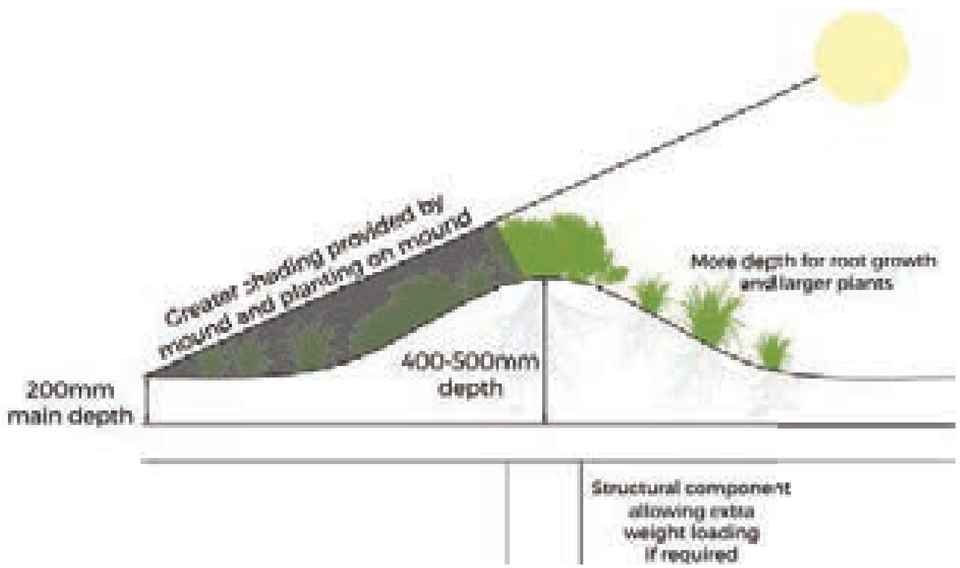


Figure 21: Mound Diagram

Mounds for Microclimate

Where the roof structure allows (such as over support pillars), the addition of small mounds of deeper substrate creates a varied microclimate on the roof, that supports a broader range of plant species and provides vital diversity of habitat such as shaded areas and shelter.

DESIGN CONSIDERATIONS

Structural loading

The structural loading of a living roof needs to be considered at the design stage. It is worth noting that many flat roof structures with ballast or paving slabs, may be able to be replaced with an extensive living roof system with no structural loading implications.

Early engagement with a structural engineer for advice on the existing or proposed buildings structural loading capacity is required. When retrofitting a living roof, wall or facade it is essential for costings and design process to understand whether the building will need to be modified. The structural engineer will need to consider the weight of plants at maturity, saturated plants and substrate.

They will consider the dead load being the constructed roof, wall or facade with maximum saturation; the live load being the weight of people using the space; and the transient load, being short term loads of wind and seismic activity.

The table below details the saturated weights of different green roofs and landscape elements:

Indicative Structural Loading for Various Types of Roof

Roof type	Loading
Gravel surface	90-150 kg/m²
Paving slabs	160-220 kg/m²
Vehicle surface	From 550 kg/m²
Extensive green roof (sedum mat)	60-150 kg/m²
Extensive green roof (substrate based)	80-150 kg/m²
Intensive green roof	200-500 kg/m²

Note: loads are fully saturated
Source: Living Roofs and Walls, Technical Report: Supporting London Plan Policy, Greater London Authority, 2008

Living Roof Vegetation Weight Loadings

Green roof vegetation type	Weight loading (kg/m²)
Low herbaceous (succulents and grasses)	10.2
Perennials and low shrubs up to 1.5m	10.2-20.4
Turf	5.1
Shrubs up to 3m	30.6
Small trees up to 6m	40.8
Medium trees up to 10m	61.2
Large trees up to 15m	150

Source: FLL The German green roof design standards - Guidelines for the Planning, Execution and Upkeep of Green Roof Sites (2008)

DESIGN CONSIDERATIONS

Fire

In Germany, buildings with a living roof get a reduction in fire insurance as a living roof system can protect the building from fire.

German FLL guidelines state that the design of a living roof should have, at a minimum, a 500mm shingle perimeter to act as a fire break. There are also guidelines for the percentage of combustible material that is to be incorporated within the living roof substrate.

A perimeter that is vegetation free can also serve as the edging for the retention of substrate also The extent of any vegetation free perimeter will also be guided by the type of vegetation on the living roof – larger woody shrubs and trees have a higher risk than low growing plant species.

These vegetation free areas are also useful adjacent to walls, parapets and any other structures on the roof that are constructed of non fire resistant materials.

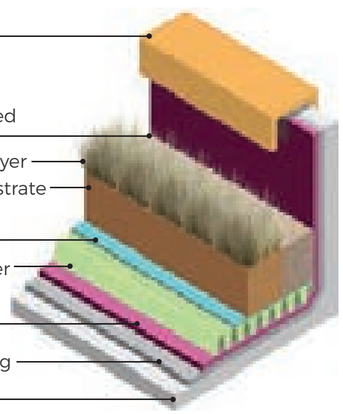


Figure 22: Non-vegetated zone of living roofs

Building Structure, Slope, Drainage and Size

There are a number of building components that need consideration as part of the site analysis process. These include the building design and size, roof slope, drainage features and water collection.

Perform an assessment of the size of useable roof or wall area taking into consideration roof equipment/infrastructure and windows. The condition and quality of the roof and wall materials, existing or proposed waterproofing, and the slopes or angles of the roof and wall being covered also need to be taken into consideration.

Living roofs are easiest to design and build on slopes less than 15 degrees. They can be built on steeper slopes but this requires additional design consideration and materials to hold the soil and plants in place.

Does the roof have positive drainage, as ponding on the roof can cause problems for the plants and add to the structural loading? What type of drainage is proposed? Where are the stormwater discharge points? Are overflow drains required in the case of severe weather?

Water storage, collection and use needs to be assessed for living roofs and walls as well. Water reuse tanks can service both irrigation and toilet flushing. As such, consideration of water use and collection early in the design stage is important.

Musée du Quai Branly, Paris, France
Photo Zoë Avery

DESIGN CONSIDERATIONS

Access

Physical access onto the roof or to the green wall needs to be carefully assessed at the site analysis stage. Permanent access by users for recreational or private open space living roofs will need to consider safety requirements, access points, viewing points, seating, paths and balustrades.

Temporary installation access for machinery and delivery of and storage of materials during the construction period also needs to be considered in the design phase. This can include scissor lifts, cranes, trucks and substrate blower.

Assessment of how users will access the living roof during the build period, maintenance and use by stairs, lifts and viewing platforms is necessary. Safety, working at heights or fall protection once on the roof needs to be allowed for within the design of the roof with either balustrades, clip points, cables and ladders.

Living walls or facades can usually provide for this type of requirement at ground level allowing space and access for scissor lifts or similar.

Living Roof Design

The design stage is the most critical part of creating a successful living roof as it informs whether the project drivers are met, how easy it will be to build and maintain, the cost, use and enjoyment.

The scale of the living roof, wall or facade will inform the level of planning, detailed design and expert input required. Following the site analysis the design stage considers the project drivers, brief or aspirations; budget; maintenance; and all of the core elements of a living roof system.

There are some core elements of a living roof system that all projects require for success and then beyond this components that are optional depending on the type of outcomes desired for the living roof.

Essential components:

- Vegetation
- Substrate
- Root barrier
- Filter layer
- Drainage layer
- Waterproof layer
- Structural roof deck

Optional components:

- Access features such as walkways
- Railings
- Lighting
- Ecological features
- Irrigation
- Erosion protection layer
- Water retention layer
- Membrane protection layer
- Leak detection device
- Insulation

Access features such as walkways

All living roofs require some form of access to be accommodated within the design. This might be for maintenance, or for human use. If a living roof is to be used either in part or fully, by residents or visitors to the building, then accessibility on the roof must meet all the building code requirements. Generally, design in these instances will require balustrades or guardrails, lighting, fire safety, disability access, seating and signage.

Paths can either be paved, aggregate or structural elements elevated over plantings such as raised aluminium grates over plantings. Aluminium grated paths are considered to provide dappled shade and shelter, reducing substrate temperature and evapotranspiration This is considered to provide longer-term moisture supply for plants and shading should be considered when selecting plants for these areas.

DESIGN CONSIDERATIONS

Success with native plants

NZ native plants can be used and survive on extensive/semi-intensive living roofs. Documented living roofs include 71 different native plant species used. Some key success factors for NZ native plants on living roofs include:

- Summer drought irrigation increases the survival and growth of NZ native plants on living roofs.
- Soil depth (over 150mm and ideally 150-200mm) increases the growth and success of NZ native plants on living roofs.

Vegetation

The vegetation choices for a living roof in NZ include both exotic and native plant species. The choice of plant is influenced by the type of living roof (and conditions the plant will be required to adapt to) and the aesthetic and ecological outcomes desired for the roof.

The plant options outlined in this guide are provided from both known NZ examples of living roofs and overseas roofs. It is not practicable to list every plant that might be suitable, but a selection of species that are most likely to be appropriate to the Whāngārei area or considered worthy of trying, have been included.

Plants have been grouped under main plant categories:

- Succulents
- Groundcovers
- Grasses, Sedges, Rushes
- Small Ferns
- Herbaceous
- Shrubs
- Trees
- Climbers & Vines

Why use Native Plants?
Many of our native plants and animals are endemic – that is, found nowhere else in the world. The level of endemism among NZ plants and animals is one of the highest in the world. We have 2,500 native species of conifers, flowering plants, and ferns; and 80% are endemic. Our evergreen forests are among the most ancient and unique in the world and have evolved over millions of years with lineage dating back 100 million years. Many of our birds, animals, fish, insects and fungi are also endemic.

About 1–15% of the total land area of NZ is covered with native flora, from tall kauri and kohekohe forests to rainforest dominated by rimu, beech, tawa, mataī and rātā; ferns and flax; dunelands with their spinifex and pīngao; alpine and sub-alpine herb fields; and scrub and tussock.

But it's not just about the scientific facts. NZ's flora and fauna provides the predominant genius locii of our place where Māori believe that man and plants have a common origin. Māori saw plants as having senior status, Tane created them before mankind, and they were therefore respected as older relatives. They are the link between man and sacred ancestors, Papatūānuku and Ranginui. So there is a strong cultural and spiritual imperative to ensure the use of native plants in our built environments.

In NZ the expansion of the urban palette of biodiversity to living roofs and walls by referencing our unique and adaptable natural ecosystems and using native plants and local substrate mixes, will build biodiversity and the inherent efficiency and contributions these systems have to the ecosystem of the city.

Selection of plant options for a living roof are derived by looking at plants that are adapted to the types of conditions that are found on a living roof.

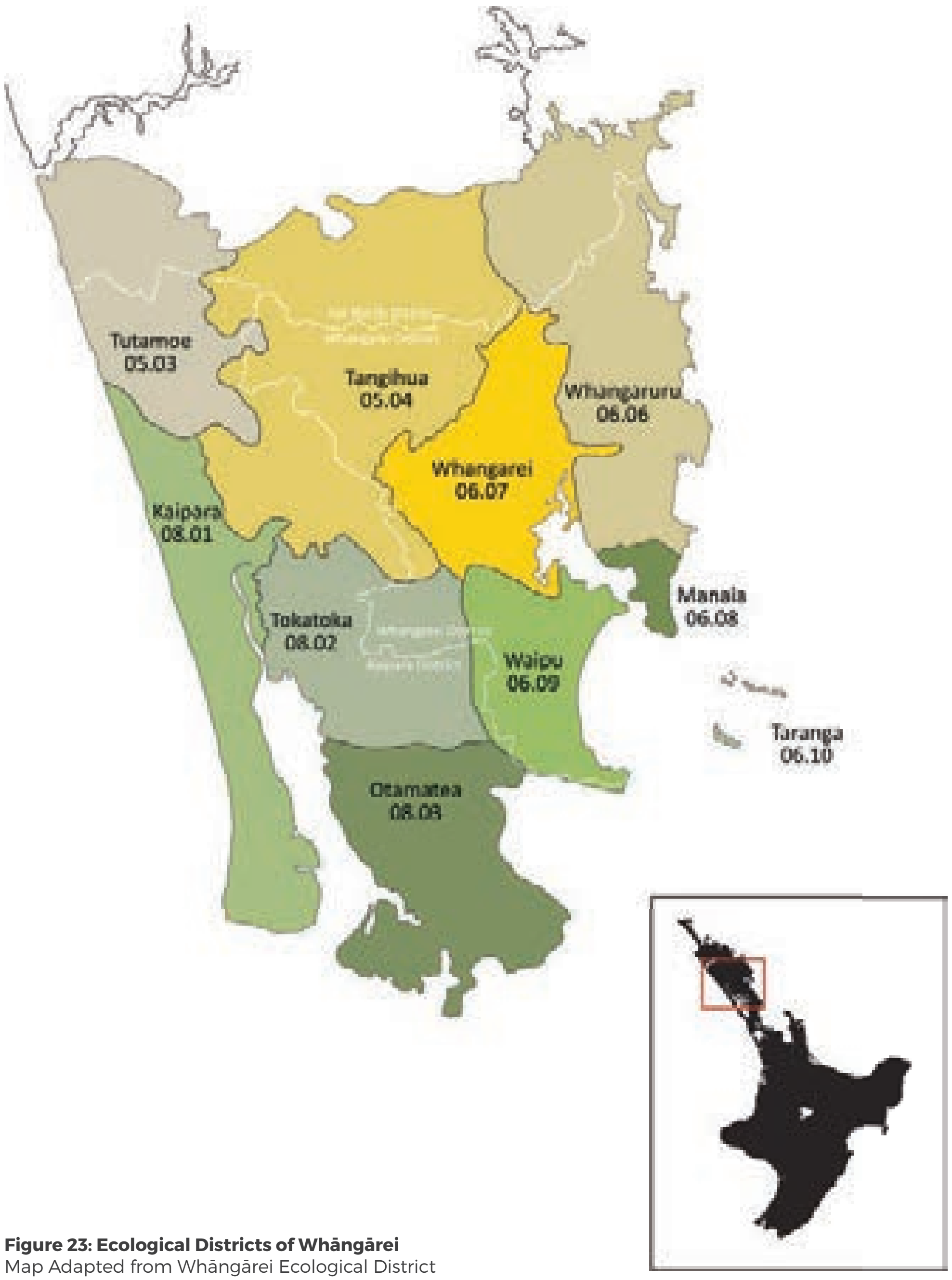


Figure 23: Ecological Districts of Whāngārei
Map Adapted from Whāngārei Ecological District Report by Department of Conservation (2001)

Whāngārei Ecological District

The topography of the Whāngārei District is complex with a varied landscape of predominantly low hills, indented coastlines and numerous islands close to the shore.

The climate is warm and humid with mild winters and an average annual rainfall of 1500-2400mm. Summer droughts occur as do occasional tropical storms from the north east and north.

Soils are predominantly clay, strongly leaches and generally acidic. There are some areas of volcanic loam soils.

The original vegetation of the District is mainly kauri-dominated, species-rich forest. There are large areas of towai shrubland and *Leptospermum* scrub, dense kauri and podocarp regeneration (tōtara, kahikatea, rimu) and coastal forest remnants dominated by pūriri and pōhutukawa.

Within and around the Whāngārei District boundary there are a number of ecological regions and districts represented. These include:

- Western Northland
- Maungataniwha
- Hokianga
- Tutamoe
- Tangihua
- Eastern Northland
- Eastern Northland and islands
- Tāranga
- Otamatea
- Whāngārei
- Waipū
- Manaia
- Whangaruru
- Poor Knights
- Kaipara

DESIGN CONSIDERATIONS

Offshore Island Plant Options

Whāngārei and its nearby offshore island neighbours have a range of threatened plant species that would be a great option to explore for local living roof environments. Not only because they're beautiful and uniquely adapted to harsh conditions - but also because their use would assist in the preservation of these special treasures.

Plants that are worth trying include:

- *Alectryon grandis* (Three Kings Titoki)
- *Carmichaelia williamsii* (giant flowering broom)
- Chinochloa bromoides
- *Colensoa physalioides* (koru)
- *Coprosma neglecta* (Maunganui Bluff)
- *Coprosma repens* 'Poor knights' (Poor Knights coprosma)
- *Dianella latisama* (Waimea dianella)
- Elingamita johnsonii
- Hebe adamsii
- *Hebe brevifolia* (prostrate form)
- *Hebe diosmifolia* 'Wairua beauty'
- Hebe parviflora
- Hibiscus diversifolius
- Hibiscus richardsonii
- Lipidium oleraceum
- Macropiper mechior
- Macropiper psittacorum
- Myoporum decumbens
- *Myrsine aquillina* 'Poor knights'
- Nestegis apelata
- Pennantia baylisiana
- Phebalium nudum
- Pimelea tomentosa
- Pittosporum cornifolium
- *Pittosporum fairchildii* (Three Kings karo)
- *Pittosporum obcordatum* (Kōhūhū)
- Pomaderris prunifolia var edgerleyi
- *Scleranthus biflorus* 'Tutukaka'
- *Streblus banksii* (Coastal milk tree)
- Streblus smithii
- Tecomanthe speciosa
- Xeronema callistemon

How to Use Plant Lists:

The following plant lists are suggestions for a range of either native or exotic species that have been grown on living roofs in NZ. The table can be used to help filter plant choices depending on the outcomes needed from the living roof.

As living roofs are in their infancy in NZ, the table is based on known species that have been used on living roofs in this country. There are new species being trialled all the time and new information coming from projects across NZ, so the table should be viewed as a working document.

- If you want to use plants specific to the Whāngārei ecological district, then restrict your search to plants with that column ticked in the table.
- If your focus is providing bird or insect food then focus on those plants identified to provide ecosystem services.
- You might want to only have threatened plants on your roof or a particular form or plant such as all low growing or a mix of textures and forms.
- If you want a particular colour palette, then looking at the characteristics of leaf and flower colour will assist.

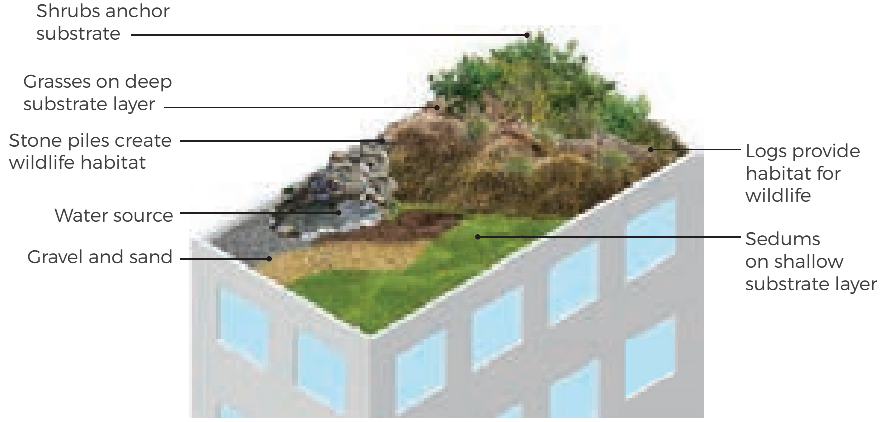
The table also identifies the type of roof conditions best suited to the particular plant species (ie. level of sun and shade). The table outlines if irrigation is required and also the recommended minimum substrate depth.

To assist with choosing plants depending on the look wanted for a living roof, there is a general guide to leaf, flower and or berry colour. The form of a plant will make a big difference to the look of a living roof, so the guide outlines the form of the plant.

If there is a particular interest in providing food for birds, insects or lizards then the table indicates if a plant provides ecosystem services for those fauna species.

The success ranking indicates what we know, based on existing living roofs in NZ, of the relative success of the plant species listed (these range from unknown, excellent to poor).

Figure 24: The components of a biodiverse living roof



Native Plant Selection

KEY: Fully tolerant | Tolerates some | Not tolerant | Mounded or spreading | Oval | Spiky | Prostrate | Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Succulents		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/ or lizard food	**Success ranking**
Crassula sieberiana		Fully tolerant	Tolerates some	50-150	✓	Green	Pink	Prostrate	Not threatened	Varied	✓			**2**
Disphyma australe	Horokaka, NZ Ice Plant	Fully tolerant	Not tolerant	150-500	✓	Green	Pink	Prostrate	Not threatened	Coastal	✓		✓	**4**
Groundcovers														
Acaena microphylla	Piripiri	Tolerates some	Fully tolerant	150-500	✓	Green	Red	Prostrate	Not threatened	Bush edge	✓		✓	**3**
Anaphalioides bellidioides	Everlasting Flower	Fully tolerant	Tolerates some	150-500	✓	Green	White	Prostrate	Not threatened	Montane			✓	**0**
Calystegia soldanella	Rauparaha	Fully tolerant	Tolerates some	150-500	✓	Green	Pink	Mounded or spreading	Not threatened	Coastal	✓*		✓	**3**
Centella uniflora		Fully tolerant	Fully tolerant	150-500	✓	Green	Red	Prostrate	Not threatened	Varied				**3**
Coprosma acerosa	Tātaraheke	Fully tolerant	Tolerates some	150-500	✓	Orange	White	Mounded or spreading	At risk	Coastal	✓*		✓	**1**
Coprosma brunnea		Fully tolerant	Tolerates some	150-500	✓	Orange	Blue	Mounded or spreading	Not threatened	Inland rocky areas			✓	**0**
Coprosma acerosa f. mangatangi	Coprosma mangatangi	Fully tolerant	Tolerates some	150-500	✓	Orange	Red	Mounded or spreading	Not threatened	Bush edge			✓	**0**
Dichondra brevifolia	Mercury Bay Weed	Tolerates some	Fully tolerant	150-500	✓	Green	White	Prostrate	Not threatened	Coastal	✓*			**2**
Dichondra repens	Mercury Bay Weed	Tolerates some	Fully tolerant	150-500	✓	Green	White	Prostrate	Not threatened	Coastal	✓*			**2**
Fuchsia procumbens	Creeping fuchsia	Tolerates some	Fully tolerant	150-500	✓	Green	Red	Prostrate	At risk – naturally uncommon	Coastal	✓		✓	**3**
Leptinella dioica	Bachelors Buttons	Fully tolerant	Fully tolerant	150-500	✓	Green	Yellow	Prostrate	Not threatened	Coastal			✓	**2**
Lobelia anceps	Shore lobelia	Fully tolerant	Fully tolerant	150-500	✓	Green	White	Mounded or spreading	Not threatened	Coastal	✓*		✓	**3**
Muehlenbeckia axillaris	Creeping Pōhuehue	Fully tolerant	Tolerates some	150-500	✓	Green	White	Prostrate	Not threatened	Rocky			✓	**3**

* distribution North Island

Native Plant Selection

KEY: ● Fully tolerant · ◖ Tolerates some · ✗ Not tolerant · Mounded or spreading · Oval · Spiky · Prostrate · Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Groundcovers continued		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/ or lizard food	**Success ranking**
Muehlenbeckia complexa	Pōhuehue	Fully tolerant	Fully tolerant	150-500	✓	Green	White	Mounded or spreading	Not threatened	Coastal			✓	2
Pimelea prostrātā	Pinātoro	Fully tolerant	Tolerates some	150-150	✓	Grey	White	Prostrate	Not threatened	Coastal to montane			✓	1
Raoulia australis	Common Mat Daisy	Fully tolerant	Tolerates some	150-500	✓	Grey	Yellow	Rounded	Not threatened	Montane	✗		✓	3
Leptospermum scoparium	Prostrate Mānuka	Fully tolerant	Tolerates some	150-500	✓	Green	Red	Prostrate	Not threatened	Cultivar			✓	1
Pratia angulata	Panakenake	Tolerates some	Fully tolerant	150-500	✓	Green	White	Prostrate	Not threatened	Coastal/Bush	✓		✓	3
Raoulia hookerii	Scabweed	Fully tolerant	Tolerates some	150-500	✓	Grey	Yellow	Rounded	Not threatened	Montane	✗		✓	3
Raoulia parkii	Celadon Mat Daisy	Fully tolerant	Tolerates some	150-500	✓	Grey	Yellow	Rounded	Not threatened	Montane	✗		✓	3
Samolus repens	Māakoako	Fully tolerant	Tolerates some	150-500	✓	Green	White	Prostrate	Not threatened	Coastal	✓		✓	2
Selliera radicans	Remuremu	Fully tolerant	Fully tolerant	50-150	✓	Green	White	Prostrate	Not threatened	Coastal to alpine	✓*			3
Grasses, sedges & rushes														
Anementhele lessoniana	Hunangamoho	Fully tolerant	Tolerates some	150-500	✓	Green	Yellow	Spiky	At risk – relict	Cliff & Forest				3
Apodasmia similis	Oioi	Fully tolerant	Tolerates some	150-500	✓	Brown	Brown	Spiky	Not threatened	Coastal	✓*		✓	0
Arthropodium cirratum	Rengarenga	Fully tolerant	Tolerates some	150-500	✓	Green	White	Spiky	Not threatened	Coastal rocky	✓		✓	3
Astelia banksii	Wharawhara	Fully tolerant	Fully tolerant	150-500	✓	Green	Yellow	Spiky	Not threatened	Coastal epiphyte	✓		✓	3
Austrostipa stipoides	Buggar Grass	Fully tolerant	Tolerates some	150-500	✓	Grey	Grey	Spiky	Not threatened	Coastal	✓*			
Carex pumila	Sand Sedge	Fully tolerant	Tolerates some	150-500	✓	Green	Green	Spiky	Not threatened	Coastal	✓*			2

distribution North Island *

Native Plant Selection

KEY: ● Fully tolerant · ◐ Tolerates some · ✗ Not tolerant · Mounded or spreading · Oval · Spiky · Prostrate · Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Grasses, sedges & rushes continued		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/ or lizard food	**Success ranking**
Chionochloa rubra	Haumata	●	◐	150-500	✓	Red		Spiky	Not threatened	Montane			✓	3
Festuca actae	Banks Peninsula Fescue	●	◐	150-500	✓	Orange	White	Spiky	At risk	Coastal to montane	✗			1
Festuca coxii	Cox's Fescue	●	◐	150-500	✓	Green	Pink	Spiky	At risk	Coastal	✗			1
Festuca mathewsii		●	◐	150-500	✓	Green	Green	Spiky	Not threatened	Montane	✗			2
Libertia ixioides	Mīkoikoi	●	◐	150-500	✓	Orange	White	Spiky	Not threatened	Coastal/River/ Montane	✓		✓	3
Phormium cookianum	Wharariki	●	●	500-1500	✓	Green	Yellow	Spiky	Not threatened	Coastal	✓	✓	✓	4
Poa cita	Wī	●	◐	150-500	✓	Orange	Red	Spiky	Not threatened	Montane coastal	✓			2
Xeronema callistemon	Raupōtāranga	●	◐	150-500	✓	Green	Red	Spiky	At risk	Montane – rocky coastal	✓*		✓	1
Herbaceous														
Anaphaloides bellidiodes	Everlasting Flower	●	◐	150-500	✓	Green	White	Mounded or spreading	Not threatened	Montane	✗		✓	3
Apium prostratum	Tūtae Kōau	●	●	150-500	✓	Green	Brown	Mounded or spreading	Not threatened	Coastal	✓			3
Euphorbia glauca	Waiū atua	●	◐	150-500	✓	Grey	Red	Mounded or spreading	At risk	Coastal cliffs			✓	3
Fuchsia procumbens	Creeping fuchsia	◐	●	150-500	✓	Green	Red	Prostrate	Not threatened	Coastal	✓		✓	3
Haloragis erecta	Toatoa	●	●	150-500	✓	Green	Pink	Mounded or spreading	Not threatened	Costal to montane	✓*		✓	3
Veronica obtusata	Hebe	◐	●	150-500	✓	Green	White	Spiky	At risk	Coastal rocky			✓	2
Hibiscus diversifolius	Prickly Hibiscus	●	◐	150-500	✓	Green	Yellow	Mounded or spreading	Critically threatened	Coastal wetlands/ streamsides			✓	3

∗ distribution North Island

Native Plant Selection

KEY:

Full circle	Fully tolerant
Half circle	Tolerates some
✗	Not tolerant
Form	Mounded or spreading
Form	Oval
Form	Spiky
Form	Prostrate
Form	Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements: Sun	Requirements: Shade	Requirements: Minimum substrate depth (mm)	Requirements: Irrigation required	Characteristics: Leaf colour	Characteristics: Flower or berry colour	Characteristics: Form	Ecology: Conservation status	Ecology: Ecosystem origin	Ecology: Whāngārei Ecological District	Ecosystem services: Bird food	Ecosystem services: Insect and/ or lizard food	Performance: **Success ranking**
Herbaceous continued														
Hibiscus richardsonii	Puarangi	Fully tolerant	Fully tolerant	50-150	✓	Green	Yellow	Mounded or spreading	Critically threatened	Coastal	✓		✓	0
Leptostigma setulosum		Fully tolerant	Fully tolerant	150-500	✓	Green	Yellow	Prostrate	Not threatened	Varied	✓			3
Microlaena stipoides	Pātītī	Fully tolerant	Tolerates some	150-500	✓	Green		Spiky	Not threatened	Varied	✓			3
Microtis unifolia	Onion Leaf Orchid	Fully tolerant	Tolerates some	50-150	✓	Green	Green	Spiky	Not threatened	Varied	✓			1
Tetragonia implexicona	Rengamutu, Native Spinach	Fully tolerant	Tolerates some	150-500	✓	Green	Yellow	Prostrate	Not threatened	Coastal to montane	✓		✓	1
Ferns														
Austroblechnum penna-marina	Alpine Hard Fern	Fully tolerant	Tolerates some	150-500	✓	Green	Red	Prostrate	Not threatened	Coastal to alpine	✓		✓	3
Doodia australis	Pukupuku	Fully tolerant	Fully tolerant	150-500	✓	Green	Red	Prostrate	Not threatened	Coastal to lowland	✓		✓	0
Pteris tremula	Turawera, Shaking Brake	Fully tolerant	Tolerates some	150-500	✓	Green		Rounded	Not threatened	Coastal to montane	✓*			3
Pyrrosia eleagnifolia	Ngārara Wehi	Fully tolerant	Fully tolerant	50-150	✗	Green		Prostrate	Not threatened	Coastal to montane	✓			2
Shrubs & Trees														
Veronica hectorii	Hebe					Green		Rounded	Not threatened	Montane	✗		✓	4
Hebe obtusata	Pānako	Fully tolerant	Fully tolerant	150-500	✓	Green	Pink	Rounded	At risk	Coastal	✗		✓	2
Plagianthus divaricatus	Mākaka/Runa	Fully tolerant	Tolerates some	150-500	✓	Green	Yellow	Oval	Not threatened	Coastal	✓		✓	3

distribution North Island *

Exotic Plant Selection

KEY:

- ● Fully tolerant
- ◖ Tolerates some
- ✗ Not tolerant
- Mounded or spreading
- Oval
- Spiky
- Prostrate
- Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Succulents		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/ or lizard food	**Success ranking**
Aloe humilis	Spider Aloe	●	◖	50-150	✗	Red	Yellow	Spiky	N/A	Dry	N/A			2
Bromeliad 'Night Sky'	Bromeliad	●	●	50-150	✗	Green	White	Spiky	N/A	Dry	N/A			2
Bromeliad 'Sugar and Spice'	Bromeliad	●	◖	50-150	✗	Green	Red	Spiky	N/A	Epiphyte	N/A			2
Echeveria splendens		●	◖	50-150	✗	Green	Red	Prostrate	N/A	Coastal	N/A		✓	3
Kalanchoe sp.	Kalanchoe	●	◖	50-150	✓	Green	Red	Rounded	N/A	Dry	N/A		✓	3
Lampranthus sp.		●	◖	50-150	✗	Grey	Pink	Prostrate	N/A	Coastal	N/A		✓	2
Mesembryanth-emum 'Yellow'		●	◖	150-500	✗	Green	Yellow	Prostrate	N/A	Coastal	N/A		✓	3
Sedum acre		●	◖	50-150	✗	Green	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum azore		●	◖	50-150	✗	Green	White	Prostrate	N/A	Dry	N/A		✓	1
Sedum dasphyllum		●	◖	50-150	✗	Grey	White	Prostrate	N/A	Dry	N/A		✓	1
Sedum decumbens		●	◖	50-150	✗	Green	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum hintonii		●	◖	50-150	✗	Pink	Red	Prostrate	N/A	Dry	N/A		✓	1
Sedum kamtschaticum		●	◖	50-150	✗	Green	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum mexicanum		●	◖	50-150	✗	Yellow	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum murabilis		●	◖	50-150	✗	Red	Pink	Prostrate	N/A	Dry	N/A		✓	1
Sedum moranense		●	◖	50-150	✗	Green	White	Prostrate	N/A	Dry	N/A		✓	1

Exotic Plant Selection

KEY: ● Fully tolerant; ◖ Tolerates some; ✗ Not tolerant; Mounded or spreading; Oval; Spiky; Prostrate; Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Succulents continued		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/or lizard food	**Success ranking**
Sedum oaxacanum		●	◖	50-150	✗	Green	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum pachyphyllum		●	◖	50-150	✗	Green	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum reflexum		●	◖	50-150	✗	Grey	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum rubroctinctum		●	◖	50-150	✗	Purple	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum rupestre		●	◖	50-150	✗	Grey	Red	Rounded	N/A	Dry	N/A		✓	1
Sedum spathufolium		●	◖	50-150	✗	Grey	Yellow	Prostrate	N/A	Dry	N/A		✓	1
Sedum spurium 'Dragons Blood'		●	◖	50-150	✗	Red	Pink	Prostrate	N/A	Dry	N/A		✓	1
Sedum spurium 'Voodoo'		●	◖	50-150	✗	Red	Pink	Prostrate	N/A	Dry	N/A		✓	1
Sedum ternatum		●	◖	50-150	✗	Green	White	Prostrate	N/A	Dry	N/A		✓	1
Sempervivium species		●	◖	50-150	✗	Green	Red	Prostrate	N/A	Dry	N/A		✓	2
Senecio serpens		●	◖	50-150	✗	Green	White	Prostrate	N/A	Dry	N/A		✓	2
Herbaceous/Bulbs														
Allium schoenprasum	Chives	●	●	150-500	✓	Green	Purple	Spiky	N/A	Meadow	N/A		✓	3
Crocus sativum	Autumn Crocus			50-150	✓	Green	Purple	Spiky	N/A	Meadow	N/A		✓	3
Iris reticulata	Iris	●	◖	150-500	✓	Green	Purple	Spiky	N/A	Dry	N/A		✓	1
Lavandula angustifolia	Lavender	●	◖	150-500	✓	Green	Purple	Rounded	N/A	Dry	N/A		✓	1

Exotic Plant Selection

KEY: Fully tolerant ● · Tolerates some ◐ · Not tolerant · Mounded or spreading · Oval · Spiky · Prostrate · Rounded

0 – Unknown
1 – Excellent
2 – Good
3 – Moderate
4 – Poor

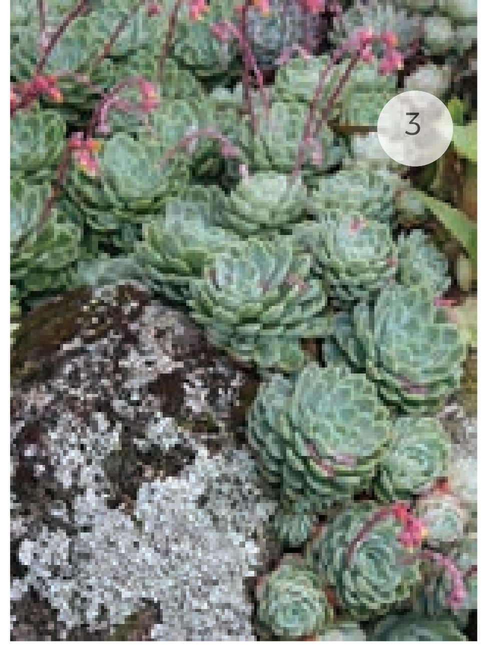
Scientific name	Common name	Requirements				Characteristics			Ecology			Ecosystem services		Performance
Herbaceous/Bulbs continued		Sun	Shade	Minimum substrate depth (mm)	Irrigation required	Leaf colour	Flower or berry colour	Form	Conservation status	Ecosystem origin	Whāngārei Ecological District	Bird food	Insect and/ or lizard food	**Success ranking**
Ophiopogon japonicus	Mondo Grass	◐	●	150-500	✓				N/A	Open & Forest slopes	N/A		✓	1
Origanum vulgare	Oregano	●	●	150-500	✓				N/A	Dry	N/A		✓	1
Thymus vulgaris	Thyme, Tāima	●	●	150-500	✓				N/A	Dry	N/A		✓	1
Grasses			●											
Lomandra tanika		●	●	150-500	✓				N/A	Dry	N/A		✓	2

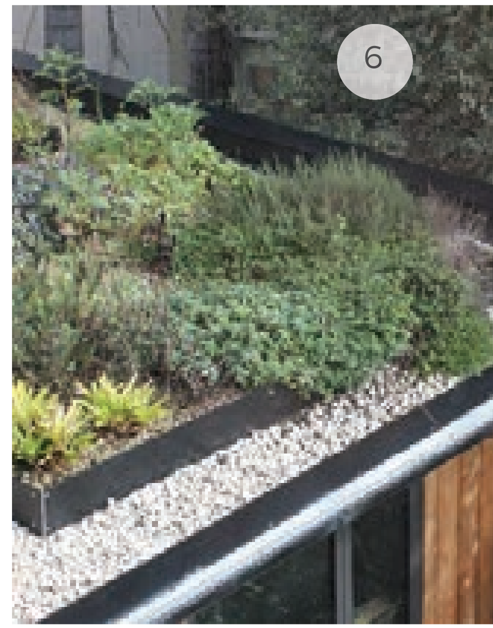
Rooftop garden in urban setting with beehive
Photo Alison Hancock, Shutterstock

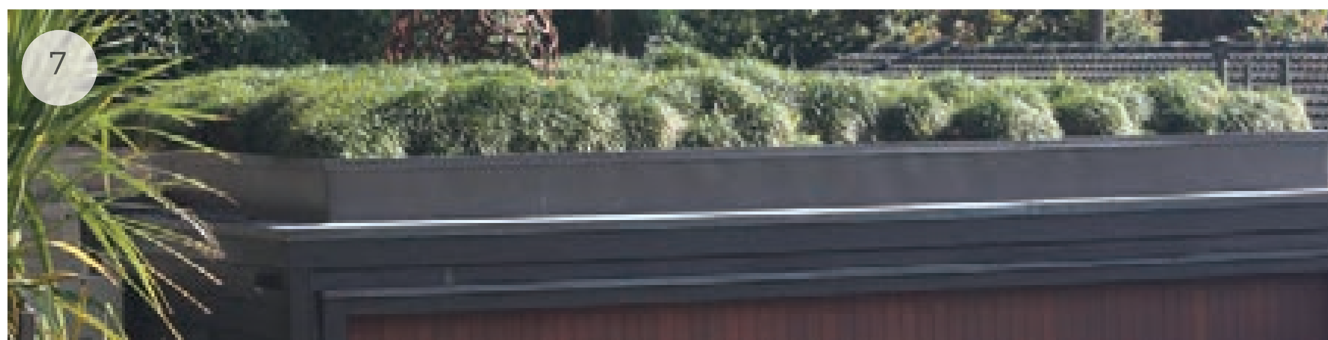
PLANTING INSPIRATION
EXOTICS

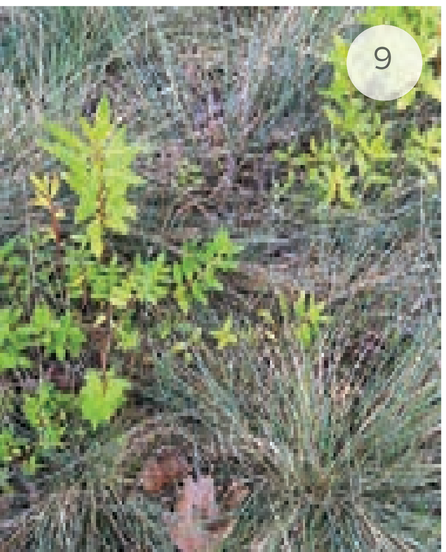
Examples shown are plant mixes from NZ and overseas living roofs

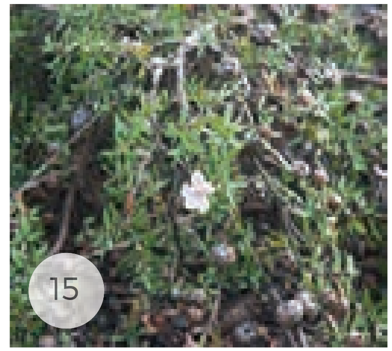
1. *Aloe, Bromeliad, Echeveria, Gazania, Iris, Lampranthus, Ornithogalum & Senecio*
2. *Succulent species*
3. *Sempivirens*
4. *Bromeliad & Sedum*
5. *Allium schoenoprasum*
6. *Hymus officinalis, Salvia officinalis, Oreganum, majoranum and small bromeliad species*

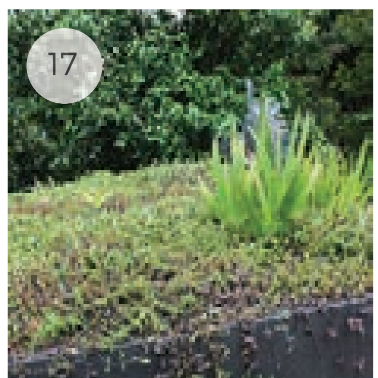


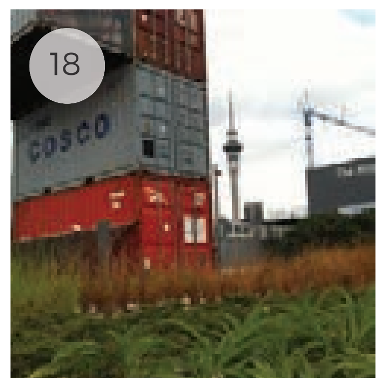












PLANTING INSPIRATION

NZ NATIVES

All examples shown are plant mixes from NZ living roofs

7. *Ophiopogon japonicus*
8. *Muehlenbeckia & Phormium cookianum*
9. *Festuca coxii & Haloragis erecta*
10. *Coprosma acerosa*
11. *Coprosma repens* 'Poor knights', *Xeronema callistemon, Doodia australis* (now *Blechnum parrisiae*), *Acaena pallida* and *Acaena novae-zelandiae*
12. *Pimelea prostrātā and Libertia grandiflora*
13. *Xeronema callistemon*
14. *Astelia banksii & Pimelea prostrātā*
15. *Leptospermum scoparium (prostrate)*
16. *Festuca coxii* and *Muehlenbeckia complexa*
17. *Acaena microphylla*
18. *Arthropodium cirratum, Carex testacea & Muehlenbeckia complexa*

DESIGN CONSIDERATIONS

Planting Methods

There are a range of methodologies that can be used to establish vegetation on a living roof. The method chosen will be dependent on the aims of the project, speed of cover, availability, impact required and budget. In many instances a mix of planting methods may be appropriate to increase the success of the vegetation cover of the roof.

The following table provides a general overview of the types of planting methods that can be considered within the NZ context and the considerations for each.

Maintenance

Maintenance is dependent on the type of living roof and access provided. It is accepted that an intensive living roof will require more maintenance in terms of weeding, irrigating and general maintenance than an extensive living roof system. Living roofs can be designed to have little maintenance requirements, where an owner can allow a system to self-seed and let nature take its course.

Commonly living roofs and walls are not well maintained due to inadequate or unsafe access. Creating safe access and understanding maintenance requirements of the plants will result in an achievable and cost effective maintenance plan.

When thinking about maintenance on a living roof it is useful to consider vegetation free zones to allow for access for maintenance and in some instances to assist with drainage away from flashings or protecting drains from root growth and also protecting vegetation from trampling during maintenance access and damage from mechanical building exhausts. Incorporation of formalised paths, parapets, balustrades or non-vegetated areas can help with maintenance and avoiding damage.

Plant selection is key to understanding maintenance requirements. For example grass lawns require significant amounts of watering and nutrients to remain green, whereas, native biodiversity planting requires occasional watering during dry periods.

It is also worth noting that some living roof companies provide maintenance as part of their service.

Right: Urquharts Bay Living Roof Planting installation
Photo Renée Davies

Planting Method	Effort	Comparative Cost	Establishment and maintenance
Self seeding No deliberate planting - seeds and spores are allowed to take root in the substrate.	Low	None	• 2-5 years • Can be very weedy • No control over look
Seeding Seeds of required species are collected and/or purchased and broadcast over the substrate.	Low	Low	• 2-5 years • Requires weeding of adventive species that self seed into the mix • Exposed substrate for first two years
Bare root plants Plants are supplied with soil-free roots wrapped in hessian or similar.	Medium	Medium-High	• Low stress • Only applicable to particular types of plants • Require immediate planting
Tubes/Root trainers Plants are nursery grown in small containers that ensure extensive roof growth.	Medium	Medium	• 1-2 years • Large spaces between plants • Exposed substrate for first two years • Greater density quicker coverage • Establish quickly due to lower transplant shock and adaptability to conditions
Container grown plants Plants are grown in a bag or container in nursery.	High	High	• 1-3 years • Can take time to adjust to conditions • Immediate impact with good substrate coverage • Weeds limited to area between plants • Plant pot or bag size determined by substrate depth
Pre-planted modular systems Plants are grown in living roof substrate in modular container designed for purpose (often includes drainage layer and protection.	Medium (for installation)	Medium - High	• Instant effect • Requires pre-planning and longer pre-ordering timeline • Weed invasion low

To weed or not to weed?

As with any living system, a vegetated roof will provide conditions for weed establishment.

The type and scale of weeds will vary and the extent of weed removal is dependent on the desired aesthetic. Many living roof weeds are small herbaceous weeds that will naturally die off each year and do not detract from the overall planted aesthetic.

Good nursery biosecurity measures are required to prevent the establishment of unwanted organisms and weeds on living roofs. Large rooted native plant seedlings such as pōhutukawa, tī kōuka/cabbage tree, karo and harakeke/flax (common adventive weeds found on NZ living roofs) should be removed to prevent their extensive root system compromising the waterproof layer.

Trampling over the roof to undertake weeding will compact the substrate reducing air pockets, permeability and drainage capacity. Minimise maintenance as much as possible and/or provide protected vegetation free zones for access.

Learn to love the smaller non-invasive weed species as a natural seasonal part of the living system.

Spontaneous Self-Seeders

A mix of perennial weeds have been found to self-seed onto living roofs in New Zealand, many of which can add to the aesthetic of the roof, are not invasive and/or die out annually over summer so do not require to be weeded out (depending on the design aesthetic for the roof). The following examples are those found in Whāngārei.

Cardamine hirsute
(Bittercress)

Helichrysum lueoalbum
(Jersey Cudweed)

Bellis perennis
(English Daisy)

Epilobium ciliatum
(Willow Weed)

Fumaria muralis
(Fumitory)

Fumaria muralis
(Lamium)

Euphorbia peplusbia
(Milkweed)

Anagallis arvensis
(Blue Pimpernel)

Plantago major
(Broad Leaf Plantain)

Prunella vulgaris
(Selfheal)

Sonchus sp.
(Sow Thistle)

Hydrocotyl moschata
(Hydrocotyl)

Taraxacum officinale
(Dandelion)

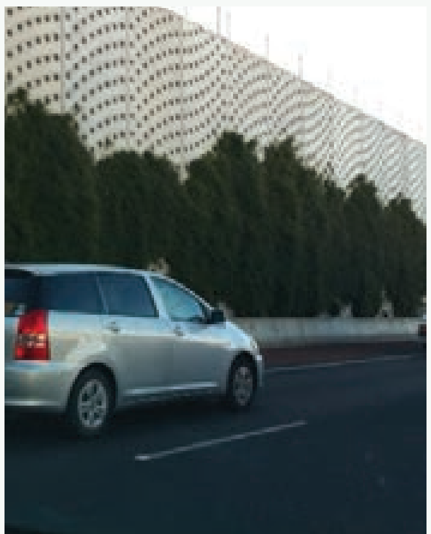
Muehlenbeckia Case Study

One potential to increase biodiveristy associated with living roofs and green walls is to focus on plants that provide habitat for our flying native invertebrates.

Resistance is an attribute that *Muehlenbeckia*, amongst the most adaptable of New Zealand's native plants, demonstrates in their natural environments of coastlines and riverbeds.

New Zealand has five species of *Muehlenbeckia*, most of which exhibit a climbing or sprawling growth habit.

Muehlenbeckia plays an important ecological role as host for native copper butterflies. *Muehlenbeckia complexa* has been shown to adapt well to green wall and living roof situations and offers potential to provide a robust contribution to native biodiversity in such situations.



Substrate

The substrate that the vegetation on a living roof grows in needs to balance the engineering requirement of light weight and rapid permeability (roofs must not flood), with water and nutrient storage for plant growth, and cost.

The basic principle of the substrate is to keep it as light as possible, generally with a maximum soil or organic content of 20%. This low organic component allows for improved drainage, lighter substrate and also a more stable substrate that has reduced need for 'top up' of new material.

There is a wide range of substrate types that can be used, depending on the tolerance of the roof loading and desired planting of the roof – from normal soil through to crushed brick, each will support different ranges and types of plants.

In NZ, the ideal substrate would be locally sourced and should meet the following criteria:

- A saturated weight that is consistent with the structural loading able to be accommodated by the roof.
- Hydraulic conductivity greater than 100mm/hour at installation to avoid ponding and potentially avoid the need for a drainage layer. This means plant roots maintain adequate aeration. Aeration is important, because many drought-tolerant plants are intolerant of continually wet and ponded root systems.
- More than 20mm moisture stored immediately after watering.
- Moderate bearing strength (i.e. able to support foot traffic for maintenance without crumbling or overly compacting).
- Minimal shrink/swell and slow development of hydrophobicity (water repellency) so the substrate absorbs water evenly and consistently.
- Moderate ability to store and supply nutrients for plant growth without leaching high concentrations of nutrients.

The most important aspect for consideration of substrate is the saturated weight. If a customised substrate is to be used where the saturated weight is not known, then tests should be carried out to determine that saturated weight loading. These can be undertaken by a number of scientific laboratories.

Coarse Pumice:Fine Pumice:CAN Bark Fines	FLL Max Moisture Content (kg/m³)	As Delivered Field Moist Weight (kg/m³)
2:2:1	953	815
1:3:1	986	827
0:4:1	1056	872

Right: Crane hoisting soil onto Wiles Ave carport living roof - consideration of access for substrate installation
Photo Robyn Simcock.

What is a saturated weight and why is it important?

The capacity of a substrate to hold water affects the volumes of water it can retain and therefore make available to the plants on a living roof and/or its retention ability (for stormwater drivers). If you are using a custom-designed substrate, the weight of the substrate on the structure can only be determined by undertaking a test of the weight of the substrate at full saturation. This test can also help to determine how quickly the substrate will reach saturation as this in turn impacts on the characteristics of the plants appropriate for the particular substrate. Tests can be done by a number of different laboratory test companies in NZ.

Figure 25: Soil saturation during rainfall event

Saturation All pores are full of water; gravitational water is lost

Field capacity Water available for plant growth

Wilting point No more water is available for plant growth

Irrigation

Depending on the type of plants you choose (and that's the fun part) you may need to allow for some irrigation, particularly in hot, droughty Whāngārei summers. This usually consists of a subsoil, low volume, low pressure drip irrigation system installed into the growing substrate. Irrigation fabric mats are also useful and distribute water throughout the mat via capillary action. Having the irrigation on an automatic controller, that's easily accessible, is important.

Filter Layer

Sometimes incorporated into root barrier, this geotextile filter layer prevents fine particles from the substrate from clogging up the drainage layer.

Drainage

It is important for living roofs, walls and facades to have good drainage to protect the plants and the building's structural integrity. Drainage systems need to be designed to remove surface and sub-surface water from the roof or wall and deal with extreme rainfall events. As such, drainage layers need to be highly porous, continuous and consistent over the whole roof.

Common drainage layers are made from a synthetic mat or a coarse aggregate. Living roof drainage mats usually have a root barrier geotextile attached. This layer can protects the waterproofing from damage by maintenance implements, such as spades, and can provide air circulation for the plant's root system. The substrate composition will also affect the flow of stormwater through the living roof system.

With the onset of modern living roof projects, a range of proprietary plastic drainage layers were developed that were an alternative to gravel or pumice. These systems have advantages for large projects in particular as they reduce the weight and thickness of the system and allow for maximum water movement off the roof. For simple DIY projects, the use of gravel or pumice type materials is a cheap and functional option.

The important element to ensure with any drainage layer, irrespective of type, is that they do not degrade thereby losing their drainage capacity or create blockages in the system. They also need to be able to withstand the weights of installation activity.

Moisture Retention Layers

These layers are often incorporated into the drainage layer and allow for the storage of a small amount of water that then increases the availability of water to plants. These are most often used in situations where there is no intended irrigation provided to the system.

Membrane protection

During construction of a living roof it is important to ensure that the waterproof membrane is protected from installation and construction activity. This can be achieved by either restricting all traffic on the membrane until the living roof components are added either at once or staged (that then provide protection) or placing some form of protective and robust mat (such as insulation) over the membrane.

Leak detection

A number of leak detection proprietary systems are available in NZ and are generally located next to the waterproof layer. These systems allow for testing to occur of the waterproof layer prior to installation of the living roof (essential as part of the flood testing of a roof) but can also be used as a permanent component that allows for quick detection of and isolation of the area of any leak that might occur within the waterproof layer of the living roof. Such systems ensure that any remedial work in the future does not necessarily require removal of the whole living roof system.

Living roof at Therme Vals, Switzerland
Photo Zoë Avery

Root Barrier

A root barrier is used to maintain the integrity of the waterproof membrane of a living roof. It essentially provides a layer of material that reduces the potential of plant roots penetrating or impacting on the waterproof membrane.

There are many different types of root barrier that can be used. Either a separate sheet of geotextile fabric or something integrated into a modular system or with the proprietary drainage layer can be used.

Waterproofing

There is a common expressed concern that flat roofs leak in NZ. If a living roof is designed to meet the German FLL standards it will include a root barrier, which will protect the waterproof layer. The living roof then protects and acts as a barrier to UV and weather damage thereby extending the roof life by two or three times. It is also noted that most waterproofing companies will leak test the waterproof membrane prior to the living roof being installed.

There are a range of waterproofing systems and materials available in New Zealand for use on the roof deck. The important considerations include:

- Whether the material chosen has a proven track record for use in living roof scenarios.
- Ensuring the material has been tested and passed the relevant standards.
- Ensuring there is a warranty (if required) in place.
- Choosing a material that is robust and will last as long as possible.
- Does it require a separate root barrier.

Right: Eco village by Luciano Pia in Torino, Italy
Photo Renée Davies

Butterflies and bees will love it!

A living roof can add an attractive and ecologically beneficial feature to garden structures like sheds, garages, chook houses and letter boxes - these domestic-scale projects are easy to install as long as some general principles are followed (large scale projects should only be carried out after advice from a specialist).

Follow the basics in the next section for instructions on installing a living roof on a hen house and you can adapt the techniques for other small garden buildings.

Kunzea robusta **(Kanuka) Flowers**
Photo Renée Davies

DIY SMALL SCALE

HANGAIA E KOE HE ĀWHATA ITI

DIY

DIY guide to creating your very own small scale living roof

The Principles

- Simple lightweight living roofs weigh between 60-150 kg/m^2. If you are unsure of the loading your roof can take, consult an architect or structural engineer before you do anything else.
- If the existing roof is unable to take the extra weight, you may be able to reinforce it using additional supports.
- Small scale DIY roofs require only 4 layers, the waterproof membrane, drainage, substrate (soil mixture) and planting.
- Typical sheds will already have a waterproof covering (tin, plywood or bitumen). Living roofs require an additional layer of waterproof material which is root resistant. A heavy-duty pond liner, as used here, is ideal.
- Drainage is important as excess water (that is not absorbed by the substrate or plants) must be able to leave the roof. A drainage outlet is required and use of pebbles or pumice will allow good drainage at the base and low point of the roof.
- The depth of the substrate will guide what type of plants can be grown. Most DIY roofs have a depth of 70 – 200mm. Therefore, 70 – 100mm depth sedums and succulents are best. If you have 150mm or more of depth you can use hardy, low-growing New Zealand native plants.
- The substrate used needs to be light-weight and low in nutrients. A good home mix would consist of 30% fine pumice, 30% larger pumice and 40% organic soil mix.
- Your living roof shouldn't require too much maintenance. If there is a dry summer, ensure plants are watered (especially while they are still establishing their root system) and remove any unwanted weeds that might have established. Keep drainage lines clear from debris.
- The living roof is contained by an upright frame around the edge of the roof which can be made from timber, but any rot-resistant material can be used.
- If the roof slope is over 15˚ you will need to ensure that the living roof does not slip. This can be done by using wood or metal battens laid over the waterproof membrane.

Living roof garden shed at Chelsea Flower Show, London
Photo Zoë Avery

The Plants

- If you are using 70mm - 150mm of substrate you will need to use sedum and succulent species that can survive in the shallow depth of soil.
- If you are using 150mm or more of substrate you can use a range of native plants such as *Festuca coxii, Coprosma acerosa, Libertia peregrinans, Pimelea prostrātā, Selliera radicans* and *Dichondra repens.*

The Chicken Coop

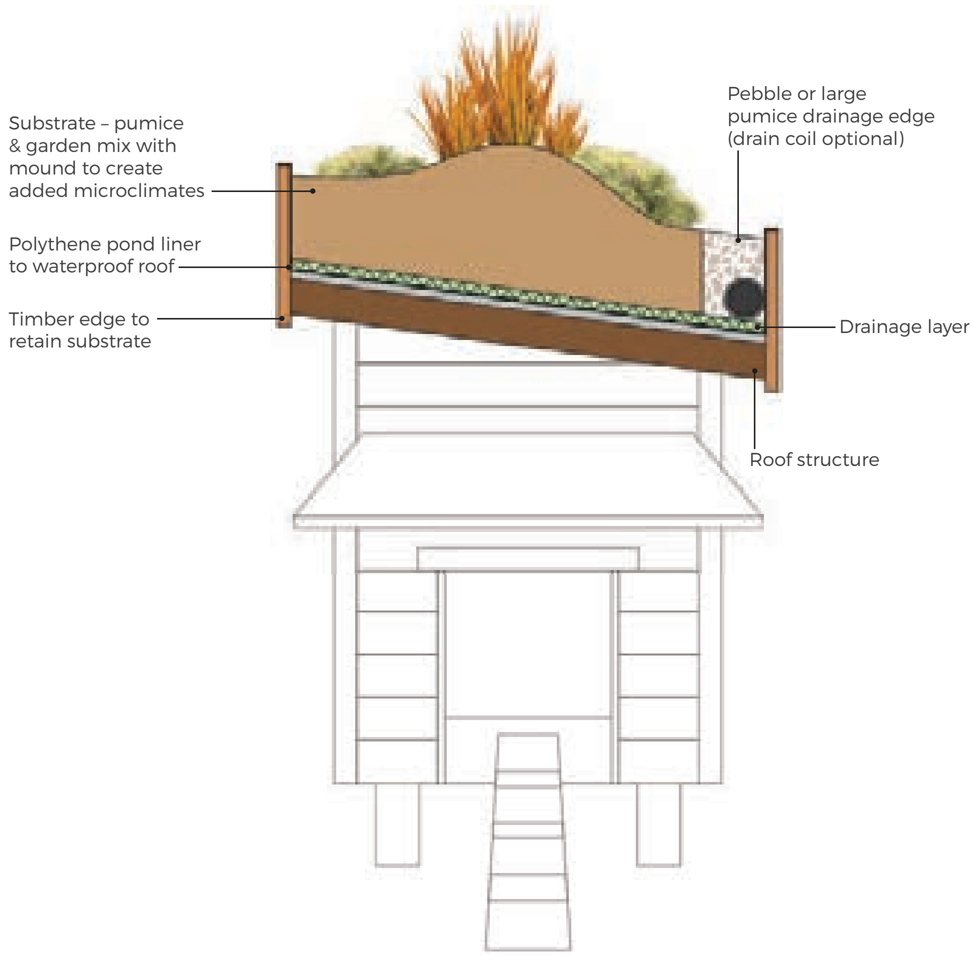
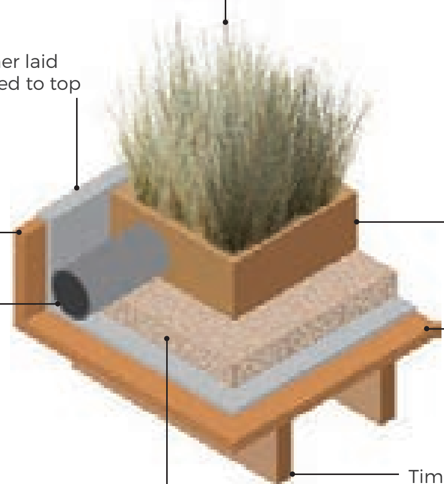


Figure 26: Cross section of the chicken coop living roof (pictured right)

Chicken coop living roof
Photo Robyn Simcock

DIY

Figure 27: The components of a DIY living roof



Shepherds Hut Sleepout
Photo Renée Davies

DIY

Example Stages of Installation: The Sleepout

Size: $10m^2$
Depth of substrate: 70mm
Plants: Succulent mix
Substrate: Pumice, organic and perlite mix

1. Timber roof support structure created (using laminated beams)

2. Creation of roof deck (plywood over laminated timber beams)

3. Laying polythene or pond liner over plywood

4. Creation of timber edges and pond liner wrapped up edges

5. Plastic drainage layer placed over pond liner

6. Substrate laid over geotextile root barrier fabric and planting undertaken into substrate

7. Planting

8. Completed living roof installation

***Xeronema* Living Roof, Auckland Zoo**
Photo Renée Davies

DESIGN CHECKLIST

RĀRANGI HIHIRI MO NGĀ WHAKAAHUA

DESIGN CHECKLIST

Living Roof Design Checklist

Living Roof Design Considerations have been detailed in this guide to ensure principal design objectives, project aspirations or reasons for incorporating a living roof, wall or facade are incorporated early in the project to result in an outcome with maximum benefits.

The following checklist should be filled in to ensure that the design and build process adequately considers all of the principles and benefits able to be achieved.

If you would like to share your project and for it to be included on a register of living roof and wall projects - please email your checklist to Living Roofs Aotearoa: Zoë@livingroofs.org.nz

Date: ______/______/______

Project location: ____________________________
____

Plans prepared by:

- ☐ Homeowner
- ☐ Landscape Architect
- ☐ Architect
- ☐ Ecologist
- ☐ Structural Engineer
- ☐ Developer
- ☐ Civil Engineer
- ☐ Other

Attach copy of plans, specifications, and design calculations.

Priorities for living roof design:

- ☐ Urban Heat Island Effect mitigation
- ☐ Employment from manufacture, design, installation, maintenance and new uses
- ☐ Noise attenuation and sound improvement
- ☐ Shading
- ☐ Aesthetic/biophilic improvements
- ☐ Improved biodiversity
- ☐ Urban food production
- ☐ Improvements to onsite stormwater management
- ☐ Carbon sequestration
- ☐ Improvements to building envelope longevity
- ☐ Support of green products and systems
- ☐ Increase in property values
- ☐ Financial savings/energy savings
- ☐ Reducing climate change effects
- ☐ Improved air and water quality
- ☐ Improved human health

Living roof system:

- ☐ Extensive system (less than 150mm growing media)
- ☐ Semi-Intensive system (less than 25% of green roof over 150mm of growing media)
- ☐ Intensive system (more than 150mm of growing media)

Also (if applicable):

- ☐ Biosolar living roof (combination solar panels and living roof)
- ☐ Biodiverse living roof

Total roof area:
______________m^2

Living roof area:
______________m^2

Substrate depth:
______________mm

Substrate composition:

- ☐ Organic
- ☐ Pumice
- ☐ Zeolite
- ☐ Other:

____

Storage volume based on substrate depth (if known):
______________mm

Total storage volume of living roof area (if known)
______________m^3

<u>Building details:</u>

Type of building:

- ☐ Residential
- ☐ Commercial
- ☐ Industrial

New or retrofit construction:

- ☐ New construction
- ☐ Retrofit construction

Height of building:
______________m
______________stories

Roof substructure:

- ☐ Wood
- ☐ Metal Sheeting
- ☐ Reinforced Concrete
- ☐ Other

Slope of roof:
______________degrees

Describe roof access:
Type of access:______________________________

- ☐ Limited for maintenance
- ☐ Permanent access

Height of parapet:
______________mm

Wind control measures:

____

Structural loading:
Calculations supplied or letter certified by licensed structural engineer stating that structural loading analysis has been completed and that the structure can support the proposed living roof system.

<u>Site considerations:</u>

Climate evaluation:

- Sun/aspect ____________________________
- Wind ________________________________
- Shade ________________________________

Evaluation of waterproofing age and condition (if retrofitted):

- ☐ Yes
- ☐ No

Analysed building infrastructure (e.g. location of HVAC systems, water storage/ supply):

- ☐ Yes
- ☐ No

Determined means of access and occupancy limits (e.g. maintenance and occupants):

- ☐ Yes
- ☐ No

Identified safety requirements (i.e. temporary or permanent fall protection measures):

- ☐ Yes
- ☐ No

Does the design include gravel/stone area around border:

- ☐ Yes
- ☐ No

Living roof construction:

- ☐ Modular tray living roof system
- ☐ Built-in-place living roof system

Type of waterproofing membrane proposed:

- ☐ EPDM
- ☐ Cold fluid applied waterproofing
- ☐ Hot applied rubberised asphalt
- ☐ Modified bitumen
- ☐ PVC
- ☐ TPO
- ☐ Hybrid:______________________________

Components incorporated in living roof design:

- ☐ Vegetation
- ☐ Growing Media
- ☐ Filter Fabric
- ☐ Drainage Layer
- ☐ Root Barrier
- ☐ Waterproofing Layer
- ☐ Deck Layer
- ☐ Wind Protection
- ☐ Moisture Retention Layer
- ☐ Membrane Protection
- ☐ Other: ______________________________

Type of irrigation:

- ☐ Overhead
- ☐ Drip
- ☐ Ecoblanket
- ☐ Other
- ☐ None

Vegetation type (attach planting plan if available):

- ☐ Native
- ☐ Exotic
- ☐ Mix Native / Exotic
- List species: ___________________________

____
____
____
____
____
____
____
____
____
____
____

Total saturated system weight: _____kg/m²

How will material be conveyed to the roof (roof access points, load bearing points, material storage requirements)?

____
____

Schedule for planting:
Planting season: ______________________
Establishment period: __________________

How will material be stored and maintained based on the structural capacity of the roof?

____
____

How will the roofing membrane be protected during installation (leak detection)?

____
____

Wind up-lift and wind erosion protection:

____
____

Water Supply

- For permanent irrigation

____
____

- For initial irrigation of extensive green roofs

____
____

Work safety/fall protection (required starting from 2m fall height):

- ☐ Scaffolding during construction phase
- ☐ Cable-guided fall protection for personal protective equipment
- ☐ Railings for escape routes and roof terraces
- ☐ Roof access - for care and maintenance work (stairwells, ladders, exits)

DESIGN CHECKLIST

Living Wall Design Checklist

Living Roof Design Considerations have been detailed in this guide to ensure principal design objectives, project aspirations or reasons for incorporating a living roof, wall or facade are incorporated early in the project to result in an outcome with maximum benefits.

The following checklist should be filled in to ensure that the design and build process adequately considers all of the principles and benefits able to be achieved.

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Date: _____/_____/_____

Project location: ______________________________
____
____
____

Plans prepared by:
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- ☐ Landscape Architect
- ☐ Architect
- ☐ Ecologist
- ☐ Structural Engineer
- ☐ Developer
- ☐ Civil Engineer
- ☐ Other

Attach copy of plans, specifications, and design calculations.

Priorities for living wall design:
- ☐ Urban Heat Island Effect mitigation
- ☐ Employment from manufacture, design, installation, maintenance and new uses
- ☐ Noise attenuation and sound improvement
- ☐ Shading
- ☐ Aesthetic/biophilic improvements
- ☐ Improved biodiversity
- ☐ Urban food production
- ☐ Improvements to onsite stormwater management
- ☐ Carbon sequestration
- ☐ Improvements to building envelope longevity
- ☐ Support of green products and systems
- ☐ Increase in property values
- ☐ Financial savings/energy savings
- ☐ Reducing climate change effects
- ☐ Improved air and water quality
- ☐ Improved human health

Total wall area:
_____________m²

Living wall area:
_____________m²

Living wall system
- ☐ Living Wall Hydroponic
- ☐ Living Wall Substrate
- ☐ Living Facade
- ☐ Hybrid System

Substrate composition
- ☐ Organic
- ☐ Pumice
- ☐ Zeolite
- ☐ Other

<u>Building details:</u>

Type of building:
- ☐ Residential
- ☐ Commercial
- ☐ Industrial

New or retrofit construction:
- ☐ New construction
- ☐ Retrofit construction

Height of building:
_____________m
_____________stories

Wind control measures:
____

Structural loading:
Calculations supplied or letter certified by licensed structural engineer stating that structural loading analysis has been completed and that structure can support the proposed living roof system.

<u>Site considerations:</u>
Climate evaluation:
- Sun/aspect ___________________________
- Wind ______________________________
- Shade ______________________________

Evaluation of waterproofing age and condition (if retrofitted):
- ☐ Yes
- ☐ No

Analysed building infrastructure (e.g. location of HVAC systems, water storage/ supply)?:
- ☐ Yes
- ☐ No

Determined means of access for maintenance?
- ☐ Yes
- ☐ No

Identified safety requirements (i.e. temporary or permanent fall protection measures)?
- ☐ Yes
- ☐ No

Vegetation type (attach planting plan if available):

- ☐ Native
- ☐ Exotic
- ☐ Mix Native / Exotic
- List species: ____________________________

____
____
____
____
____
____

Total saturated system weight:
______________kg/m^2

Construction material storage requirements considered?

- ☐ Yes
- ☐ No

Schedule for planting:
Planting season: __________________________
Establishment period: _____________________

Wind up-lift and wind erosion protection:

____
____

Water Supply

- For permanent irrigation

____
____

Work safety/fall protection (required starting from 2m fall height):

- ☐ Scaffolding during construction phase
- ☐ Cable-guided fall protection for personal protective equipment

***Xeronema* flower**
Photo by Renée Davies

About the Authors

Zoë Avery has been working on sustainable development in New Zealand, Australia and the United Kingdom, including the encouragement of green infrastructure through design, planning and policy development for twenty years. She has a Master of Landscape Architecture (by Design), a Bachelor of Planning (Hons) and is currently completing a Master of Urban Design. A key part of her work has been researching how we can better integrate living roofs and green walls as urbanistic systems into our cities in light of urban population growth. Zoë has just finished researching living roof morphological aspects, discovering the importance of describing the notion of integrating human wellbeing and sustainability alongside design process and urban functionality. Living urbanism is a concept she has developed to address this. In addition to her role as Principal at 4Sight Consulting Limited, she is a Board Member of Green Roofs Australasia and Director of Living Roofs New Zealand. Zoë's values are very much founded on the principles of an equitable society, in terms of economic, social, ecological and cultural capital.

Renée Davies is an award winning landscape architect and ecologist. She is past president and Fellow of the New Zealand Institute of Landscape Architects and currently Principal Landscape Architect with 4Sight consulting. Renée's research portfolio established while Head of Landscape Architecture at Unitec Institute of Technology has focused on the blend between landscape architecture and ecology, with a particular focus on living roof and urban ecology. Under her guidance Waitakere City Council in partnership with Landcare Research and Architectus and Athfield Architects won a coveted NZILA Sustainability Excellence Award for the Waitakere City Council Green Roof. Renée has designed and implemented a range of living roofs and green walls providing her with a detailed knowledge of living roof issues for the New Zealand context from concept and design right through to practical implementation and maintenance.

Living roofs, walls and facades are becoming increasingly common in cities throughout the world. The purpose of this guide is to highlight the multitude of economic, social and environmental benefits that these living systems can provide to improve the quality of Whāngārei for its people, land, water, nature and visitors.

This is a living guide that will grow, change and develop with time to provide locally relevant information for anyone embarking on a living roof, wall or facade project.