Burnley Green Roof Plant Guide

An evidence-based guide to plant species and palettes for Australian conditions

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Introduction

The uptake of green roofs in Australian cities is gaining momentum, with a steady increase in the number of green roofs seen in all major Australian cities over the last ten years. Despite this, one of the barriers limiting wider implementation is knowledge of the types of plants that both thrive on Australian green roofs and deliver environmental and social benefits. The *Burnley Green Roof Plant Guide* will be a valuable resource for practitioners for identifying plants that deliver functional green roof outcomes for people, biodiversity, stormwater management and cooling. This guide provides proven plant palettes for five green roof typologies – ranging from low maintenance and shallow succulent green roofs to more intensive and productive green roofs.

Over 15 years of research at the University of Melbourne's Burnley campus has highlighted the importance of selecting plant species which are suited to the unique conditions on Australian green roofs. Recommended plant species in this guide are informed by green roof research undertaken by the authors in glasshouse experiments and on green roofs at Burnley, including a demonstration green roof, a biodiversity green roof and an experimental green roof. Plant performance data is complemented by social research around designing aesthetically appealing green roofs that can improve the wellbeing of visitors and viewers of green roofs.

Figure 1.1 Diverse plant palettes containing a range of plant forms have been used to create exemplary green roofs overseas (left) and in Australia (right). Matching species to site conditions, supporting infrastructure, irrigation and maintenance is key to achieving flourishing green roofs.
Images: Green roof on a commercial building in the United States (J. Rayner) and Skypark in Melbourne (R. Bathgate)

This guide provides practical information on plant selection to design sustainable, flourishing green roofs for local conditions. As successful green roofs also depend on specifying the right substrates, irrigation and maintenance regimes, information on these is summarised here with more details available in guides developed by University of Melbourne researchers and partners: the *Growing Green Guide*[1] and *Maintenance Guidelines for Australian Green Roofs*[2].

Recommended plant palettes are provided for five green roof typologies which are commonly built in Australian cities. The green roof typologies are based on substrate depth; planting outcomes (succulents, flowers and foliage or food plants); accessibility (e.g. green roofs for social interaction, recreation and wellbeing) and specific benefits (habitat and biodiversity or food production). These green roofs can all provide building cooling and stormwater management. The five green roof typologies are:

1. **Shallow succulent green roof**
   10-20 cm deep substrate
2. **Shallow biodiverse green roof**
   10-20 cm deep substrate
3. **Green roof showcasing flowers and foliage**
   20-50 cm deep substrate
4. **Green roof for amenity and recreation**
   30-80 cm deep substrate – more for trees
5. **Green roof for food production**
   30-100 cm deep substrate

Each green roof typology includes a discussion of how plant selection relates to its desired function, a suggested plant palette and case studies demonstrating practical application in Australia. The sample plant palettes for each typology include robust and proven Australian and exotic plant species. While plants in these palettes are mostly perennial to maximise longevity, we also provide a list of plants that can be added for bursts of seasonal colour and interest – including Australian annuals that grow from seed, and both Australian and exotic flowers that resprout from bulbs, corms, rhizomes or tubers (geophytes).

These plant palettes represent a fraction of the plants that could be grown on Australian green roofs and there is considerable opportunity to expand the plant selection. To facilitate selection of new species, we have identified plant traits or characteristics which are related to plant survival or function on green roofs. As this guide is based on research in Melbourne, it is most suited to southern Australia where climates are characterised by hot and dry summers and mild and wet winters. There are significant opportunities for similar green roof plant palettes for tropical and subtropical regions, further expanding the range of species and Australia's green roof sector.

2

Selecting plants for Australian green roofs

Green roofs can provide multiple environmental and social benefits in cities including reducing stormwater runoff, lowering building energy use and air pollution, and improving wellbeing, human-nature connection and biodiversity. As these benefits depend on healthy plants and good vegetation coverage, appropriate plant selection is critical.

Green roofs are made up as a series of layers. From the roof structure upwards these include a waterproofing layer (or membrane), protection layers, drainage layer, filter sheet (geotextile), growing substrate and plants. In many cases, irrigation is also an essential part of green roof design to sustain non-succulent plants over summer months (regardless of substrate depth).

2.1 Green roof substrates

A comprehensive site analysis should be undertaken before plant selection to identify key physical conditions and constraints including climate factors such as temperature, rainfall and humidity. The site analysis should also identify site-specific microclimatic conditions such as reflected heat, exposure to wind and solar radiation, and rain shadows created by surrounding buildings and green roof structures (e.g. balustrading and hard-landscaping). The resulting site report should also factor in the infrastructure required for maintenance access, irrigation and protection against extreme weather (e.g. shade structures for green roofs designed for social interaction). The outcomes of the site analysis can then be used to select plants which match these local conditions. A major constraint for green roof plant selection in many sites is the combination of heat (high solar radiation), drought and wind while shading can also be a problem on green roofs which are built on southern aspects of buildings or overshadowed by taller buildings.

Plant growth and survival are affected by green roof configuration and site conditions, making these important drivers of plant selection and planting design. While design approaches at ground level can be readily applied to green roofs, there are additional constraints that affect successful planting design:

- Green roof substrates are engineered to be free-draining and therefore have lower water holding capacities (< 50%) than most soils or growing media. Most substrates also have reduced fertility due to low amounts of organic matter.
- Roof weight limitations which limit green roof substrate depth and volume; the saturated bulk density of substrates should always be used to calculate green roof loads.
- Maintenance of green roofs is often compromised due to problems with access and insufficient resources to sustain the original design intent.
- Green roofs are hotter and drier than ground-level landscapes due to increased solar radiation and wind.

Green roof substrates are designed to maintain green roof drainage to prevent waterlogging and potential flooding, to be stable over time and relatively lightweight, while also storing water for plant survival between rainfall or irrigation events. Balancing these competing outcomes is a challenge in substrate design and can affect plant selection. Mineral components such as scoria, sand, or crushed bricks make up 80-90% of most green roof substrates because they do not break down and are very stable over time. However, organic components such as barks, compost and coir are added to reduce green roof substrate weight and increase water and nutrient retention[3]. While additives such as biochar can enhance water retention, plant available water and permeability, their main advantage is in decreasing green roof substrate weight[4,5]. Low amounts of organic matter (less than 20% organic matter) are suggested for most green roof typologies in this guide but food production on green roofs requires greater amounts of organic matter to provide enough nutrition. Organic-rich substrates will require regular topping up to maintain substrate depths as they decompose and need careful management to reduce nitrogen and phosphorus concentrations in stormwater runoff.

2.2 Roof weight limitations and substrate depth

Plants grown in deeper green roof substrates generally show better growth and survival as deeper substrates can store more water and provide greater rooting volume[6,7]. Increasing substrate depth expands the list of plant life-forms and species able to be grown on green roofs – meaning larger plants and greater plant diversity in plant palettes (Fig. 2.1–2.2). There are, however, load-bearing trade-offs and costs associated with deeper substrates - for example in the need to increase engineering specifications and materials required to support heavier loads. In Australia, at least 10 cm deep substrates are recommended due to extreme summer heat which can elevate substrate temperatures beyond the physiological limits of plants (e.g. 65 °C), even when irrigated. Weight-loading limitations, particularly for green roofs retrofitted on existing buildings, mean most 'lightweight' green roofs are shallow (< 20 cm substrate depth), making them challenging for most non-succulent plants to survive. However, some drought tolerant grasses, perennial herbs and small shrubs can also be grown in 10-20 cm deep substrates if irrigated during summer months. Small trees need at least 60 cm depth to survive but growth and canopy cover will often be reduced under these conditions. Deeper (e.g. 1 m plus) substrates of adequate volume will support healthier, more resilient trees.

Green roof system weight loads (also called 'dead loads') include the mass of all layers, including substrates and plants, as well as hard-landscaping elements like planters, paths and edging. Examples of typical plant loads are provided in Table 2.1.

As trees grow, their mass increases. Tree load calculations should be undertaken and include the mass of the entire tree at installation (including root ball), the substrate mass and estimated mature tree mass, including trunk and canopy dimensions[8]. Wind loading on larger trees can also contribute to green roof weight and requires a specialist engineering assessment.

Table 2.1 Example of green roof vegetation weight loadings

Green roof vegetation type	Weight loading (kg/m²)
Succulents, low growing herbaceous plants and grasses	10.2
Perennial herbs and small shrubs (< 1.5 m tall)	10.2 – 20.4
Turf	5.1
Shrubs (1.6–3 m tall)	30.6
Small trees (<6 m tall)	40.8
Medium trees (6.5–10 m tall)	61.2
Large trees (10.5–15 m tall)	150

Source: FLL Guidelines[9], adapted from Growing Green Guide[1]

Figure 2.1 Increasing substrate depth increases rooting volume and water storage, supporting larger plants and more diverse plantings.

2.3 Maintenance inputs

Maintenance inputs are a key consideration in green roof plant selection and are often overlooked during the design phase. The expected maintenance regime, including tasks, frequency and expertise, should be matched to plant selection. Green roofs require specific knowledge and skills for maintenance which are frequently underestimated, often leading to poor plant performance. There is no point selecting plants for high visual amenity without a documented maintenance plan, access for maintenance and inputs to maintain vegetation to a high standard. Low maintenance, succulent green roofs require maintenance every 3-6 months, whereas amenity green roofs require weekly maintenance with several person hours and tasks per visit. For more information on the maintenance tasks and frequency for different green roof types refer to *Maintenance Guidelines for Australian Green Roofs*[2].

2.4 Green roofs are hot and dry

Green roofs are challenging for plants as their shallow substrates limit water availability and plants are often exposed to hot and dry conditions. Finding plants able to survive on green roofs was previously a major barrier to green roof uptake in Australia[10] and has been the focus of over 15 years of research at Burnley (Fig. 2.3).

Under non-irrigated conditions on a shallow (125 mm substrate depth) experimental green roof at Burnley, exotic succulents with very succulent leaves and an upright, compact form had the greatest survival (e.g. *Sedum pachyphyllum,* Jelly Beans). Conditions on the green roof were extremely hot and dry, with substrate temperatures reaching 65°C and evaporative demand exceeding rainfall for 48 weeks[11]. Under these conditions many exotic succulents with prostrate forms experienced severe heat damage and died, despite having large succulent leaves. Prostrate Australian succulents with large succulent leaves (e.g. *Carpobrotus modestus,* Inland Pigface, and *Disphyma crassifolium*, Rounded Noon Flower) also had lower survival as they used more water and dried out faster[12].

Figure 2.2 A range of engineering solutions can be used to create the required substrate depth and volume to support trees on green roofs, including raised planters (Skypark, Melbourne) and integrated structures (Little Island, New York). Images: R. Bathgate and J. Rayner

Figure 2.3 Observing plant growth and performance on existing green roofs should inform plant selection. Not all succulents are equal! Under extended heat and drought in an unirrigated shallow green roof *Echeveria* 'Black Prince' (top) was considerably less robust than ×*Sedeveria* 'Pats Pink' (below). Images: J. Rayner

Figure 2.4 Looking to plants from habitats that are naturally dry and hot, such as rocky outcrops, can provide a useful guide to their use in green roofs. *Stypandra glauca* on a granitic rocky outcrop, Victoria (top) and *Chrysocephalum apiculatum* (below). Images: C. Farrell and J. Rayner

A large range of non-succulent plants can also be grown successfully on shallow green roofs (<20 cm) if irrigated during summer (either by hand-watering or with an irrigation system). This includes native grasses, grass-like plants, herbs and small shrubs which originate from natural habitats with conditions that are similar to green roofs, e.g. rocky outcrops, coastal dunes and grasslands[13-15] (Fig 2.4). While this habitat template approach is useful, not all plants selected from habitat templates will be suitable for green roofs. For example, in dryland ecosystems there are many different ways plants can tolerate drought stress but some of these strategies will not ensure survival on green roofs[14]. This is particularly the case for plants which avoid drought stress through deep root systems[16]. Therefore, when selecting green roof plants, it is best to combine information on habitat of origin with plant traits or characteristics related to greater survival on green roofs (Fig 2.5). These plants feature in the plant palette for *Shallow biodiverse green roof.*

Figure 2.5 Not all plants from hot and dry habitats are suitable green roof species, so selecting plants based on both habitat of origin and plant traits is a more useful approach. *Arthropodium milleflorum* is a native lily that can live in hot, dry habitats (A) and has been grown successfully on Melbourne green roofs (B). Foliage can die-off in response to excessive drought and heat, with plants able to resprout from underground storage tubers (C) under more favourable conditions. Image: C. Farrell

Plant traits or characteristics related with increased survival on green roofs under hot, dry conditions include:

- Succulent leaves, stems or roots – storage of water in leaves and stems (e.g. *Crassula arborescens* 'Blue Bird') increases plant survival during extended dry periods as plants can draw on this water to maintain function[11,12,14].
- Resprouting from underground bulbs, corms, rhizomes or tubers – the shoots of these plants die off and plants survive hot and dry periods beneath the soil and resprout when conditions improve e.g. *Arthropodium milleflorum* (Pale Vanilla-lily)[14].
- Small plants with small leaves or plants with sparser canopies use less water and can have greater survival on green roofs e.g. *Eutaxia microphylla* (Small-leaved Mallee Pea)[17]. These traits can also reduce heat damage of leaves.
- Small shrubs (e.g. *Rosmarinus officianalis,* Rosemary) generally have better survival than herbaceous plants (unless herbaceous plants have high succulence)[7].
- Upright plants – prostrate plants can suffer from heat damage on green roofs while more upright plants (especially succulents) have better survival e.g. upright *Sedum pachyphyllum* (Jelly Beans) versus prostrate *Disphyma crassifolium* (Rounded Noon Flower)[11].
- Vegetative spread – lateral growth below the surface via rhizomes or adventitious roots will allow species to persist if other parts of the plant die, for example *Dianella revoluta* (Black Anther Flax Lily).
- Annual species – these plants die during hot and dry periods and seeds germinate when there is sufficient moisture (e.g. *Rhodanthe manglesii*, Pink Sunray)[18]

In addition to the above plant traits, plant survival can also be enhanced by increasing substrate depth, as previously noted,[7,19] and by using hard-landscape features to manipulate planting orientation and exposure (solar radiation and wind) – thus creating areas where substrates stay wetter and cooler for longer periods.

Wind exposure on green roofs can exacerbate desiccation under dry and hot conditions or cause physical damage. Wind speed increases with height above ground level and should be considered in plant selection. Plant traits associated with wind tolerance include tough or small leaves, low plant height, multi-stemmed habit and having flexible, non-brittle stems. Wind exposure can also be mitigated during design through engineering solutions (e.g. structural wind barriers, higher balustrades and tree anchors).

Matching plants to site conditions

Plant selection needs to be robust to ensure optimum plant performance on green roofs. However, the selection of plants in most settings will be a trade-off between seeking environmental and social outcomes, and the realities of the site itself, including available maintenance and resources to sustain the planting over time.

Many green roofs are not homogeneous and there will be spaces that can support different plant selections. This is shown at the Burnley Demonstration Green Roof (Fig 2.6) at the University of Melbourne's Burnley campus. Located on a two-storey building, this accessible 166 m^2 green roof has substrate depths from 100 to 300 mm with around 200 plant species. Plants with different attributes and tolerances are selectively grown in 14 distinct 'planting zones' across the roof. These planting zones are defined by differences in soil depth (100, 150, 200, 250, 300 mm), irrigation (summer only/none), substate type (ash, scoria, mix) and dominant plant types (succulents, flowering, productive, etc.).

One way to select plants for use in green roofs is to evaluate candidate/potential plants against clear selection criteria that have been framed around the overall planting design goals and outcomes for the project. Individual plants are scored or ranked against criteria through a 'plant selection matrix'. Such a method helps to analyse candidate species where there is limited information on the likely environmental tolerances or their performance, a challenge in many urban green infrastructure projects[20].

Figure 2.6 Good plant selection is illustrated in the highly diverse plant palette across 14 distinct 'planting zones' on the University of Melbourne's Burnley Demonstration Green Roof. Image: University of Melbourne

2.5 Irrigation

All green roofs require supplementary water during establishment with any ongoing irrigation tailored to plant water use, local climate and microclimatic conditions across the roof. In Australia, all non-succulent green roofs will require at least summer irrigation to ensure plant growth and survival[21]. Non-irrigated green roofs planted with very tough, exotic succulents with high leaf succulence may also show poor health, reduced aesthetics and some mortality in response to extreme conditions[11]. In these cases, contingency irrigation can be considered to improve plant health and aesthetic outcomes during hot or dry periods, particularly preceding, during and following heatwaves when substrates can reach excessive temperatures[11].

The water use requirements of plants vary and therefore horticultural plant knowledge and expertise is important when designing green roofs for specific objectives. There are a number of publications detailing the water requirements for different plant species and cultivars which can assist plant selection for different climates, irrigation regimes and substrate depths (e.g. WUCOLS[22]).

Table 2.2 summarises the irrigation requirements for the five green roof typologies based on research into plant survival and observations of existing green roofs. The three irrigation categories are a general guide and should be tailored to each project based on the species planted, substrate depth and local climate.

1. **No irrigation** – Green roofs planted with very succulent drought tolerant plants where irrigation is used for establishment only. Contingency or supplementary irrigation (can be hand-watering) can be considered to improve plant survival and prevent foliage die-back during heat waves or extended dry periods.
2. **Summer irrigation** – Green roofs that are mostly reliant on rainfall in winter (no irrigation) with additional irrigation over summer.
3. **Year-round irrigation** – Green roofs that receive regular irrigation (adjusted seasonally) to maximise growth and survival of plants with higher water use or for food production. Irrigation should be zoned across green roofs to match areas of different substrate depth and plant types.

Table 2.2. Irrigation requirements for five different green roof typologies and example plant species

Irrigation regimes	Green roof type	Example species
No irrigation or contingency irrigation	Shallow succulent green roof	• *Aloe brevifolia* (Short-leaved Aloe) • *Crassula arborescens* 'Blue Bird' • *Sedum pachyphyllum* (Jelly Beans)
Summer irrigation	Shallow biodiverse green roof	• *Arthropodium milleflorum* (Pale Vanilla-lily) • *Dianella revoluta* (Black Anther Flax Lily) • *Geranium solanderi* var. *solanderi* (Austral Cranesbill)
	Green roof showcasing flowers and foliage	• *Chrysocephalum semipapposum* (Clustered Everlasting) • *Lavandula angustifolia* (English Lavender) • *Pelargonium sidoides* (South African Geranium)
Year-round irrigation	Green roof for amenity and recreation	• *Trachelospermum jasminoides* (Star Jasmine) • *Coreopsis lanceolata* (Tick Seed) • Turf
	Green roof for food production	• *Capsicum annuum* (Chillies, Capsicum) • *Citrus limon* (Lemon) • *Solanum lycopersicum* (Tomato)

Contingency and establishment irrigation can be delivered via hand-watering, whereas summer or year-round irrigation requires an irrigation system e.g. sprinklers or drip systems (below or above surface). If using drip lines, the emitters should be spaced close together to ensure adequate saturation as green roof substrates are very free-draining and water tends to percolate directly down with limited horizontal flow. In some situations, spray irrigation can be more effective at ensuring even watering across substrate surfaces, although more water can be lost under windy conditions. It is also better to apply more frequent irrigations of small volumes than a single larger irrigation volume as water drains quickly and does not reach field-capacity. Water sensors and timers can be used to deliver a set volume of water at regular intervals during irrigation periods. Smart-water sensors can also reduce irrigation frequency and volume when rainfall is forecast, improving water use efficiency as well as maximising rainfall retention on the green roof – the latter also being beneficial for stormwater management.

While sprinklers and drip systems are the predominant forms of irrigation on Australian green roofs, wicking systems are being increasingly used in containerised modules for food growing. Wicking systems store water in a reservoir beneath the substrate and water is 'wicked' by capillary action into the root zone. All wicking systems rely on substrates having adequate 'capacity rise' for the vertical movement of water through the profile which becomes difficult in deeper substrates (> 500 mm depth), or as physical properties change as substrates age. Supplementary overhead irrigation is usually required during establishment to allow roots to grow and access the water reservoir.

Use of harvested rainfall for irrigation is recommended and is increasingly incorporated into new builds as it improves stormwater retention at a building scale[23]. Because potable water is also subject to restrictions during drought periods, relying on drinking water as the only water source could impact green roof longevity. Climate change modelling indicates a trend towards higher temperatures, more frequent and longer heatwaves and more severe water scarcity in Melbourne and other Australian cities[24]. Future green roofs should therefore include irrigation based on alternative water sources in their design. Rainfall patterns are also expected to become more variable – for example, Melbourne is predicted to have less rain in winter and spring (and to a lesser extent autumn) with more intense and variable rainfall events across all seasons[24].

Image: R. Bathgate

3

Plant selection for environmental and social benefits

There is now a considerable body of scientific evidence underpinning green roof plant selection and the benefits plants provide on Australian green roofs[21]. Plant survival, plant health and vegetation cover are essential elements for delivering functional green roofs and environmental and social benefits. Good green roof design extends beyond selecting plants based only on their ability to survive, but also considers how they perform when combined with other species to create functional, healthy plant assemblages that persist over time. The characteristics that enable plant survival may not necessarily maximise green roof function. For example, plants with small, tough and grey leaves which can survive on unirrigated green roofs are unlikely to provide social benefits as they are less preferred from a visual perspective than plants with green, grass-like leaves[25]. Similarly, plants with dense canopies of larger leaves may deliver greater cooling benefits through shading and transpiration than smaller leaf plants with sparse canopies, however large-leaf plants are likely to be higher water users and die more rapidly in response to hot and dry green roof conditions[17].

This section outlines some of the recent research that illustrates how appropriate plant selection can contribute to stormwater management; building thermal regulation; biodiversity; and amenity, recreation and wellbeing.

3.1 Stormwater management

Green roofs are an excellent tool for managing stormwater runoff in southern Australia. In Melbourne, a 10 cm deep green roof can retain 89-95% of all annual rainfall[26]. As most current and historical rainfall events in Melbourne are small (< 2mm), studies have found that doubling substrate depth from 15 to 30 cm does not double rainfall retention[19]. However, increased substrate depth does reduce plant stress as more water is stored in the substrate for plants to use between rainfall events[19]. Where weight loading is limited, a 15 cm substrate depth balances the need for rainfall retention with avoiding plant drought stress[21,26].

To maximise rainfall retention on green roofs it is important to minimise hard surfaces such as decking and paving and increase planted areas. Vegetation cover on accessible amenity green roofs or roof gardens is generally lower than for other green roof types. A recent survey of Melbourne amenity green roofs found an average of 40% plant cover with the remainder hard landscaping (Schiller, unpublished data) . While hard surfaces such as paving and decking provide communal spaces and valuable opportunities for social interaction, respite and restoration, they decrease rainfall retention. Where these design constraints exist stormwater benefits can still be achieved at a site level by rainwater capture and storage for subsequent irrigation on the green roof or surrounding landscape.

3.2 Building thermal regulation

Green roofs can reduce heating and cooling costs of rooms located directly below as green roofs are typically cooler in summer and warmer in winter than traditional roofs. Green roofs can regulate roof surface temperatures though shading, insulation, reflecting solar radiation and through evapotranspiration from plants and substrates[27]. While all green roofs with healthy vegetation and good coverage will provide some cooling benefits, mixtures of species such as *Lomandra* (Mat-rush), *Dianella* (Flax Lily) and *Stypandra glauca* (Nodding Blue Lily) are generally better at cooling than monocultures (single species plantings) due to their greater leaf area and higher albedo[28]. In southern Australia, irrigated green roofs lower substrate temperatures which, when combined with the insulative properties of the substrates themselves, reduces heat gain into the underlying building[29]. In Melbourne, 15 cm deep substrates strike a balance between providing optimal cooling and reducing weight-loading of green roofs[30].

3.3 Biodiversity

Green roofs designed to support floral and faunal diversity can be planted with Australian native or indigenous species, exotics, or a mixture of natives and exotics, depending on the design objectives. Green roofs designed for biodiversity are gradually increasing in Australia but tend to be generalist in nature – meaning they are designed for any potential native faunal species in the local area, rather than tailored for specific species. Green roof habitats are not equivalent to ground-level urban habitats in terms of types and numbers of species, and communities are dominated by mobile urban generalists with few rare species[31]. However, even when planted with exotic species, all green roofs support some level of faunal diversity and are more beneficial than bare roofs in terms of habitat provision. Further information on designing Australian biodiversity green roofs can be found in *Guidelines for Biodiversity Green Roofs*[32].

Foliage, flowers and non-living materials provide habitat and food resources for insects, birds and bats, and green roofs can potentially act as habitat stepping-stones to connect populations at a landscape scale. Green roof design features which can provide habitat and food resources for invertebrates, birds and bats include:

- Using a diverse range of plants, especially indigenous or native Australian plants. Exotic succulent species are generally not planted for their biodiversity benefits, however honeybees and native bees have been observed on small succulent flowers e.g. *Curio repens* (Blue Chalksticks).
- Plants that flower at contrasting times provide nectar and pollen throughout the year for pollinators and birds.
- Providing a range of vegetation layers (from ground covers and herbs to shrubs and small trees) on green roofs increases biodiversity by providing more types of habitats[33,34] which will be supported by deeper substrates (>20 cm).
- Seasonal growth and die-off of foliage can create habitat structure, a food source for some invertebrates and nesting material for birds.
- Non-living features such as ephemeral and permanent sources of water, dead wood and rocks.
- Using a range of substrate types and different particle sizes and providing bare patches and small mounds to create microhabitats for burrowing invertebrates.

Figure 3.1 Green roof plants can provide food for a range of faunal life stages, including invertebrate larvae, as seen here on the native Australian *Isotoma axillaris*. Image: J. Rayner

3.4 Amenity, recreation and wellbeing

Green roofs are an important part of healthy and liveable cities and can provide benefits for city residents and workers, by improving views and outlooks, and by creating spaces for recreation and restoration[21,35]. Views of green roofs can provide vistas of seasonal change while access to green roofs can provide nature connections and opportunities for social interaction[35]. Viewing images of a highly preferred flowering grassy green roof, compared to a standard city view, has also been found to improve attention during complex tasks[36], and may improve workplace productivity[37].

Most new green roofs in Australian cities have been built on new apartment buildings to provide recreational opportunities, or in health care and educational settings for their restorative benefits. This contrasts with most roofs overseas where shallow green roofs are predominantly built for their environmental benefits[21,38]. Accessible green roofs or roof gardens with deeper substrates are more costly to build but also contribute to building sustainability and associated accreditation through platforms such as Green Star (Green Building Council Australia) and the Green Factor Tool (City of Melbourne).

An important consideration in plant selection when designing green roofs for wellbeing is that people prefer viewing green roofs with flowering, green, grass-like plants (e.g. *Dianella revoluta,* Black Anther Flax Lily, and *Arthropodium milleflorum,* Pale Vanilla Lily) and prefer taller plants over low-profile species[25]. Factors which contribute to creating beneficial green roofs for people include the physical environment (e.g. healthy plants), social climate (e.g. green roofs as nature), activities (e.g. socialising), and individual adaptation (e.g. flexible spaces) on and around the green roof[35].

A recent global survey (Lee et al., In Prep) found people had distinct preferences for different green roof typologies and engaged more with 'structural roofs' - roof gardens that have both planted areas and hard landscaping such as paths (Fig 3.1). People preferred 'structural roofs' over colourful succulent green roofs, followed by messy biodiverse meadows. The least preferred green roof was one featuring traditional open lawns. In a related study based on virtual green roof tours, researchers found people wanted green roofs that could deliver multiple experiences, including social connection as well as solitude, an escape from the city/work, and the ability to actively engage with the space[39]. Green roof design features that people responded positively to include:

- Complexity – people engage in interesting and connected features and forms
- Change – anticipation of seasonality in growth, flowering, leaf colour
- Movement – the ability to explore and engage with landscape features during and across visits through different zones, hidden parts and a variety of views
- Multi-sensory – using sight, smell, touch, and sound to create an immersive experience
- Distant vistas – roof height, vastness, and scale, including natural features such as the sky, water, and city features

These features are captured in the plant palettes of *Green roof showcasing flowers and foliage* and *Green roof for amenity and recreation* (Chapter 4). Both palettes include diverse plant forms, variation in foliage and flower colour and, for amenity green roofs, the use of trees and climbing plants.

Figure 3.1 Selection of green roof images used in a vegetation preference study showing the most preferred (top row) and least preferred (bottom row) green roof plantings (from Lee at al., In Prep). Image 2: Andrew Clements – greenroofs.com, Image 3: Linda Valazquez – greenroofs.com. Other images Uni Melb.

4

Plant palettes for Australian green roofs

This chapter presents example plant palettes for five green roof typologies representative of those found in Australian cities. Recommended species and cultivars are based on our research and experience from established green roofs in southern Australian climates. These lists are not exhaustive and readers are encouraged to experiment with other plants with comparable traits and habitats of origin. Some of the recommended species will flourish on more than one green roof type, while others are more restricted.

Green roof plants rarely reach the sizes of their species counterparts at ground level because of the limited substrate volumes, substrate characteristics and climatic factors at elevation. See Chapter 6 for more information on species characteristics including life-form, common name and indicative sizes.

Green roof typologies:

1. **Shallow succulent green roof**
   10-20 cm substrate depth
2. **Shallow biodiverse green roof**
   10-20 cm substrate depth
3. **Green roof showcasing flowers and foliage**
   20-50 cm substrate depth
4. **Green roof for amenity and recreation**
   30-80 cm substrate depth (1 m for trees)
5. **Green roof for food production**
   30-100 cm substrate depth

Green roofs are multifunctional and all of these green roofs will provide varying degrees of stormwater management, cooling and biodiversity benefits.

4.1 Shallow succulent green roof

Shallow, succulent green roofs are designed to be low maintenance, low irrigation vegetated systems and are useful in retrofitting situations where the loadbearing capacity of the underlying structure is restricted. Lightweight succulent green roofs are very common in North America and Europe and are frequently used in situations where resilient, low maintenance green roofs are required e.g. on factory roofs.

Robust, low-growing and upright forms of exotic succulents have been found to have better survival outcomes that native succulents on shallow green roofs in southern Australian summers[11]. Exotic species with very succulent leaves and low water use (e.g. *Sedum pachyphyllum,* Jelly Beans) can survive hot periods of extended drought better than succulents with small leaves. While native succulents such as *Carpobrotus modestus* (Inland Pigface) and *Disphyma crassifolium* (Rounded Noon Flower) have very succulent leaves, they are higher water users, and therefore have lower survival as they lose stored water more rapidly[12].

Generally, succulents are easy to propagate and can be sourced as small plugs (tubestock) or larger pots. Roll-out succulent mats and pre-planted modules are used overseas, although Australian nurseries are yet to provide these options. Succulents should be planted at high density (up to 18 plants per m^2) to provide adequate coverage and aid shading across the substrate surface[1].

- Shallow substrate 10-20 cm deep
- Low-growing, succulent plants tolerant of hot and dry green roofs
- Dense planting – spacing of 16-18 plants per m^2 for rapid coverage (assuming plants as tube stock)
- Foliage colour and leaf texture are the main design features and can be emphasised by clumping or grouping similar plants
- Plant form, shape and flowers also provide contrast and variety – many succulents flower winter-spring
- Geophytes (bulbs, corms, rhizomes and tubers) and Australian annuals (direct seeding) can be added to enhance flowering (See Section 4.6)

Snapshot

Plant palette	Drought-tolerant succulents
Substrate depth and composition	10 – 20 cm deep substrate Primarily mineral-based (80-90% by volume), less than 20% organic components. Low fertiliser
Primary functions	Stormwater management and building thermal regulation
Other functions	Aesthetics. May have some biodiversity outcomes due to succulent flowers. Biodiversity can be increased if planted with additional geophytes and Australian annuals
Irrigation	Establishment No irrigation except under extreme conditions (e.g. extended heatwaves)
Access	Maintenance access
Maintenance frequency	Quarterly to biannual. More frequently in the first 3-6 month establishment period.

4.1 Shallow succulent green roof

Succulent


Aeonium ‘Velour’


Aeonium haworthii


Aloe brevifolia


Aloe perfoliata


Cotyledon orbiculata


Crassula arborescens ‘Blue Bird’


Crassula atropurpurea var. *anomala*


Crassula biplanata

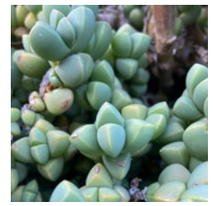

Crassula capitella ‘Campfire’


Crassula tetragona


Curio repens


Curio talinoides var. *mandraliscae*


Delosperma echinatum


Delosperma lehmannii


Drosanthemum floribundum


Echeveria ×imbricata


Euphorbia flanaganii


Hesperaloe parviflora


Hylotelephium ‘Autumn Joy’


Kalanchoe beharensis

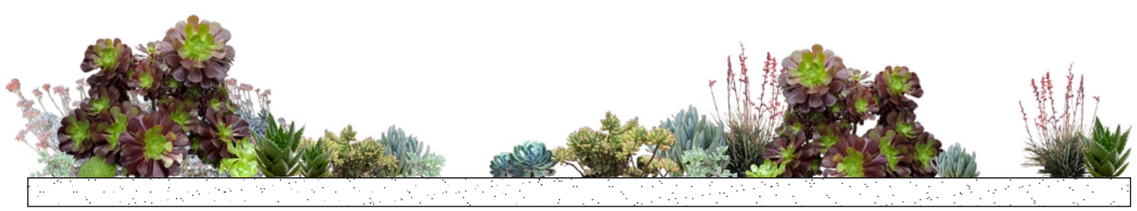

Lampranthus aureus


Lampranthus deltoides


Sedum confusum


Sedum pachyphyllum


×*Sedeveria* ‘Pat’s Pink’



4.2 Shallow biodiverse green roof

This palette showcases Australian temperate grassland species but a wide range of other plant types drawn from other habitats or local/indigenous vegetation communities can be used – for example rocky outcrops or coastal habitats. Use of a wide range of plant species and forms can create diverse habitat and food provisions for a correspondingly diverse range of invertebrates, birds and bats. Minimal irrigation is required for biodiverse roofs but is recommended during establishment and extended hot/dry periods to ensure survival. 'Biodiversity' can also create problems on a green roof – for example possums and rats may forage on plants and large numbers of exotic birds may use green roofs for habitat and nesting.

Habitat features such as rocks, wooden branches, areas of bare substrate and ponds diversify the range of habitat niches and provide access to water.

- **Water** Permanent or ephemeral water sources can minimise the risk of mortality for less mobile species and life-stages. Water features can be designed as a small pond or a low-flow stream using water diverted from a downpipe or air conditioner.
- **Substrates** Using different substrates with different particle sizes (fine to coarse) can increase diversity of fauna using green roofs. Some burrowing invertebrates and birds prefer bare, unvegetated substrates. Creating microtopographical variation with mounds and depressions can increase habitat niches and promote seed germination.
- **Rocks** Varying sizes of rocks, broken bricks and tiles can creating habitat, areas for sunning and refuges from predators.
- **Branches and logs** Can provide roosts for birds and habitat for insects. Decaying wood can be colonised by mosses, lichen, fungi, beetles and flies, which can in turn provide food for other animals. Branches and logs need to be secured to the roof to prevent movement and fall hazards.
- **Artificial nests, hollows and cavities** May be utilised by insects, birds and bats, particularly where natural nesting sites have been lost through urbanisation. For birds and bats these can create safe havens from foxes and cats.

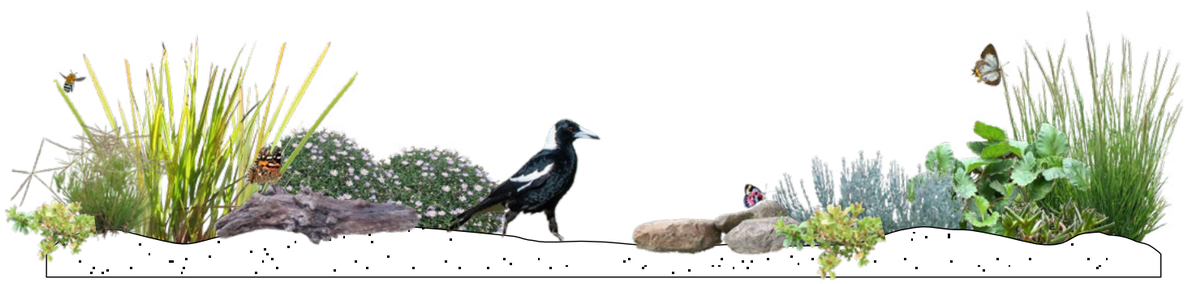
While many native plants have high visual appeal the visual amenity of these green roofs is less important than their biodiversity benefits. In general, human access to biodiverse roofs is restricted to maintenance activities to minimise disturbance to plants and animals and as a safety precaution as many biodiverse green roofs are not fitted with balustrades.

- Glass balustrades should be avoided due to chance of bird collision and use of artificial lights is also undesirable as it attracts animals with potential detrimental effects on animal health. For more on biodiverse roofs for Australian conditions see *Guidelines for Biodiversity Green Roofs*[32].
- Shallow substrate 10-20 cm deep
- Plant palette is mostly indigenous to Melbourne with additional native plant species that have known habitat and biodiversity values
- When adding other species, local plant communities can be used as habitat templates for plant selection, taking into account hot and dry conditions on shallow green roofs, even when irrigated
- Planting design should maximise plant cover across the green roof with additional habitat features such as ephemeral and permanent sources of water, dead wood and rocks (need to consider these when calculating green roof weight loading)

Snapshot

Plant palette	Australian drought-tolerant herbaceous plants, including grasses and strappy leaf plants (i.e. sedges and rushes) and flowering perennials and annuals. Non-living features such as logs, bee hotels, water elements and undulating substrates provide additional habitat
Substrate depth and composition	10 – 20 cm deep substrate Primarily mineral-based (80-90% by volume) to ensure low weight and stability over time
Primary functions	Biodiversity
Other functions	Stormwater management and building thermal regulation
Irrigation	Establishment and over summer
Access	Maintenance access
Maintenance frequency	Bimonthly to quarterly. More frequently in the first 6-month establishment period.

Image: J. Schiller



4.2 Shallow biodiverse green roof

Grasses and strappy leaf plants

Arthropodium milleflorum

Chloris truncata

Dianella revoluta

Dichelachne crinita

Themeda triandra

Perennial herbs and succulents

Brachyscome multifida

Calocephalus citreus

Calocephalus lacteus

Carpobrotus rossii

Dichondra repens

Geranium retrorsum

Geranium solanderi var. solanderi

Hypericum gramineum

Isotoma axillaris

Linum marginale

Pelargonium rodneyanum

Plantago gaudichaudii

Podolepis jaceoides

Senecio quadridentatus

Wahlenbergia capillaris

Shrubs and subshrubs

Chrysocephalum semipapposum

Correa reflexa

Eutaxia microphylla

Hibbertia obtusifolia

Platylobium obtusangulum

4.3 Green roof showcasing flowers and foliage

These green roofs are designed for aesthetic values to enhance urban vistas and provide restorative natural views in cities where skylines tend to be dominated by hard infrastructure. These roofs may be inaccessible and viewed from inside the building or surrounding buildings, or may be wholly accessible, providing an immersive nature experience.

The use of deeper substrates (up to 50 cm) increases the range of plant types with the mix of Australian and exotic long-flowering perennials and small shrubs designed to deliver maximum visual impact. This plant palette contains flowering species that can provide pollen and nectar to native invertebrates, bees and birds, while foliage offers habitat. This plant list contains only a sample of the extensive range of suitable species and also draws on social research on preferred green roof plant characteristics[25].

Irrigation of these green roofs depends on species selection. Drought tolerant species only need summer irrigation but year-long irrigation ensures year-round visual benefits and supports a wider plant palette. Perennial species may be supplemented by quick growing annuals and ephemerals, particularly those originating from dry and arid climates[1]. Flowering annuals and geophytes (bulbs, corms, rhizomes and tubers) can also add to the changing seasonal display (See 4.6).

- 20-50 cm deep substrate
- Plant palette features mass plantings of a diverse range of flowering Australian and exotic perennials and small shrubs with an emphasis on flowering and interesting foliage for year-round display
- Planting design and selection needs to be based on substrate depth, irrigation and maintenance (horticultural skills and time to maintain the intended design)
- For lower maintenance plantings, select compact plant forms which do not require deadheading of flowers or frequent pruning
- Irrigation is essential during establishment and either summer or year-round irrigation should be used to maintain plant growth and survival to maximise aesthetics
- Planting design can be based around simple combinations of clump or block-style plantings at low density, through to complex, matrix approaches with high density and diversity. Contrast can be achieved through different colours and texture

Image: R. Bathgate

Snapshot

Plant palette	Long-flowering Australian and exotic perennials and small shrubs. Diverse plant forms – emphasis on flowering and interesting foliage
Substrate depth and composition	20-50 cm deep substrate Primarily mineral-based (80-90% by volume) to ensure low weight and stability over time
Primary functions	Visual display, building thermal regulation and stormwater management
Other functions	Biodiversity and wellbeing. Social benefits if accessible.
Irrigation	Establishment Summer irrigation if planted with low water use species Year-round irrigation if planted with high water use species or create irrigation zones across the roof to match plant type
Access	Access varies with location and design – may be accessible and designed for recreation or social benefits or designed to be overlooked (access for maintenance only)
Maintenance frequency	Fortnightly – monthly. May be more frequent in the initial 6-12 month establishment period.

4.3 Green roof showcasing flowers and foliage

Grasses and strappy leaf plants

Anigozanthos spp. and cv.

Arthropodium milleflorum

Bulbine frutescens

Lomandra longifolia

Miscanthus ‘Kleine Fontaine’

Perennial herbs

Achillea ‘Moonshine’

Brachyscome multifida

Cerastium tomentosum

Chrysocephalum apiculatum

Chrysocephalum semipapposum

Cota tinctoria ‘Susanna Mitchell’

Dianthus cultivars

Erysimum cheiri

Euphorbia ‘Silver Swan’

Lotus berthelotii

Nepeta ‘Walkers Low’

Oreganum vulgare

Pelargonium sidoides

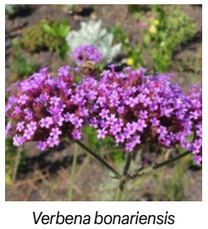
Puya ferruginea

Salvia fruticosa ‘Greek Skies’

Scaevola albida

Stypandra glauca

Tulbaghia violacea



Verbena bonariensis

Veronica perfoliata

Shrubs

Goodenia ovata (prostrate)

Lavandula angustifolia

Lechenaultia formosa

Leonotus leonuris

Olearia axillaris

4.4 Green roof for amenity and recreation

Roof gardens support a wider plant palette and can include trees as most are installed on new buildings engineered to accommodate greater weight-loading. Installing turf and trees requires careful consideration and expert advice.

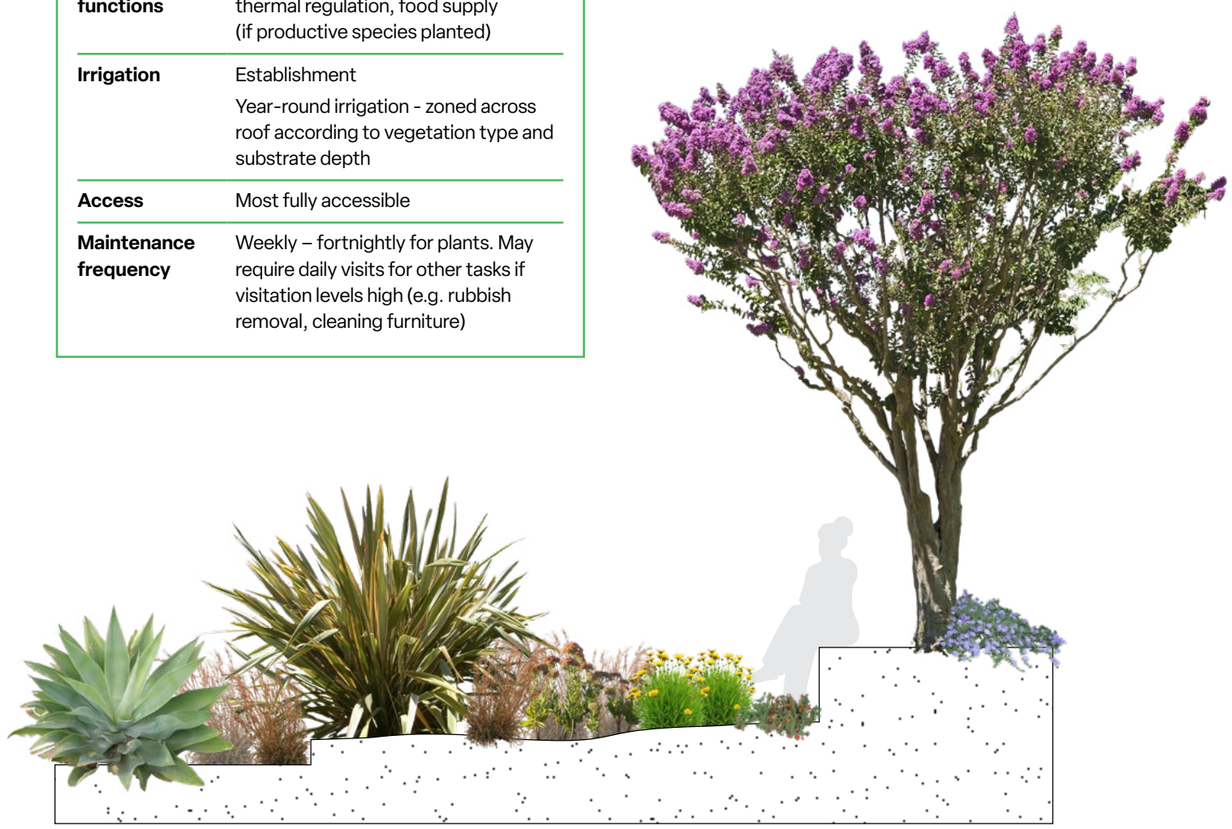
Installing turf should be done in consultation with a turf specialist and the green roof membrane provider as some species can damage waterproofing membranes[1]. On smaller green roofs, avoid species with excessive vigour, such as Couch Grass (*Cynodon dactylon*) and Kikuyu (*Pennisetum clandestinum*). Turf can be intensive to maintain as it needs regular irrigation, fertilising and mowing. Substrates with greater amounts of organic matter are needed and turf can be susceptible to damage from high use.

Trees present unique challenges on green roofs due to wind, exposure and shallow substrate depths. All trees require anchoring and will be limited by substrate depth and volumes. While small trees (< 6 m) can be successfully grown in 60 cm deep substrates, at least 1 m deep substrates are recommended, especially if trees are used for shading[1]. The engineering requirements for larger trees (to 10 m) are beyond the scope of this guide. Climbing plants on arbours and trellises can also provide shade and privacy, but plants need to tolerate increased wind force at elevation and around built structures.

- 30 – 80 cm deep substrate, up to 1 m for trees
- Substrate depths and planting types may vary across the roof, with zoning for different design outcomes. Examples include:
  - → Smaller trees for shade near seating or passive spaces
  - → Areas of turf for recreation
  - → Sensory planting (fragrance, visual, sounds, taste) near seating
  - → Planting to frame views beyond the green roof
  - → Using plant heights to promote circulation and movement or screening from wind and sun
- Even though substrates are deeper, choose robust and reliable species that will perform well as green roofs are more hostile than ground-level landscapes
- May include small productive spaces or use of potted plants for seasonal interest or for plants that are difficult to grow in the green roof beds
- Year-round irrigation – zoned across roof according to vegetation type and substrate depth
- Consider using long-flowering plants when the maintenance inputs are restricted and expectations are high. Green roofs can also produce longer flowering for many perennials and shrubs due to elevated temperatures
- Consider how hard landscaping influences and complements plantings and vice versa, for example the use of barriers for wind mitigation and safety

Snapshot

Plant palette	A wide range of plant palettes focused on aesthetics plus hard landscape elements. May include trees, shrubs, herbaceous perennials and food plants.
Substrate depth and composition	30-80 cm deep – can vary according to planting zones/plant type 100 cm depth and adequate volume recommended for larger trees Primarily mineral-based (80-90% by volume) with more organic-based substrate if growing food species or turf
Primary functions	Amenity, social connections, restoration, health and wellbeing
Other functions	Stormwater management, building thermal regulation, food supply (if productive species planted)
Irrigation	Establishment Year-round irrigation - zoned across roof according to vegetation type and substrate depth
Access	Most fully accessible
Maintenance frequency	Weekly – fortnightly for plants. May require daily visits for other tasks if visitation levels high (e.g. rubbish removal, cleaning furniture)



4.4 Green roof for amenity and recreation

Grasses and strappy leaf plants


Anigozanthos 'Big Red'


Helictrotrichon sempervirens


Lomandra filiformis


Phormium tenax


Themeda triandra

Perennial herbs and succulents


Agave attenuata


Convolvulus sabatius


Coreopsis lanceolata


Eschscholzia californica


Hylotelephium 'Matrona'


Isotoma axillaris


Kennedia prostrata


Salvia nemorosa


Silene coronaria


Tradescantia 'Sweet Kate'

Shrubs


Calytrix tetragona


Cistus salviifolius


Grevillea 'Seaspray'


Lechenaultia formosa


Teucrium marum

Climbers


Aphanopetalum resinosum


Bougainvillea glabra


Hardenbergia violacea


Thunbergia alata 'Aurantiaca'


Trachelospermum jasminoides

Trees


Corymbia citriodora 'Scentuous'


Cupaniopsis anacardioides


Ficus macrocarpa var. hillii


Geijera parvifolia


Lagerstroemia indica

4.5 Green roof for food production

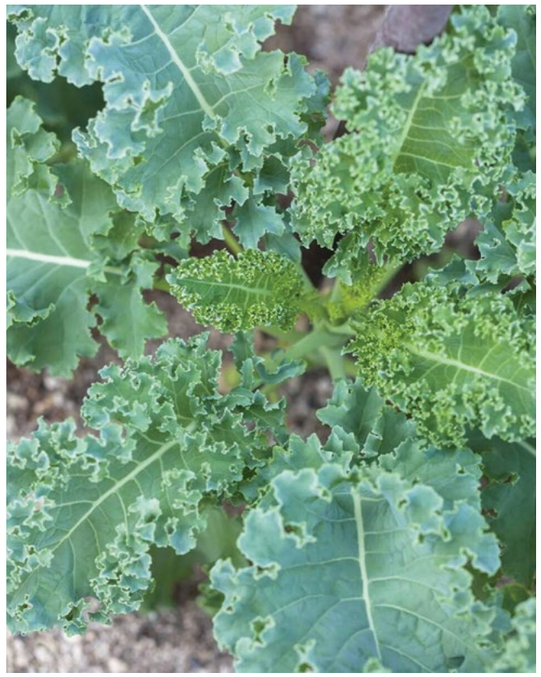
Rooftops and terraces offer space to cultivate and connect with food, bring people together and experience nature. Rooftop farms also provide opportunities for developing skills, education and community cohesion. Herbs, fruit trees and crops such as broccoli, tomatoes and lettuces can all be successfully grown on green roofs. Productive green roofs in Australia have seen a diversification in planter types including wicking beds, hydroponics, traditional planter boxes and garden beds. Substrate depth will vary with plant type, with deeper substrates recommended for fruit trees. Substrates used in productive green roofs have higher organic matter and need topping up to maintain depth. Productive green roofs have higher maintenance as plants tend to have shorter life spans (annual and biennial plants) and require regular plant replacement. During maintenance, care is needed to avoid damaging roof waterproofing membranes with digging or stakes.

While sustainability may be an objective of some productive green roofs, for example in the reduction of food miles, some consideration needs to be given to other factors that may impact food species and quality of produce, for example proximity to major roads and urban air quality. These factors can be assessed during the initial site analysis.

- 30-100 cm deep substrate
- Substrate depths and planting types may vary across the roof. Examples include:
  - → Shallow-rooted plants (~30 cm) e.g. lettuce, annual herbs
  - → Deeper-rooted species (30-50 cm) e.g. tomatoes, beetroot
  - → fruit trees (50-100 cm)
- Plant selection for different zones should focus on plant tolerances to solar radiation/light, as well as access for maintenance and harvesting
- Substrate volumes are also important as they will help to guide plant density as overplanting can lead to competition and affect crop yields
- Substrate nutrition needs to be carefully managed and regularly tested to ensure that nutrient levels lie within specified ranges
- Year-round irrigation – zoned across roof according to vegetation type and substrate depth. Many crops will have a higher water demand compared to ground-level conditions due to the elevated heat and solar radiation
- Selection of disease and pest resistant cultivars of crop plants can be more important on a green roof due to difficulties in using some forms of pest and disease controls at elevation. Management of pests and diseases should include Integrated Pest Management, fallowing and crop rotation
- Crop protection from possums, birds and other animals may be needed

Snapshot

Plant palette	Vegetables, fruit trees and herbs
Substrate depth and composition	30-100 cm deep – can vary according to plant type and rooting depth. Lightweight, organic rich substrate. Will naturally break down and require topping up
Primary functions	Food production
Other functions	Social interaction, wellbeing, biodiversity, stormwater management and building thermal regulation
Irrigation	Establishment Year-round irrigation – zoned across roof according to crop/vegetation type and substrate depth
Access	Fully accessible
Maintenance frequency	Daily-weekly



4.5 Green roof for food production

Cullinary herbs

Chives
Allium schoenoprasum

Coriander
Coriandrum sativum

Peppermint
Mentha ×piperita

Basil
Ocimum basilicum

Oregano
Oreganum vulgare

Parsley
Petroselinum crispum

Rosemary
Rosmarinus officinalis

Sage
Salvia officinalis

Thyme
Thymus vulgaris

Lemon balm
Melissa officinalis

Vegetables and fruits

Garlic
Allium sativum

Beetroot
Beta vulgaris subsp. vulgaris

Broccoli
Brassica oleracea vars.

Kale
Brassica oleracea vars.

Capsicum
Capsicum annuum

Chillies
Capsicum annuum, C. frutescens & C. chinense var.

Cucumber
Cucumis sativus

Arugula/Roquette
Eruca vesicaria subsp. sativa

Strawberry
Fragaria ×ananassa

Lettuce
Lactuca sativa

Beans
Phaseolus vulgaris

Peas
Pisum sativum

Radish
Raphanus sativus

Tomato
Solanum lycopersicum

Eggplant
Solanum melongena

Vegetables and fruits

Feijoa
Acca sellowiana

Lemon
Citrus limon

Fig
Ficus carica

Apple
Malus domestica

Pomegranate
Punica granatum

4.6 More flowers and foliage

Seasonal flowers and foliage are excellent at providing visual interest to green roofs and the plants listed here can be used across the different green roof typologies. These additional species can be added either through direct seeding (flowering annuals) or by planting bulbs, corms, rhizomes or tubers (geophytes). Geophytes flower annually then die off – persisting in the substrate through storage organs such as bulbs and corms, and resprouting under favourable conditions. Ideally annuals that rely on seeds to establish would be self-seeding on the green roof, minimising the need for supplementary seeding while bulbs that multiply can be divided and used to replenish other areas of the roof. The Australian annuals listed here have been trialled successfully under green roof conditions by University of Melbourne researchers[18], with geophytes found to grow well on the Burnley Demonstration Green Roof and overseas[40].
For more details of these and other species see Chapter 6.

Image: inaturalist.org/observations/142424613

4.6 More flowers and foliage

Australian flowering annuals

Brachyscome iberidifolia

Calandrinia eremaea

Craspedia variabilis

Podotheca gnaphalioides

Rhodanthe chlorocephala subsp. *rosea*

Rhodanthe humboldtiana

Rhodanthe manglesii

Rhodanthe stricta

Schoenia cassiniana

Schoenia filifolia subsp. *subulifolia*

Schoenia macivorii

Xerochrysum bracteatum

Geophytes

Allium amplelоprasum

Allium schoenoprasum

Allium tuberosa

Arthropodium milleflorum

Bulbine bulbosa

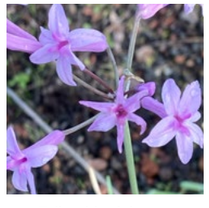
Crocosmia ‘Lucifer’

Freesia cvs.

Iris germanica

Narcissus ‘Grand Soleil d’Or’

Pelargonium rodneyanum



Tulbaghia violacea

Wahlenbergia stricta

5

Green roof case studies

The case studies in this chapter showcase green roofs where plant selections have been made that satisfy both the design brief and local site conditions. Each case study represents one of the green roof typologies outlined in this guide, with a focus on sites in Melbourne and regional Victoria. Information on species performance is included along with notes on the key challenges and learnings associated with sustaining plants at individual sites. The plant palettes provided in each case study are an additional resource that can be used to guide new green roof designs, with many of the species adaptable to a wide range of contexts and green roof typologies.

- Shallow succulent green roof case study: Burnley Demonstration Green Roof, University of Melbourne
- Shallow biodiverse green roof case study: Minifie Park, City of Boroondara
- Green roof showcasing flowers and foliage case studies: Victorian Parliament House and Skyhouse Garden, Melbourne
- Green roof for amenity and recreation case studies: Skypark, Melbourne and Bendigo Hospital
- Green roof for food production case study: Acre Farm, Burwood

5.1 Burnley Demonstration Green Roof – Shallow succulent green roof

The Burnley Demonstration Green Roof is used for demonstration, teaching and research and provides a valued outdoor space for building occupants and visitors. Retrofitting on a heritage building necessitated the use of shallow substrates (mineral-based substrates e.g. 'Burnley scoria green roof mix') and plants are a mix of drought-tolerant Australian and exotic succulent species that provide seasonal interest and are low maintenance.

Plants in the shallow 10-20 cm zones are succulents which have been trialled in green roof experiments at Burnley and others which grow successfully in tough ground-level landscapes or on overseas green roofs in similar climates. A wide range of species and cultivars have been trialled on this roof and knowledge around plant tolerances has informed the plant palettes in this guide. The best performing plants have highly succulent stems and leaves e.g. ×*Sedeveria* 'Pat's Pink', *Aloe perfoliata* (Mitre Aloe) and *Crassula tetragona* (Miniature Pine Tree).

Table 5.1 Best performing succulent plants in unirrigated 10-20 cm zones

Succulent herbs

×*Sedeveria* 'Pat's Pink'
Aptenia cordifolia (Baby Sun Rose)
Crassula capitella 'Campfire'
Echeveria ×imbricata (Blue Rose Echeveria)
Hesperaloe parviflora (Red Yucca)
Hylotelephium telephium 'Autumn Joy'
Lampranthus aureus yellow form (Iceplant)
Delosperma echinatum (Pickle Plant)
Delosperma lehmannii (Ice Plant)
Sedum 'Star Carpet'
Curio talinoides subsp. *mandraliscae* (Blue Chalksticks)
×*Disphyma* 'Sunblest'

Succulent shrubs

Aloe brevifolia (Short-leaf Aloe)
Aloe perfoliata (Mitre Aloe)
Crassula tetragona (Miniature Pine Tree)
Crassula arborescens 'Blue Bird'

Figure 5.1 Burnley Demonstration Green Roof showing substrate depths and irrigation of different zones. Plants in this case study are found in the 10, 15 and 20 cm unirrigated scoria beds zones 1-3. Images: University of Melbourne.

Design Objective
Demonstration green roof for teaching and research. Different substrate depths, substrate types and irrigation regimes. The shallow (<20 cm deep), unirrigated zones are planted with a range of succulents

Location
Main Building, Burnley campus, University of Melbourne

Area
Unirrigated 10-20 cm zones within a larger 166 m^2 roof

Completed
2013

Green Roof Design and Plant Selection
Design by Hassell, with plant selection by University of Melbourne researchers

Images: University of Melbourne

5.2 Minifie Park – Shallow biodiverse green roof

Minifie Park Green Roof is one of the earliest biodiversity green roofs in Australia to use indigenous plants. It was designed as part of a new build to improve building thermal regulation, integrate the building into surrounding parkland, and create habitat for fauna using indigenous plant species[1] .The plant palette is a mix of low-growing Victorian perennial grasses and herbs representative of the remnant vegetation that would have naturally occurred in the area – Plains Grassy Woodlands and Creekline Grassy Woodlands[41,42]. Flowers provide seasonal colour and interest over a significant part of the year. The low plant height (< 1m) works well to visually connect the roof planting to ground-level vegetation and integrate the building into the surrounding parkland. No additional habitat features, (e.g. branches or rock piles) feature in this design. Recent faunal surveys on the green roof have found high numbers of native invertebrates, including beneficial pollinators (Paul Birch pers. comm.).

Table 5.2 Minifie Green Roof plants

Grasses & Monocots

Dianella longifolia var. *grandis* (Arching Flax Lily)
Dianella revoluta (Black Anther Flax Lily)
Linum marginale (Native Flax)
Poa morrisii (Velvet Tussock Grass)
Rytidosperma racemosum (Wallaby Grass)
Rytidosperma setaceum (Bristly Wallaby Grass)
Themeda triandra (Kangaroo Grass)

Herbaceous perennials and subshrubs

Bossiaea prostrata (Creeping Bossiaea)
Bulbine bulbosa (Bulbine Lily)
Chrysocephalum apiculatum (Common Everlasting)
Chrysocephalum semipapposum (Clustered Everlasting)
Einadia nutans (Nodding Saltbush)
Glycine tabacina (Variable Glycine)
Kennedia prostrata (Running Postman)
Pimelea humilis (Dwarf Rice Flower)
Pterostylis pedunculata (Maroon Greenhood) and other *Pterostlyis* spp. (Greenhood orchids)

Nine species were originally planted, of which eight remain, and the City of Boroondara's horticulturalists continue to trial and add new species including native orchids.

The 10 cm-deep mineral substrate is a mix of scoria and crushed brick plus 35% composted organics (Junglefy mineral mix)[43]. As the green roof is located on a highly visited childcare centre, and is visible from the street, it is maintained more frequently and receives more irrigation than some biodiverse roofs to enhance its visual appeal. Maintenance is undertaken weekly (less frequently in winter) by City of Boroondara horticulturalists. Excessive weed growth, particularly of clovers, was a maintenance issue in the establishment period but has since been controlled through hand weeding and adjusting irrigation levels. Water sensitive design was a key principle in the building design and the green roof is irrigated with harvested rainwater. The drip irrigation is controlled by a rain sensor which turns off irrigation if rain events have exceeded a specified threshold, thereby improving water efficiency[1].

This green roof provides valuable insights into how biodiversity green roofs can be designed and managed:

- Planting mixes of perennial native species that differ in life span – longer-lived species (e.g. *Dianella revoluta* – Black Anther Flax Lily, *Bulbine bulbosa* – Bulbine Lily, *Themeda triandra* – Kangaroo Grass) can achieve good coverage and provide biodiversity resources over multiple years, while shorter-lived species (e.g. *Chrysocephalum apiculatum,* Common Everlasting) will need replacement.
- Fast-growing species (e.g. Kangaroo Grass) need management to reduce competition with other species and maintain plant diversity across the roof.
- Green roofs with a biodiversity focus should include monitoring of flora and fauna to ensure objectives are being met.

Image: J. Murphy

Design Objective
To improve building thermal regulation, integrate building into surrounding parkland and create habitat for biodiversity

Location
Minifie Park, Balwyn, Victoria, (City of Boroondara)

Area
440 m^2

Completed
2012

Green Roof Design and Plant Selection
Junglefy and City of Boroondara horticulturalists

5.3 Victorian Parliament House Green Roof – Green roof showcasing flowers and foliage

The Parliament House Green Roof was installed on top of the new annex adjoining the historic Victorian Parliament House and provides vistas and accessible open space for members of parliament and staff. Public access is limited to events and garden tours at times when Parliament is not sitting.

Objectives included enhancing biodiversity, thermal insulation and the creation of iconic spaces for events and contemplation. Conceived as an Australian 'meadow', the design sees groups of low-growing Australian shrubs and herbaceous species arranged around a winding bluestone path. Horticultural staff were consulted on plant selection to ensure species compatibility with site conditions and maintenance inputs.

The roof is planted with 160 native species comprising a total of 12,000 plants, mostly Western Australian. Species were selected to grow less than 1 m high to maintain views of the surrounding gardens including large historic trees. Shrubs such as *Eremophila nivea* (Silky Eremophila) create movement and structure and are contrasted with plants with different form and foliage colour, including *Banksia petiolaris* and *Calothamnus hirsutus* (Hairy Claw Flower). Seasonal colour is provided by flowering shrubs and herbs, including Grevilleas (*G. bipinnatifida and G. lanigera*), *Epacris impressa* (Pink Heath), *Scaevola aemula* 'Purple Fanfare' (Fairy Fan Flower) and *Xanthorrhoea minor* (Small Grass Trees). Some species are endangered in their natural habitats (e.g. *Persoonia nutans* – Nodding Geebung, NSW and *Eremophila nivea* – Silky Eremophila, WA).

Some of the most successful plants have been:

- One-sided Bottlebrushes (*Calothamnus graniticus* and *C. hirsutus*)
- Heath-myrtles (*Micromyrtus ciliata* and *M. leptocalyx*)
- Lemon-scented Myrtle (*Darwinia citriodora*)
- Tea Trees (*Leptospermum rotundifolium* and *Leptospermum* 'Julie Ann')
- Wattle *Acacia cardiophylla* prostrate (some die back, but able to resprout)
- Flannel Flower (*Actinotus helianthi*) has been appearing in areas outside of where originally planted, successfully recruiting across the roof
- Grevilleas (*Grevillea leptobotrys* graft, *G. lanigera*, *G. bipinnatifida*)
- Dwarf Lilly Pilly (*Syzigium* 'Tiny Trev')
- Fan Flowers (*Scaevola* spp.)
- *Eremophila nivea* (Silky Eremophila) and *E. glabra* (Tar Bush)
- Kangaroo Paws (*Anigozanthos* spp. – with larger cultivars performing better)
- Banksias (*Banksia* spp.)

Plants are growing in 20-48 cm deep sandy, low-nutrient, free-draining substrate with added organic matter. A 50 mm organic mulch has been applied however the original specification was for a mineral mulch. Substrate properties replicate those found in soils throughout the species' natural range (i.e. typically free-draining and low in nutrients). Spray irrigation uses potable water while stormwater runoff is captured from the roof and re-used for irrigation on surrounding gardens. The green roof is maintained by an inhouse horticultural team of three people who also tend the surrounding ground-level gardens.

Images: R. Bathgate

Table 5.3 Subset of the 160 native species planted on the Parliament House Green Roof

Strappy leaf plants

Anigozanthos cultivars (Kangaroo Paw)
Conostylis candicans (Grey Cottonhead)

Herbaceous perennials and subshrubs

Actinotus helianthi (Flannel Flower)
Brachyscome multifida (Cut-leaf Daisy)
Chrysocephalum apiculatum (Common Everlasting)
Dampiera teres (Terete-leafed Dampiera)
Pimelea spp. (Rice Flower)
Scaevola aemula 'Purple Fanfare' (Fairy Fan Flower)

Shrubs

Acacia cardiophylla (prostrate) (Wyalong Wattle)
Adenanthos sericeus (Woolly Bush)
Banksia petiolaris
Calothamnus graniticus (Granite Claw Flower)
Darwinia citriodora (Lemon-scented Myrtle)
Epacris impressa (Pink Heath)
Eremophila glabra (Tar Bush)
Eremophila nivea (Silky Eremophila)
Goodenia varia (Sticky Goodenia)
Grevillea lanigera (Woolly Grevillea)
Leptospermum rotundifolium 'Julie Ann'
Micromyrtus ciliata (Fringed Heath-myrtle)
Syzigium 'Tiny Trev'
Veronica perfoliata (Digger's Speedwell)

Design Objective
An accessible green roof providing recreational and social opportunities and restorative views of nature; to highlight the diversity of Australian native plant forms; to create a sense of place.

Location
Victorian Parliament House Annex, Spring St, East Melbourne, Victoria

Area
4850 m²

Completed
2018

Green Roof Design and Plant Selection
TCL (Taylor Cullity Lethlean) Landscape Architects with Paul Thompson; Peter Elliott Architecture and Urban Design

Image: R. Bathgate

5.4 Skyhouse Garden – Green roof showcasing flowers and foliage

This private green roof on an inner Melbourne apartment building provides the owners with a green space for relaxation and socialising, and connection to nature. The green roof extends around all four sides of the rooftop apartment and features planters of different substate depths. There are 24 plant types including robust, evergreen perennial shrubs and flowering herbs, ornamental grasses and turf. Robust, wind tolerant plants were selected to withstand the exposed and windy rooftop conditions. A 1.2 m high glass balustrade around the roof perimeter creates a wind buffer, while still allowing sunlight to reach the garden beds.

The plant palette contains mostly exotic species selected for their contrasting textures, colours and forms including plants from New Zealand, the Mediterranean and coastal habitats. Included are large grasses such as *Miscanthus transmorrisonensis*, perennial herbs (*Perovskia atriplicifolia* 'Blue Spire', Russian Sage) and fleshy succulents (*Cotyledon* 'Macrantha', Green Pig's Ear). Plants are arranged according to their light tolerance - for example *Hedera canariensis* (Canary Island Ivy) in dark areas outside bedrooms and *Pelargonium sidoides* (South African Geranium) on the hot western side. Plants are also grouped to create different themes and moods around the roof, with taller plants including *Phyllostachys nigra* (Black Bamboo) used for privacy screening.

A lawn runs along the eastern side of the building and is accessible from the living room. Clipped balls of *Westringia fruticosa* 'Grey Box' and *Elaeagnus ×ebbingei* (Ebbing's Silverberry) border the lawn area and add a formal element while *Dichondra repens* (Kidney Weed) grows around the steps. Culinary rosemary and other herbs are grown in cylindrical planters and raised garden beds that are easily accessed from the north-facing kitchen.

Planter boxes, garden beds and cylindrical pots contain a range of substrate volumes and depths. A mineral-based Rooflite® green roof mix was used across the roof, ranging 15–80 cm in depth to match the rooting volumes required by different plants, with 30 cm deep substrate under the turf area. The beds are mulched with 14 mm rock aggregate.

The garden is maintained fortnightly but could be done less frequently because of the robust nature of the plants. Fertiliser is applied 2-3 times a year. Drip irrigation is linked to a smart controller, with bamboo in troughs watered with shrubblers.

Image: Erik Holt

Table 5.4 Skyhouse Garden species list

Grasses and strappy leaf plants

TifTuf Bermuda (Turf)
Miscanthus transmorrisonensis
Lomandra confertifolia ‘Seascape’
Phyllostachys nigra (Black Bamboo)

Herbaceous perennials

Geum ‘Tangerine’
Perovskia atriplicifolia ‘Blue Spire’ (Russian Sage)
Pelargonium sidoides (South African Geranium)
Arthropodium cirrhatum ‘Matapouri Bay’ (New Zealand Rock Lily)
Euphorbia rigida (Gopher Spurge)
Strelitzia reginae (Bird of Paradise)

Climbers

Hedera canariensis (Canary Island Ivy)

Shrubs

Cedrus libani ‘Hedgehog’
Cotyledon ‘Macrantha’ (Green Pigs)
Dichondra repens (Kidney Weed)
Elaeagnus ×ebbingei (Ebbing’s Silverberry)
Ligustrum japonicum ‘Rotundifolium’ (Waxleaf Privet)
Ophiopogon japonicus (Mondo Grass)
Pittosporum tenuifolium ‘Stephens Island’ (Dwarf Pittosporum)
Pseudopanax ‘Cyril Watson’ (Large Leaf Pseudopanax)
Rosmarinus officinalis ‘Chefs Choice’ and prostrate form
Westringia fruticosa ‘Grey Box’

Image: Erik Holt

Image: Erik Holt

Design Objective
A ‘Sky Garden’ on a private residence providing restorative green space for socialising, growing food, and for framing and softening city views

Location
Top floor of 18 storey residential building in inner Melbourne

Area
410 m²

Completed
2021

Green Roof Design and Plant Selection
Lisa Ellis Gardens

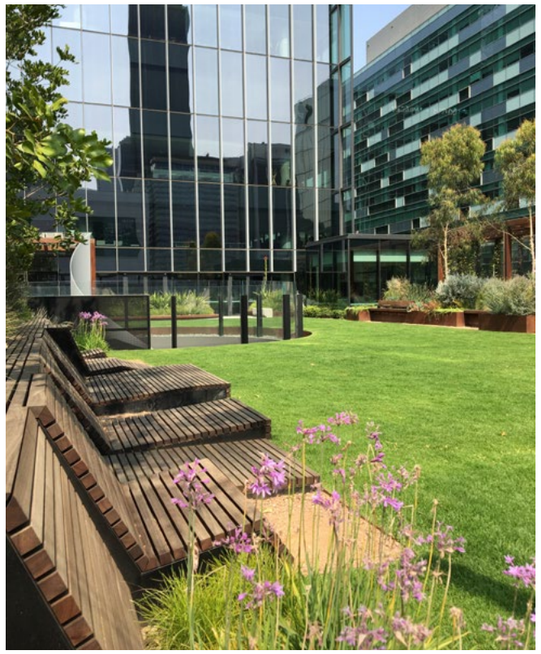
5.5 Skypark – Green roof for amenity and recreation

Skypark is a secluded, tranquil green retreat in the city of Melbourne where Australian and exotic species are used in a naturalistic planting design to create a series of distinct spaces for different uses and experiences. The green roof is accessible to tenants in the adjoining building as well as being publicly accessible from the ground via a lift/stairway. Skypark is well-used by building occupants and lunchtime city workers who make use of the lawn area and a range of seating options to lounge, socialise or for respite, with the pathway enabling gentle exercise.

The landscape architects focused on 'plants and people' in their design with specific plant palettes for each social area. For example, the 'Cluster' creates an informal privacy screen between private and public space and features larger plants (*Doryanthes excelsa*, Gymea Lily) and a dense understory planting of *Patersonia occidentalis* (Native Iris) and *Lomandra confertifolia* 'Little Con'. Low-level planting beds designed to provide different textures and colours for year-round diversity are used around seating. The large lawn area is encircled by garden beds of dwarf Native Frangipani (*Hymenosporum flavum* 'Gold Nugget'), banksia (*Banksia blechnifolia*) and *Eucalyptus* 'Blue Lagoon'.

The perimeter is encircled in a wire-mesh safety barrier which also acts as a trellis for climbing plants – deciduous *Wisteria floribunda* (Japanese Wisteria), evergreen *Pandorea jasminoides* (Bower Vine) and *Pandorea pandorana* (Wonga Wonga Vine). The climbers integrate with ground covers (*Myoporum parvifolium* and *Grevillea lanigera* 'Mt Tamboritha'), feature shrubs (*Westringia fruticosa* 'Grey Box') and cascading plants (*Convolvulus sabatius*). The Docklands area is subject to intermittent strong winds which are tempered by the use of glass-panelled wind protection around the roof. Wind-tolerant plants were used.

The green roof is maintained weekly and tasks include weeding, mowing and pruning. Mulching and fertilising are undertaken when required. Irrigation is delivered via sprinklers on the lawn and drippers in garden beds. Mineral-based green roof substrates were used in planters and under the turf area.



Images R. Bathgate

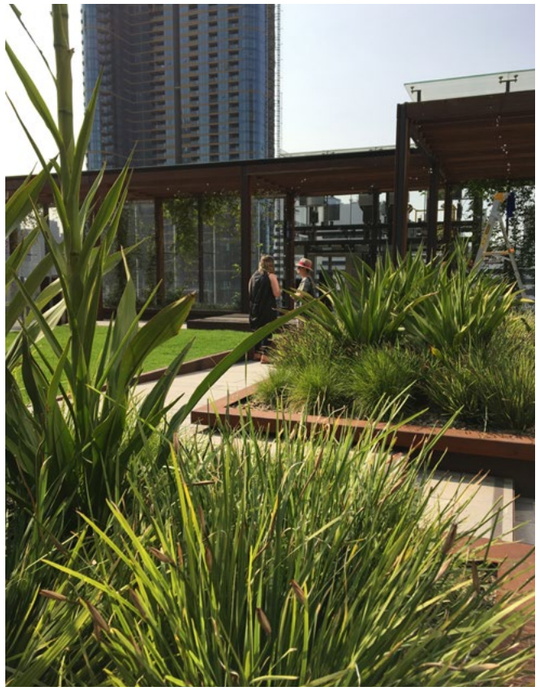


Table 5.5 Skypark Green Roof species list

Grasses and strappy leaf plants

Dichelachne crinita (Longhair Plume Grass)
Poa poiformis (Coast Tussock Grass)
Lomandra confertifolia 'Little Con' (Small Mat Rush)
Lomandra longifolia 'Nyalla' (Mat Rush)

Trees and trellis climbers

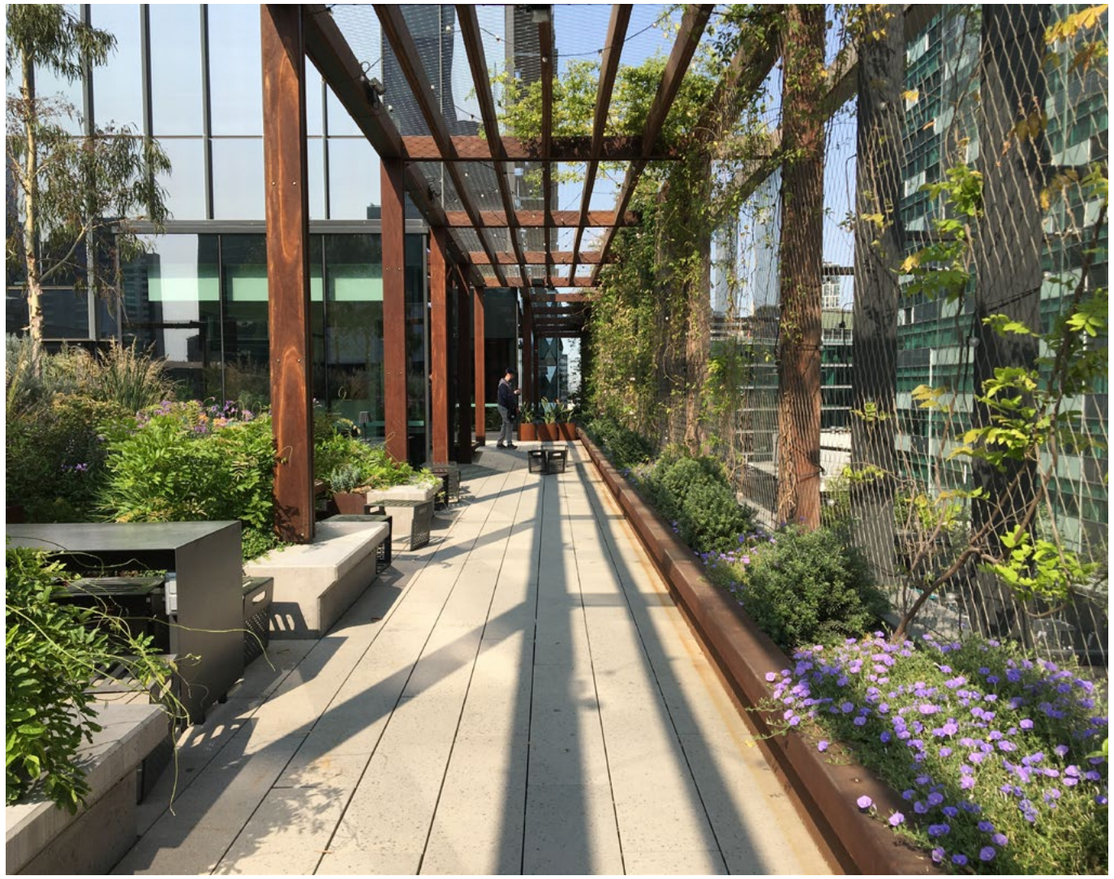
Corymbia citriodora 'Scentuous' (Dwarf Lemon-scented Gum)
Cupaniopsis anacardioides (Tuckeroo)
Pandorea jasminoides (Bower Vine)
Pandorea pandorana (Wonga Wonga Vine)
Wisteria floribunda (Japanese Wisteria)

Shrubs and ground covers

Acacia cognata 'Limelight' (River Wattle)
Asparagus densiflorus 'Myersii' (Foxtail Fern)
Artemisia 'Powis Castle'
Banksia blechnifolia (Southern Blechnum Banksia)
Callistemon viminalis 'Little John'
Callistemon citrinus 'Firebrand'

Shrubs and ground covers (continued)

Convolvulus sabatius (Ground Morning Glory)
Curio repens (Blue Chalksticks)
Crowea exalata (Small Crowea)
Doryanthes excelsa (Gymea Lily)
Eremophila nivea (Silky Eremophila)
Eucalyptus 'Moon Lagoon'
Euphorbia rigida (Gopher Spurge)
Euphorbia characias subsp. *wulfenii* (Wulfen Spurge)
Grevillea lanigera 'Mt Tamboritha' (Woolly Grevillea)
Hymenosporum flavum 'Gold Nugget' (Dwarf Native Frangipani)
Juniperus conferta (Shore Juniper)
Myoporum parvifolium (Creeping Boobialla)
Patersonia occidentalis (Native Iris)
Salvia 'Waverly'
Strelitzia juncea (Narrow-leaved Bird of Paradise)
Tulbaghia violacea (Society Garlic)
Westringia fruticosa 'Grey Box'
Vinca minor 'Alba' (White Periwinkle)
Vinca minor 'Elizabeth Cran' (Periwinkle)



Design Objective

A sheltered, sun-filled space that provides a tranquil, secluded retreat for city workers and visitors

Location

One Melbourne Quarter, 699 Collins St, Docklands, Melbourne

Area

880 m², with 395 m² covered by vegetation

Completed

2018

Green Roof Design and Plant Selection

Oculus with Aspect Studios, in collaboration with Denton Corker Marshall. Web mesh by Tensile

Image: R. Bathgate

5.6 Bendigo Hospital Green Roofs – Green roof for amenity and recreation

Bendigo Hospital demonstrates how green roofs can be used in a health care setting to improve patient wellbeing while also increasing building sustainability through thermal regulation and stormwater management. Ten green roofs (including internal courtyards) were designed and installed as part of a new build.

Some green roofs are for viewing only while others are accessible – including the green roof courtyards adjoining the rehabilitation and maternity wards. As a 'hospital within a garden' the design team adopted a biophilic approach and incorporated patterns from nature, natural and local materials, moving water and textured plantings. Access to nature, positive distractions for therapeutic outcomes and the site's cultural significance to the Dja Dja Wurrung Traditional Owners guided the landscape design across the entire precinct.

Images: Fytogreen

The external green roof plant palette features low-growing drought-tolerant Australian and exotic plants and contains a mix of grasses, flowering shrubs, herbs and ground covers adapted to different light levels. In sunny locations, tussocks and grasses create movement while long-lasting seedheads of *Pennisetum alopecuroides* (Swamp Foxtail) and *Themeda triandra* (Kangaroo Grass) provide visual interest. Warm flowering colours and variation in foliage form are provided by heat-tolerant African daisies and gazanias, and flowering shrubs such as Jerusalem Sage and correas. Purple tones are provided by lavenders, rosemary and native coastal rosemary. Ground covers include succulents *Carpobrotus modestus* (Inland Pigface) and *Sedum reflexum* (Blue Spruce Stonecrop).

Green 'roofs' on balconies are more sheltered and have lower light levels. These are planted with green, lush foliage, including tree ferns, maples and palms with native *Dichondra repens* (Kidney Weed) as a ground cover.

Fortnightly maintenance includes weeding, checking plant health and irrigation with pruning and mulching done seasonally. A mineral-based green roof substrate is used at various depths across the roof. Irrigation draws water harvested from across the precinct and is seasonally adjusted - four times daily in summer and none in winter unless excessively dry. The plant selection has been successful across the multiple green roofs, particularly sun-tolerant natives and grasses as well as exotic species originating from dry and hot regions (e.g. Rosemary, *Rosmarinus* 'Blue Lagoon' and Lamb's Ears, *Stachys byzantina*). There has been limited plant mortality across the roof, with occasional, localised die-off usually related to irrigation (too little or excess) which has been addressed through modifying irrigation configuration and replanting.

Images: Fytogreen (left) and Oculus, courtesy of Exemplar Health (above)

Grasses and strappy leaf plants

Dianella revoluta (Black Anther Flax Lily)
Lomandra ‘Tanika’ & *L. confertifolia* ‘Little Pal’ (Mat-rush cultivars)
Pennisetum alopecuroides ‘Nafray’ (Swamp Foxtail Grass)
Poa poiformis & *P. sieberiana* (Tussock Grass)
Themeda triandra (Kangaroo Grass)

Ground covers

Carpobrotus modestus (Inland Pigface)
Dichondra repens (Kidney Weed)
Disphyma crassifolium (Rounded Noon Flower)
Rosmarinus spp. (Rosemary, prostrate form)
Sedum reflexum (Blue Spruce Stonecrop)

Flowering shrubs and perennials

Correa ‘Dusky Bells’ (Native Fuchsia)
Lavandula ‘Hidcote’
Lavandula ‘Lavenite Petite’
Phlomis cultivar (Jerusalem Sage)
Rosmarinus ‘Blue Lagoon’
Stachys byzantina (Lamb’s Ears)
Westringia ‘Grey Box’
Arctotis ‘Sunset Gold’ and other cultivars (African Daisy)
Brachyscome multifida (Cut-leaf Daisy)
Bulbine bulbosa (Bulbine Lily)
Cistus ×*pulverulentus* ‘Sunset’ (Rock Rose)
Gazania rigens (Gazania)
Plectranthus neochilus (Spur Flower)

Table 5.6.1 Bendigo Hospital Green Roof native and exotic species list (high sun areas)

Image: Fytogreen

Design Objective
Patient wellbeing and building sustainability through thermal regulation and stormwater management

Location
Bendigo Hospital, Barnard St, Bendigo

Area
965 m² across 10 green roofs spread over 4 levels

Completed
2019

Green Roof Design and Plant Selection
Oculus, Bates Smart and Fytogreen. Courtyard green roofs in collaboration with Silver Thomas Hanley

5.7 Acre Urban Farm – Green roof for food production

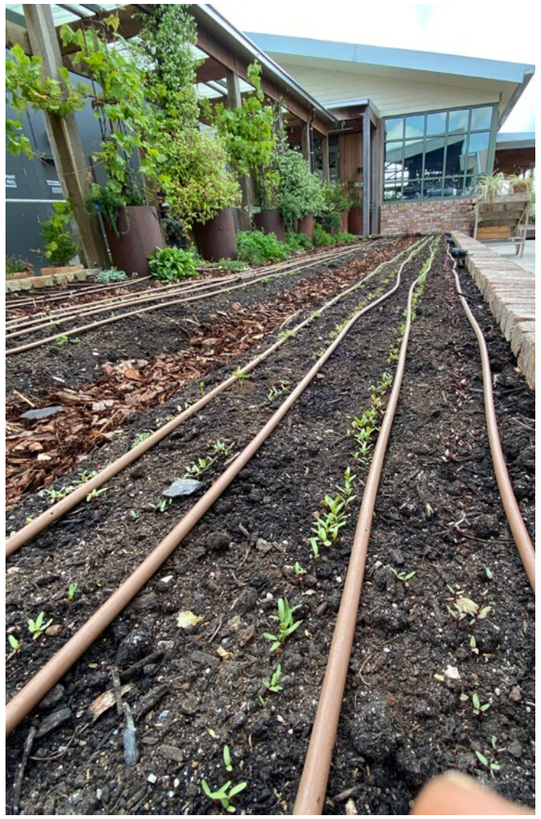
The Acre Urban Farm is part of a new shopping centre in Melbourne's eastern suburbs and provides fresh produce for an adjoining rooftop restaurant, and a space for events and community horticultural activities. International accreditation through the Living Building Challenge meant that 20% of the development was dedicated to urban agriculture. Acre Rooftop Farm is the first productive roof garden of its size and complexity in southern Australia and demonstrates the potential for growing food on multi-storey commercial buildings and creating novel spaces for socialising and horticultural education.

The green roof includes:

- garden beds of seasonal vegetables
- raised planters and large pots with fruit trees and vines
- a greenhouse for propagation
- an indoor hydroponic system for herbs and microgreens
- coops for chickens and quails.

The need to maintain a regular harvest for the restaurant means there is a focus on fast-growing, long-producing species such as kale and silver beet, although more recently the gardeners have been planting cauliflower and broccoli. Leafy greens, herbs and microgreens are grown hydroponically in the greenhouse throughout the year. Surplus harvest is sold to restaurants at other locations.

The green roof is maintained five days a week by three part-time staff, led by a head gardener. Tasks include propagation, weeding, crop rotation and composting. The original substrate was a proprietary Rooflite® mix which has since been supplemented with an organic compost mix to 30 cm depth. The high organic content of the original substrate led to slumping over time and a decline in water holding capacity. The garden team have since focused on enhancing substrate volume and properties through regular application of compost brought up onto the roof and have now established an onsite composting system that uses kitchen waste and coffee grounds. Invertebrates – both welcome (earthworms) and unwelcome (snails) – are present on the green roof. Irrigation is supplied via driplines and there are plans to improve water efficiency through smart-sensor irrigation technology linked to meteorological forecasts.



Images: R. Bathgate

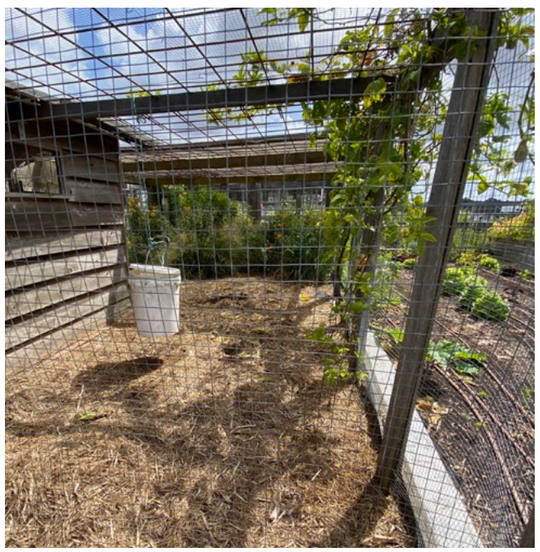


Table 5.7 Examples of food plants grown on the Acre Green Roof

Garden beds	Garden beds (continued)
Zucchini (*Cucurbita pepo*)	Pumpkin (*Cucurbita* spp.)
Tomatoes (*Solanum lycopersicum*)	Eggplant (*Solanum melongena*)
Asparagus (*Asparagus officinalis*)	Radishes (*Raphanus sativus*)
Watermelon (*Citrullus lanatus*)	**Pots**
Green Beans (*Phaseolus vulgaris*)	Olives and citrus including lemons and oranges
Broadbeans (*Vicia faba*)	**Hydroponic system**
Peas (*Pisum sativum*)	Herbs, lettuces, strawberries, microgreens
Silverbeet (*Beta vulgaris* var. *cicla*)	**Greenhouse**
Kale (*Brassica* spp.)	Plant propagation, seeds etc.
Parsley (*Petroselinum crispum*)	
Spring onion (*Allium fistulosum*)	

Design Objective
Food production for adjacent rooftop restaurant, community engagement and building sustainability

Location
Burwood Brickworks Shopping Centre, Burwood East, Victoria

Area
Farm approximately 2000 m² with 1200 m² productive area

Completed
2019

Green Roof Design and Plant Selection
Tully Heard for Frasers Property Group, with NH Architecture in consultation with Joost Bakker

Image: R. Bathgate

6

Species information

This chapter provides additional information on the species recommended for the five green roof typologies introduced in Chapter 4, including family and common names, origin (Australian or Exotic) and indicative plant size at maturity. Green roof plants tend to be smaller than the same species planted at ground level because of differences in substrate depth and volume, substrate characteristics and climatic factors. For some species these conditions can also lead to early or extended flowering.

As for plant selection in all landscape projects, please consider the weed potential of these plants in your state and local area, avoid the use of invasive species and choose sterile cultivars as appropriate.

Species	Common name	Family	Origin	Indicative mature height x width (m)	Plant notes
Grasses and strappy leaf plants					
Anigozanthos spp. and cultivars e.g. 'Frosty Red', 'Big Red'*	Kangaroo Paw	Haemodoraceae	Aust	1 x 0.75	Sparse, clumping perennial with fans of broad linear leaves, can be short-lived, but newer hybrid cvs. are more vigorous with less disease. Prune back over winter.
*Arthropodium milleflorum**	Pale Vanilla-lily	Asparagaceae	Aust	0.8 x 0.3	Tufted, grassy, tuberous herb, dormant in late summer or dry season.
*Bulbine frutescens**	Bulbine Lily, Orange Bulbine	Asphodelaceae	Exotic	0.5 x 0.3	Succulent, spreading perennial herb. Fleshy, linear grey-green leaves with adventitious roots on stems. Yellow/orange star-shaped flowers in upright racemes above the foliage, mainly in spring.
Chloris truncata	Windmill Grass	Poaceae	Aust	0.3-x 0.5	Tuft-forming and either annual or perennial grass, often stoloniferous, produces attractive inflorescences and heads.
Dianella revoluta	Black Anther Flax Lily	Asphodelaceae	Aust	0.75 x 0.5	Erect and rhizomatous plant, forming dense and vigorous clumps, blue flowers, variable in form and habit.
Dichelachne crinita	Long-hair Plume Grass	Poaceae	Aust	0.7 x 0.2	Upright, sparse, tussock-forming grass, light in habit but with very showy flowers on long stems.
Helictotrichon sempervirens	Blue Oat Grass	Poaceae	Exotic	0.75 x 0.6	Dense, tussock-forming, grass with linear, blue-grey leaves, flowers oat-like, rising above foliage.
Lomandra filiformis	Wattle Mat-rush	Asparagaceae	Aust	0.5 x 0.3	Variable, tuft-forming, evergreen rush, with a slow, spreading rhizome. Cane be sparse in habit or form short, dense mats of foliage.
Lomandra longifolia	Spiny-headed Mat-rush	Asparagaceae	Aust	0.4 x 0.75	Upright, tussock-forming evergreen rush, slowly spreading clumps, flowers on spiny stems.
Miscanthus 'Kleine Fontaine'	Chinese Silver Grass	Poaceae	Exotic	1.2 x 1.0	Deciduous, upright clump of narrow leaves and bamboo-like culms, becomes arching and pendulous when flowering, creamy-pink feather like heads.
*Phormium tenax**	New Zealand Flax	Asphodelaceae	Exotic	2 x 1.5	Robust, evergreen, clumping flax, of striking form; sword-like leaves and bronze-red flowers on stems, many forms available, smaller ones best for green roofs.
Themeda triandra	Kangaroo Grass	Poaceae	Aust	0.9 x 0.75	Dense, tufting or clump-forming perennial grass, robust and variable in form. It produces bronze-coloured flowers over summer.
*Strappy leaf species also listed in other category type					
Perennial herbs and subshrubs					
Achillea 'Moonshine'	Achillea Moonshine	Asteraceae	Exotic	0.6 x 0.6	Clump-forming perennial with upright heads of yellow-gold flowers, dies back to basal rosette of leaves in winter. Tolerates heat but irrigation improves performance over summer.
Brachyscome multifida	Cut-leaf Daisy	Asteraceae	Aust	0.2 x 0.75	Low-growing, bushy perennial, variable in form and habit, some compact, others more open and spreading. Blue daisy flowers, pruning improves form and flowering.
Calocephalus citreus	Lemon Beauty-heads	Asteraceae	Aust	0.5 x 0.3	Small perennial herb with erect stems and lemon-yellow, dense compound flower heads.
Calocephalus lacteus	Milky Beauty-heads	Asteraceae	Aust	0.3 x 1	Low-growing, spreading, perennial herb. Flowers in dense, rounded compound heads of many tiny, white florets.
Cerastium tomentosum	Snow in Summer	Caryophyllaceae	Exotic	0.15 x 2	Fast-growing, rhizatamous, evergreen perennial, forms a dense mat with silver foliage and white flowers. Dies out from the centre with age.
Chrysocephalum apiculatum	Common Everlasting	Asteraceae	Aust	0.4 x 0.6	Fast-growing, sprawling perennial, variable forms with green or silver leaves, yellow heads of flowers produced for long periods, can seed freely.
Chrysocephalum semipapposum	Clustered Everlasting	Asteraceae	Aust	0.8 x 0.8	Variable, clumping, perennial herb or subshrub, with dense basal foliage and taller, showy flowering stems. Individual stems die after two years.
Convolvulus sabatius	Blue Rock Bindweed	Convolvulaceae	Exotic	0.1 x 2.0	Prostrate evergreen semi-woody sprawler of dense habit, long-flowering: lilac-blue funnel-shaped flowers spring-autumn. Leaves grey-green.
Coreopsis lanceolata	Tickseed	Asteraceae	Exotic	0.45 x 0.45	Clump-forming perennial, both basal and stem foliage, many yellow-orange flowers from spring to autumn. Numerous cultivars and forms available.
Cota tinctoria 'Susanna Mitchell'	Golden Marguerite	Asteraceae	Exotic	0.5 x 0.8	Sprawling evergreen perennial, finely divided grey-green leaves and pale yellow/white heads of flowers produced over a long period. Regular division and replanting needed, pruning improves form and extends flowering.
Dianthus hybrids e.g. *Dianthus* `Doris'	Pinks, Carnation	Caryophyllaceae	Exotic	0.2 x 0.2	Evergreen, compact perennial herb, attractive silver leaves and pink flowers over spring and summer. Prune hard infrequently to rejuvenate and deadhead to extend flowering.
Dichondra repens	Kidney Weed	Convolvulaceae	Aust	0.1 x indefinite	A dense and vigorous, stoloniferous mat-forming evergreen herb with kidney-shaped leaves. Tolerates dry shade and near death experiences!
Erysimum cheiri	Wallflower	Brassicaceae	Exotic	0.5 x 0.5	Short-lived evergreen perennial herb, upright habit, lance-shaped leaves and terminal, long-lasting flowers. Often grown as an annual or biennial.
Perennial herbs and subshrubs					
Euphorbia 'Silver Swan'	None	Euphorbiaceae	Exotic	0.6 x 0.6	An evergreen, mounded subshrub, composed of juicy, upright stems surrounded by densely spiralling variegated leaves and heads of green/white flowers. Regular pruning post flowering improves form.
Geranium retrorsum	Common Cranesbill	Geraniaceae	Aust	0.3 x 0.8	Trailing or spreading perennial herb, has a thick taproot, rounded, softly haired leaves and pink flowers over winter-summer. Grows well in part-shaded locations.
Geranium solanderi var. solanderi	Austral Cranesbill, Native Geranium	Geraniaceae	Aust	0.2 x 0.8	Trailing, sometimes scrambling perennial herb with rounded taproot, divided pubescent leaves and pink flowers. Can sometimes be a useful ground cover.
Hypericum gramineum	Small St John's Wort	Hypericaceae	Aust	0.3 x 0.2	Erect perennial herb, spreads through wiry rhizomes, blue-green leaves and bright orange-yellow flowers over spring-summer.
Isotoma axillaris	Rock Isotome	Campanulaceae	Aust	0.5 x 0.7	Small evergreen perennial herb to subshrub. Can form a dense mat of ovate leaves and masses of pink starry flowers over spring and summer. Hard pruning post-flowering can extend form and longevity.
Kennedia prostrata	Running Postman	Fabaceae	Aust	0.05 x 3	Small, relatively sparse evergreen trailer-climber with scarlet to crimson pea flowers and grey-green leaves with undulating margins.
Linum marginale	Native Flax	Linaceae	Aust	1 x 1	A slender perennial herb consisting of numerous fine, soft, tangling stems with light blue flowers. Often glaucous with a light and airy texture.
Lotus berthelotii	Parrot-beak	Fabaceae	Exotic	0.2 x 0.9	Prostrate or cascading evergreen perennial to subshrub with fine, silver-grey leaves and gold, orange or red pea-shaped flowers over spring and summer. Can be short-lived, light pruning improves density and flowering.
Nepeta 'Walkers Low'	Catmint	Lamiaceae	Exotic	0.3 x 0.6	A semi-evergreen suckering perennial herb. Basal foliage is quite dense. Lavendar-blue blooms on short spikes on aromatic grey-green foliage.
Origanum vulgare	Oregano	Lamiaceae	Exotic	0.45 x 0.6	A sprawling or erect, aromatic, slightly woody perennial herb, forming a mat of green or golden leaves with emergent flowering stems.
Pelargonium rodneyanum	Magenta Stork's-bill	Geraniaceae	Aust	0.45 x 0.5	Small, perennial herb, leaves are oval in shape and lobed, pink flowers arise over summer and autumn on slender stalks rising above the foliage, can withstand very dry and hot conditions by dying back to a large tuberous root.
Pelargonium sidoides	South African Geranium	Geraniaceae	Exotic	0.3 x 0.3	Low growing perennial herb, has a clumping habit with a basal rosette of grey-green leaves arising from a solid taproot and clusters of dark purple-red flowers.
Phormium tenax	New Zealand Flax	Asphodelaceae	Exotic	2 x 1.5	Robust, evergreen, clumping flax, of striking form; sword-like leaves and bronze-red flowers on stems, many forms available, smaller ones best for green roofs.
Plantago gaudichaudii	Narrow-leaf Plantain	Plantaginaceae	Aust	0.35 x 0.2	Perennial herb, with a long, fleshy taproot and sometimes adventitious roots. Largely grey-green basal leaves and clusters of small flowers in upright and compact heads.
Podolepis jaceoides	Showy Podolepis	Asteraceae	Aust	0.6 x 0.5	Rosette-forming perennial herb, multi-stemmed and flowering stems topped with heads of attractive yellow flowers, often dying back to base in summer.
Puya ferruginea	Puya Bromeliad	Bromeliaceae	Exotic	1.5 x 1	A pineapple-like, clumping perennial, forms a rosette of vicious, silver-green, spiny foliage. Over summer a tall inflorescence of brown-sheathed white flowers is produced. Very tough and robust plant.
Salvia fruticosa 'Greek Skies'	None	Lamiaceae	Exotic	0.6 x 0.6	Low growing subshrub with dense habit and masses of silver-green, aromatic foliage, followed by soft pink to blue-mauve flowers in spring held on large inflorescences.
Salvia nemorosa	Meadow or Woodland Sage	Lamiaceae	Exotic	0.8 x 0.5	Upright perennial herb or sub-shrub that forms a compact clump with repeat blue-violet flowers over summer. Variable, a number of different cultivars available.
Scaevola albida	Fan Flower	Goodeniaceae	Aust	0.2 x 0.8	Low growing often mat-forming perennial to subshrub. Has a fine textured habit, thin wiry stems topped with masses of blue-white flowers for much of the year.
Senecio quadridentatus	Cotton Fireweed	Asteraceae	Aust	0.8 x 0.6	Erect perennial herb, branching, leaves and stems covered in dense white cottony hairs and sparse and small, yellow flower heads. Often annual from a solid rootstock.
Silene coronaria	Dusty Miller	Caryophyllaceae	Exotic	0.5x 0.6	Evergreen perennial herb with upright flowering stems from a basal clump of grey-felted leaves. Flowers white or crimson pink on erect branching stems from spring-early summer.
Stypandra glauca	Nodding Blue Lily	Asphodelaceae	Aust	0.6 x 1	Upright and tall perennial herb with slender arching stems, greyish-green leaves and small blue-star flowers with yellow anthers in spring.
Tradescantia 'Sweet Kate'	None	Commelinaceae	Exotic	0.5 x 0.5	Semi-deciduous perennial herb, clumping habit. Narrow lanceolate golden-yellow leaves on fleshy stems and violet blue flowers in small clusters.
Tulbaghia violacea	Society Garlic	Amaryllidaceae	Exotic	0.45 x 0.6	A clump-forming, rhizomatous evergreen perennial herb, strap-like leaves and lilac flowers on slender scapes almost all year.
Verbena bonariensis	Purpletop Verbena	Verbenaceae	Exotic	1.5 x 0.45	An erect, short-lived perennial herb with four-sided stems, slightly hairy serrated leaves and open, branched, candelabra-like inflorescences of small tubular purple flowers.
Veronica perfoliata	Digger's Speedwell	Plantaginaceae	Aust	0.8 x 1.0	A suckering, evergreen perennial herb with erect stems with triangular grey-green-blue leaves and clusters of small mauve-blue flowers in tapering terminal stems.
Wahlenbergia capillaris	Tufted Bluebell	Campanulaceae	Aust	0.4 x 0.2	Tufted or open erect perennial herb with thickened taproot, branching from base. Plants often die back in dry seasons and reshoot in winter.

Species	Common name	Family	Origin	Indicative mature height x width (m)	Plant notes
Flowering annuals					
Brachyscome iberidifolia	Swan River Daisy	Asteraceae	Aust	0.4 x 0.4	Fast growing and slender annual with branched stems and light green, finely divided foliage. The bright flower-heads in a range of colours are held above the foliage from spring to summer.
Calandrinia eremaea	Small Purslane	Montiaceae	Aust	0.2 x 0.1	Erect to decumbent annual herb, small, succulent, leaves with long flowering stems covered in white, pink to purple flowers. Can seed freely.
Craspedia variabilis	Common Billy Buttons	Asteraceae	Aust	0.4 x 0.2	Erect with pale olive-green leaves and compound yellow globular heads of flowers on several flowering stems. Often a short-lived perennial.
Eschscholzia californica	Californian Poppy	Papaveraceae	Exotic	0.1 x 0.45	Low-growing annual herb forming a mat of grey-blue soft-textured foliage and papery golden-yellow petals. Can seed freely, best in contained or highly maintained green roofs.
Podotheca gnaphalioides	Golden Long-Heads	Asteraceae	Aust	0.6 x 0.1	Erect or decumbent annual, small basal leaves and yellow/orange-yellow flowers produced over spring.
Rhodanthe chlorocephala subsp. *rosea*	Rosy Sunray	Asteraceae	Aust	0.7 x 0.2	Erect, leafy, slender herb. Grey-green leaves and terminal papery, 'everlasting' daisies white-pink in colour.
Rhodanthe humboldtiana	Golden Clusters Everlasting	Asteraceae	Aust	0.5 x 0.1	Erect herb, with grey-green divided leaves and rounded heads of bright yellow, papery flowers over winter-spring. Can seed freely at times.
Rhodanthe manglesii	Pink Sunray	Asteraceae	Aust	0.5 x 0.2	Slender, branching annual with heart-shaped, stem-clasping leaves and pink flower heads mainly during spring and summer.
Rhodanthe stricta	Slender Sunray	Asteraceae	Aust	0.4 x 0.1	Upright, and open annual herb, with small leaves and heads of white or white-yellow flowers over winter-spring.
Schoenia cassiniana	Pink Cluster Everlasting	Asteraceae	Aust	0.4 x 0.1	Erect, sometimes rounded annual herb, largely basal, pubescent leaves with masses of terminal flowers, deep pink in colour over winter-spring.
Schoenia filifolia subsp. *subulifolia*	Mingenew Everlasting	Asteraceae	Aust	0.5 x 0.1	Compact annual herb, long linear leaves with masses of terminal yellow flowers, mainly over spring and summer.
Schoenia macivorii	Paper Sunflower Everlasting	Asteraceae	Aust	0.1 x 0.1	Annual herb, masses of terminal yellow flowers, mainly over winter-spring.
Xerochrysum bracteatum	Golden Everlasting	Asteraceae	Aust	0.8 x 0.6	Various colours. Occurs in both annual and short-lived perennial forms. Variable form, coarse-textured, rounded evergreen annual or perennial herb to subshrub. Grey leaves, golden-yellow (or lemon or cream coloured) daisies, spring to summer.
Shrubs					
Calytrix tetragona	Fringe Myrtle	Myrtaceae	Aust	1.5 x 1.5	Evergreen shrub variable in form from open to dense, profuse white-pale pink flowers and small leaves.
Cistus salviifolius	Sage-leaf Rock Rose	Cistaceae	Exotic	1.2 x 1.0	Dense, rounded evergreen shrub, sage-like leaves and numerous white flowers that last one day.
Correa reflexa	Common Correa, Native Fuchsia	Rutaceae	Aust	1.0 x 2	Variable evergreen shrub, leaves dull green and hairy, flowers are red or green bells in autumn to spring.
Eutaxia microphylla	Common Eutaxia	Fabaceae	Aust	0.4 x 1	Low growing, mat-like shrub, dense with small grey-green leaves and dark yellow and red pea flowers.
Goodenia ovata	Hop Goodenia	Goodeniaceae	Aust	0.3 x 0.75	Upright and evergreen dense shrub, bright green leaves, yellow flowers spring-summer. A prostrate, low growing form is also common.
Grevillea 'Seaspray'	None	Proteaceae	Aust	0.75 x 1.5	Mounding, low-growing, and often dense evergreen shrub. Grey-green, hairy segmented leaves and deep pink to cherry red flowers.
Hibbertia obtusifolia	Long-leaved Guinea-flower	Dilleniaceae	Aust	0.2 x 0.9	Small, evergreen prostrate subshrub to mound-forming perennial, downy to woolly leaves and reddish stems, masses of yellow flowers.
Lavandula angustifolia	English Lavender	Lamiaceae	Exotic	0.45 x 0.75	Small and upright evergreen shrub with fragrant flowers produced over summer. Many different forms of Lavender with varying height, habits and flowering traits.
Lechenaultia formosa	Red Lechenaultia	Goodeniaceae	Aust	0.5 x 0.5	Small evergreen shrub, prostrate to erect in habit with small linear leaves, mainly orange flowers, sometimes red or cream over winter-spring.
Leonotus leonuris	Lions' Ear	Lamiaceae	Exotic	1.5 x 2	Upright semi-evergreen shrub, basal foliage and erect, flowering stems with bright orange or white velevety flowers.
Olearia axillaris	Coast Daisy-bush	Asteraceae	Aust	1.5 x 1	Dense, rounded evergreen shrub, narrow, silver foliage and covered with white heads of closely packed daisy flowers.
Platylobium obtusangulum	Common Flat-pea	Fabaceae	Aust	0.8 x 1.0	Open and scrambling evergreen shrub, sometimes no more than a few meandering stems, but more compact forms occur. Triangular leaves and yellow-brown pea flowers in spring.
Teucrium marum	Cat Thyme	Lamiaceae	Exotic	0.45 x 0.6	Small, dense, mounded evergreen shrub with small aromatic leaves and magenta pink flowers. Benefits from hard pruning once a year.

Species	Common name	Family	Origin	Indicative mature height x width (m)	Plant notes
Climbers					
Aphanopetalum resinosum	Gum Vine	Aphanopetalaceae	Aust	1.5 x 1.5	Dense and twining evergreen climber with dark green leaves, wiry stems and masses of white-green flowers in spring. Prune hard when young to promote the climbing habit.
Bougainvillea glabra	Bougainvillea	Nyctaginaceae	Exotic	8 x 8	Vigorous, spiny, scandent shrub with long trailing stems covered in hooked spines and often masses of mauve-pink flower-like bracts. Very heat tolerant but needs good soil depth, pruning and training for success.
Hardenbergia violacea	Native Sarsparilla	Fabaceae	Aust	4 x 4	Variable in form, ranging from vigorous stem-twining climber to an almost shrubby habit, with pink or white flowers. Tough and useful but check the cultivar before use.
Thunbergia alata 'Aurantiaca'	Black-eyed Susan	Acanthaceae	Exotic	6 x 6	Herbaceous and evergreen to semi-deciduous stem-twining climber. Produces masses of orange flowers throughout the year and can be reasonably vigorous.
Trachelospermum jasminoides	Star Jasmine	Apocynaceae	Exotic	8 x 6	Stem-twining evergreen climber with fragrant white flowers. Can be vigorous in many sites and sometimes used as a ground cover.
Trees					
Corymbia citriodora 'Scentuous'	Dwarf Lemon-scented Gum	Myrtaceae	Aust	7 x 3	Smaller form of what is normally a tall, evergreen tree. Has an attractive white trunk, lemon-scented leaves and clusters of white flowers. It needs formative pruning in situ to improve its habit and form.
Cupaniopsis anacardioides	Tuckeroo	Sapindaceae	Aust	5 x 5	Small evergreen tree, low branched and spreading. Green compound leaves, cream flowers and yellow capsular fruits. Very tough and robust in cultivation.
Ficus macrocarpa var. *hillii*	Hill's Weeping Fig	Moraceae	Exotic	12 x 8	Large evergreen tree with a rounded crown, large leathery leaves, inconspicous flowers, small fruits. Used widely in roof garden plantings where there is sufficient soil depth and volume.
Geijera parviflora	Wilga	Rutaceae	Aust	7 x 6	Wide-spreading small to medium evergreen tree. Linear and glossy foliage, long pendulous branchlets and small cream flowers on terminal ends of branches.
Lagerstroemia indica	Crepe Myrtle	Lythraceae	Exotic	5 x 7	A wide-spreading, flat-topped deciduous tree of very open habit, often multi-stemmed, attractive bark, flowers white, pink or mauve late summer to autumn.
Succulents					
Aeonium 'Velour'	None	Crassulaceae	Exotic	1.0 x 1.2	Purple-green form retains green centres while the outer leaves are a rich burgundy colour (in full sun). Forms dense, multi-stemmed plants.
Aeonium haworthii	Haworth's Aeonium	Crassulaceae	Exotic	0.6 x 1	Evergreen, succulent subshrub with slender branches terminating in a rosette of fleshy leaves. Develops a strongly rounded form with age.
Agave attenuata	Fox Tail Agave	Asparagaceae	Exotic	1 x 1	Stout, rosette-forming succulent, develops a short trunk with age and ultimately a long terminal inflorescence with dense clusters of white flowers.
Aloe brevifolia	Short-leaved Aloe	Asphodelaceae	Exotic	0.5 x 0.5	Stemless perennial succulent endemic to South Africa. Forms large groups of densely leafy rosettes. Leaves are broadly triangular and greyish green in colour.
Aloe perfoliata	Mitre Aloe	Asphodelaceae	Exotic	0.6 x 0.5	Forms a tight and low-growing succulent with rosettes on stems up to 60 cm in height, topped by attractive red flowers over winter, very cold tolerant.
Bulbine frutescens	Bulbine Lily, Orange Bulbine	Asphodelaceae	Exotic	0.5 x 0.3	Succulent, spreading perennial herb. Fleshy, linear grey-green leaves with adventitious roots on stems. Yellow/orange star-shaped flowers in upright racemes above the foliage, mainly in spring.
Carpobrotus rossii	Ross' Noonflower	Aizoaceae	Aust	0.2 x 4	Succulent perennial herb, mauve flowers over spring/early aumme. Centre of plant often dies back after stress or scale attack.
Cotyledon orbiculata	None	Crassulaceae	Exotic	0.8 x 1.0	Extremely variable form, evergreen succulent shrub to subshrub with leaves ranging in colour from green to silver-white. Cultivar 'Silver Waves' has attractive curvy leaves.
Crassula arborescens 'Blue Bird'	None	Crassulaceae	Exotic	1 x 1	A succulent, branching evergreen shrub, forms tight clusters of attractive blue, overlapping succulent leaves on short stems.
Crassula atropurpurea var. *anomala*	None	Crassulaceae	Exotic	0.3 x 0.3	Small, perennial succulent with leaves evenly spaced along erect stems. A shrubby plant with oblong or oblanceolate, glabrous or minutely papillose leaves which may turn deep red.
Crassula biplanata	None	Crassulaceae	Exotic	0.3 x 0.4	Small branching perennial succulent with tiny grey-green leaves, stems wiry and woody, small white flowers. Looks more like a sedum based on habit and leaf traits.
Crassula capitella 'Campfire'	None	Crassulaceae	Exotic	0.2 x 0.4	Evergreen succulent subshrub with succulent bright red leaves in spirals around brittle stems which can break off and root readily.
Crassula tetragona	Miniature Pine Tree	Crassulaceae	Exotic	0.8 x 0.5	Small succulent shrub, composed of erect stems that branch near the tops. Gradually develops bare stems with foliage concentrated at the top in the absence of pruning.
Curio repens	Blue Chalksticks	Asteraceae	Exotic	0.15 x 0.8	Evergreen prostrate succulent herb, with small upright bluegreen succulent leaves rooting at the stem nodes to form a slowly creeping mat.
Curio talinoides var. *mandraliscae*	Blue Chalksticks	Asteraceae	Exotic	0.3 x 0.8	Evergreen prostrate succulent herb, with long blue-green succulent and cylindrical leaves arising from lower stems. White daisy-like flowers above the foliage in spring.
Delosperma echinatum	Pickle Plant	Aizoaceae	Exotic	0.3 x 0.75	Shrubby and low-growing succulent with pairs of leaves on wiry stems, leaves covered with water vesicles and soft white bristle-like hairs/spines.

Species	Common name	Family	Origin	Indicative mature height x width (m)	Plant notes
Succulents					
Delosperma lehmannii	Ice Plant	Aizoaceae	Exotic	0.2 x 0.3	Low growing and compact succulent with thick, three-angled leaves. Creates a dense and effective groundcover in hostile conditions.
Drosanthemum floribundum	Rosea Ice Plant	Aizoaceae	Exotic	0.15 x 1	Prostrate evergreen shrub with trailing branches and erect flowering stems, covered with dew-drop-like papillae, giving a frosted appearance. Can be weedy in some locations, use with care.
Echeveria ×imbricata	Hens and Chicks, Blue Rose Echeveria	Crassulaceae	Exotic	0.10 x 0.2	Low growing succulent with blue-green rosettes of foliage, on short stems as it ages. Can be readily divided and replanted.
Euphorbia flanaganii	Medusa's Head	Euphorbiaceae	Exotic	0.15 x 0.4	Low, almost dwarf succulent with multiple arms arising from a central caudex (tuberous body) and swollen underground stem. Very small leaves on the snake-like branches.
Hesperaloe parviflora	Red Yucca	Asparagaceae	Exotic	0.8 x 0.8	Narrow and upright evergreen and stemless succulent perennial herb, forming a rosette of narrow, pointed leaves with vertical racemes of red flowers.
Hylotelephium 'Matrona'	None	Crassulaceae	Exotic	0.6 x 0.6	Succulent, perennial herb with purple-burgundy leaves and stems and bright mauve-pink flowers. Plant dies back to basal rootstock over winter.
Hylotelephium 'Autumn Joy'	None	Crassulaceae	Exotic	0.6 x 0.5	Succulent, perennial herb with green leaves and dense heads of upright flowers from summer to late autumn. First pink, then red, the flowers further darken in Autumn. Plant dies back to a basal rootstock over winter.
Kalanchoe beharensis	Feltbush, Velvet Leaf	Crassulaceae	Exotic	1.2 x 0.8	Upright evergreen shrub or tree-like succulent with large felty greyish leaves. Very susceptible to frost damage, a number of different leaf forms are available.
Lampranthus aureus	Iceplant	Aizoaceae	Exotic	0.3 x 0.5	Erect and rounded succulent shrub with dark green leaves and clusters of bright orange flowers borne above the foliage over summer.
Lampranthus deltoides	Pink Iceplant	Aizoaceae	Exotic	0.3 x 1	Low growing often trailing, evergreen succulent subshrub, with reddish stems and angular green leaves. Indestructible in hot, dry green roofs, provided there is good drainage.
Sedum confusum	None	Crassulaceae	Exotic	0.15 x 0.3	Plants spread by trailing stems to form a spreading foliage mat; shiny bright green leaves which typically form rosettes.
Sedum pachyphyllum	Jelly Beans	Crassulaceae	Exotic	0.3 x 0.3	Low growing and clump-forming evergreen succulent herb to subshrub. Small green 'jelly bean' leaves borne from horizontal stems, with yellow flowers arising from the axils.
×*Sedeveria* 'Pats Pink'	None	Crassulaceae	Exotic	0.1 x 0.2	Small spreading succulent herb to subshrub, produces rosettes of orange-green leaves branching from the base. Leaf colour is extremely variable according to growing conditions.
Bulbs, corms and related plants					
Allium amplelоprasum	Wild Leek	Amaryllidaceae	Exotic	0.5 x 0.2	Tall, stout, bulbous perennial, a few basal linear leaves, heads of purple-pink flowers over early summer.
Allium schoenoprasum	Chives	Amaryllidaceae	Exotic	0.2 x 0.3	A perennial, clump-forming bulbous herb, dormant during winter in cold climates, evergreen to semi-evergreen in warmer areas.
Allium tuberosa	Garlic Chives	Amaryllidaceae	Exotic	0.5 x 0.3	An erect, spring to summer-flowering perennial herb, with clusters of small, cylindrical bulbs.
Arthropodium milleflorum	Pale Vanilla-lily	Asparagaceae	Aust	0.8 x 0.3	Tufted, grassy, tuberous herb, dormant in late summer or dry season.
Bulbine bulbosa	Bulbine Lily	Asphodelaceae	Aust	0.4 x 0.2	Tuberous and upright perennial with almost succulent, linear leaves. Yellow star-like flowers produced over a long season from spring to autumn. Can seed freely.
Crocosmia 'Lucifer'	None	Iridaceae	Exotic	1.0 x 0.6	A clumping, cormous perennial with sword-shaped leaves and tall spikes of red flowers above the foliage over summer.
Freesia Modern Hybrids	Freesia	Iridaceae	Exotic	0.4 x 0.6	A deciduous, cormous perennial, basal leaves in flattened fans and sprays of heavily scented flowers over winter and early spring. Dormant after flowering till the following winter.
Iris germanica	Bearded Iris	Iridaceae	Exotic	0.6 x 0.8	A semi-evergreen perennial with strong basal rhizomes, leaves grey-green, flowers in spring in many colours. Tough and resilient, best divided every few years.
Narcissus 'Grand Soleil d'Or'	Daffodil cv.	Amaryllidaceae	Exotic	0.45 x 0.3	A summer dormant bulb, basal clumps of fleshy leaves, umbels of fragrant yellow flowers. One of the many Daffodils (or Jonquils) that can be used on irrigated green roofs.
Pelargonium rodneyanum	Magenta Stork's-bill	Geraniaceae	Aust	0.4 x 0.5	Small, perennial herb, leaves are oval in shape and lobed, pink flowers arise over summer and autumn on slender stalks rising above the foliage, can withstand very dry and hot conditions by dying back to a large tuberous root.
Tulbaghia violacea	Society Garlic	Amaryllidaceae	Exotic	0.45 x 0.6	A clump-forming, rhizomatous evergreen perennial herb, strap-like leaves and lilac flowers on slender scapes almost all year.
Wahlenbergia stricta	Tufted Bluebell	Campanulaceae	Aust	0.3 x 0.2	An upright and clumping perennial with a solid taproot and wiry stems of small leaves. Blue to mauve bell-shaped flowers over spring. Can seed freely once established.
Food plants					
Acca sellowiana	Feijoa (Smaller cvs.)	Myrtaceae	Exotic	2.0 x 1.5	Evergreen fruiting tree, best in cooler climates or protected locations, multiple plants will assist pollination and fruit set, needs a soil depth of at least 800 mm.
Allium sativum	Garlic	Amaryllidaceae	Exotic	1.0 x 0.2	Bulbous vegetable, best over cooler months, needs good drainage and rich soils, best in depths of at least 250 mm.
Food plants					
Allium schoenoprasum	Chives	Amaryllidaceae	Exotic	0.2 x 0.3	A perennial, clump-forming bulbous herb, dormant during winter in cold climates, evergreen to semi-evergreen in warmer areas.
Beta vulgaris subsp. *vulgaris*	Beetroot	Amaranthaceae	Exotic	0.4 x 0.2	Annual vegetable, best over cooler months to ensure beets , best in depths of at least 250 mm.
Brassica oleracea cvs.	Broccoli, Cabbage, Cauliflower	Brassicaceae	Exotic	0.5 x 0.5	Annual vegetable, best over cooler months but many cvs. can grow succesfully over summer, tolerates shallow depths (150 mm).
Brassica oleracea cvs.	Kale	Brassicaceae	Exotic	0.5 x 0.3	Annual vegetable, best over cooler months to avoid bolting and maximise leaf production, tolerates shallow depths (150 mm).
Capsicum annuum	Capsicum	Solanaceae	Exotic	1.0 x 0.5	Annual vegetable, many different forms, grows best over warmer months, pollinators assist fruit set, can tolerate shallow depths (150 mm).
Capsicum annuum, C. chinense, C. frutescens	Chillis	Solanaceae	Exotic	1.0 x 0.5	Annual vegetables, grows best over warmer months, pollinators assist fruit set, can tolerate shallow depths (150 mm).
Citrus limon	Lemon (Dwarf cvs.)	Rutaceae	Exotic	3.0 x 1.0	Evergreen fruiting tree, training, pruning and pollinators improve form and assist fruiting, needs a soil depth of at least 800 mm.
Coriandrum sativum	Coriander	Apiaceae	Exotic	0.75 x 0.2	Annual culinary herb with leaves and seeds both used, tolerates shallow depths (150 mm), best grown over cooler months to avoid 'bolting'.
Cucumis sativus	Cucumber	Cucurbitaceae	Exotic	1.0 x 0.3	Annual vegetable, a twining climber with many different forms, best over warmer months, trellis or support needed, pollinators required for fruit set, can tolerate shallow depths (150 mm).
Eruca vesicaria subsp. *sativa*	Arugula/ Roquette/Rocket	Brassicaceae	Exotic	0.8 x 0.4	Annual culinary herb, leaves mainly used, tolerates shallow depths (150 mm), best grown over cooler months to avoid 'bolting'.
Ficus carica	Fig	Moraceae	Exotic	3.0 x 1.0	Deciduous fruiting tree, tolerates warmer locations, training and pruning improves form and fruiting, pollinators assist fruit set, needs a soil depth of at least 800 mm.
Fragaria ×ananassa	Strawberry	Rosaceae	Exotic	0.4 x 0.4	Spreading perennial herb, best used in contained or well-maintained locations (due to vigorous stolons), needs annual division and pruning to ensure fruit set.
Lactuca sativa	Lettuce	Asteraceae	Exotic	0.3.x 0.3	Annual vegetable, need to select cultivar for cool vs. warm season to avoid bolting and maximise leaf production, tolerates shallow depths (150 mm).
Malus domestica	Apple (Dwarf cultivars)	Rosaceae	Exotic	2.0 x 1.0	Deciduous fruiting tree, best in cooler climates or protected locations, requires regular training and pruning, pollinators required for fruit set, needs a soil depth of at least 800 mm.
Melissa officinalis	Lemon Balm	Lamiaceae	Exotic	1.0 x 0.5	Bushy perennial herb with lemon-scented foliage. Easy to cultivate, best in soil depths of at least 250 mm, responds well to regular pruning.
Mentha ×piperita	Peppermint	Lamiaceae	Exotic	0.75 x 1.0	Spreading perennial and culinary herb used for its leaves. Best used in contained or well-maintained green roof locations (due to vigorous rhizomes). Tends to die back over cooler months.
Ocimum basilicum	Basil	Lamiaceae	Exotic	0.6 x 0.5	Annual, sometimes perennial, culinary herb and leafy green, many different forms, tolerates shallow depths (150 mm) and best grown under rich soil conditions.
Origanum vulgare	Oregano	Lamiaceae	Exotic	0.45 x 0.6	A sprawling or erect, aromatic, slightly woody perennial herb, forming a mat of green or golden leaves with emergent flowering stems.
Petroselinum crispum	Parsley	Apiaceae	Exotic	0.5 x 0.3	Biennial culinary herb with a stout taproot. Many different forms, leaves used, although seeds are also edible. Easy to cultivate, best in soil depths of at least 250 mm, often seeds freely.
Phaseolus vulgaris	Beans (Green, Snap)	Fabaceae	Exotic	0.7 x 0.4	Annual vegetable, grows best over warmer months in well-irrigated conditions, tolerates shallow depths (150 mm).
Pisum sativum	Peas	Fabaceae	Exotic	0.6 x 0.2	Annual vegetable, best over cooler months, needs trellis or support, tolerates shallow depths (150 mm).
Punica granatum var. *nana*	Dwarf Pomegranate	Lythraceae	Exotic	1.0 x 0.75	Deciduous fruiting shrub, tolerates warmer locations, training and pruning improves form and fruiting, pollinators assist fruit set, needs a soil depth of at least 800 mm.
Raphanus sativus	Radish	Brassicaceae	Exotic	0.4 x 0.1	Annual vegetable with tuberous roots, best over cooler months, requires soil depths of at least 250 mm.
Rosmarinus officinalis	Rosemary	Lamiaceae	Exotic	1.5 x 1.0	Upright to prostrate evergreen shrub (cultivar dependent), with strongly-scented foliage and generally blue-mauve flowers. Tolerates heat, benefits from hard pruning, best in soils 500 mm depth (min.).
Salvia officinalis	Sage	Lamiaceae	Exotic	0.5 x 0.75	Rounded evergreen shrub or subshrub (cultivar dependent), used as a culinary herb due to scented foliage. Tolerates heat, needs good drainage, best in soils minimum 500 mm deep.
Solanum lycopersicum	Tomato	Solanaceae	Exotic	2.0 x 0.5	Annual vegetable, best over warmer months, variable growth dimensions, pollinators assist fruit set, soil depths of at least 250 mm.
Solanum melongena	Eggplant	Solanaceae	Exotic	1.0 x 0.5	Annual vegetable, best over warmer months, pollinators required for fruit set, can tolerate shallow depths (150 mm).
Thymus vulgaris	Thyme	Lamiaceae	Exotic	0.3 x 0.6	Low growing and wiry, evergreen shrub or subshrub with pink/white spring flowers, used as a culinary herb. Tolerates heat and drought, regular pruning improves form, best in soils 250 mm depth (min.).

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