

Planting Protocol

Summary

*This document introduces the **Which Plant Where Living Lab**, a new network of urban planting sites as part of the **Which Plant Where** research program, funded by Hort Innovation Australia. The network involves the establishment and monitoring of new urban plantings across a wide range of environmental conditions to evaluate plant performance and the environmental benefits that underpin healthy urban environments.*

1. Background

The presence of vegetation in cities has been widely linked to environmental, social and economic benefits. Plants change microclimatic conditions by reducing air temperature and increasing humidity. They also provide habitat and food for other species, are excellent filters for urban pollutants, improve physical and mental health, and influence indices of human comfort.

Our **Living Lab** is part of the **Which Plant Where** research program. In this program, we are testing species responses to different environmental conditions and expanding the palette of urban plant species in both glasshouse and large-scale field plantings to determine which species characteristics are associated with climate resilience and environmental co-benefits for urban populations. The **Living Lab** involves standardized plantings of select species across a wide range of local environmental conditions and planting contexts (e.g. street versus park).

The **Which Plant Where Living Lab (WPWLL)** has two overarching aims:

- 1) To test the influence of environmental conditions, including broad climate patterns, site-specific micro-climate and soil characteristics, on species' performance and survival;
- 2) To examine the role of vegetation structure and diversity in urban plantings by measuring the benefits of co-planting trees and shrubs (compared to tree-only or shrub-only plantings), in terms of their impacts on heat mitigation and biodiversity.

2. The **Which Plant Where Living Lab**

2.1 Project definition

The **WPWLL** is a long-term project involving tree and shrub plantings in significant urban areas throughout Australia. **WPWLL** provides a platform for evaluating the role of local conditions for plant performance and the associated co-benefits within urban landscapes, over a timescale of 5-10 years.

2.2 *WPWLL* data

Site- and network-level data related to plant survival and performance from the plantings will be shared electronically among collaborators, as reports. In addition, all participants will be acknowledged in any resulting publications and/or on-line material relating to the *Living Lab*.

2.3 *Project partnerships*

Project partners will provide sites and high-quality plant material for the plantings, and will be responsible for the establishment and maintenance of plantings, including the personnel and equipment required for these activities. The first 12 months are considered as the early maintenance period, during which time watering and other maintenance activities are required (see details below). Detailed monitoring will be undertaken by our research team, with site- and project-level data being shared with project partners.

3. Methodology

3.1 *Planting options*

The network plantings represent an **ecological palette** of tree and shrub species, planted on their own and together. The *WPWLL* has three levels of network participation and, where space allows, we encourage participation in all three:

- **Level 1 (Trees)**. Standardized plantings comprising 4 trees species. One individual of each species, replicated four times, is the minimum requirement for participation in this level (i.e. 16 trees in total). Level 1 plantings are recommended for small sites such as streetscapes, paths, small parks or gardens (**Figure 1**).
- **Level 2 (Shrubs)**. Standardised plantings comprising 4 shrub species. Four individuals of each of the 4 species, replicated 4 times is the minimum requirement for this level (i.e. $4 \times 4 \times 4 = 64$ individual shrubs) (**Figure 1**). This shrub-only option is ideal where space is limited or in locations where power lines or other overhead obstacles preclude tree plantings.
- **Level 3 (Trees + Shrubs)**. This level comprises a mixture of 4 different tree species, each planted with 4 different shrub species alongside, to provide greater structural complexity of the planting. A single replicate comprises 4 trees and 16 shrubs; when replicated four times, this therefore represents a total of 16 trees and 64 shrubs. This planting level is recommended for larger sites, such as parks and open green spaces (**Figure 1**).

Comparison of tree only, shrub only and tree + shrub plantings will allow us to examine the impact of shrubs on tree performance (and vice versa), and to evaluate the co-benefits (i.e. increase in bird and invertebrate diversity, cooling effect) of a more complex vegetation structure.

Level 1: Tree only design (4 tree species)



- Suitable for:
- Streetscapes
 - Medians
 - Paths
 - Parks
 - Verges

Level 2: Shrub only design (4 shrub species)



- Suitable for:
- Streetscapes
 - Medians
 - Road verges
 - Below power lines
 - Above underground utilities

Level 3: Trees + shrub design (4 tree plus 4 shrub species)



- Suitable for:
- Parks
 - Gardens
 - Open spaces









Figure 1. Example of linear plantings for the three levels of participation. Non-linear planting designs are also appropriate. All sites require a minimum of four replicates for each level.

3.2 Species

As part of a target list of several hundred species being tested under the *Which Plant Where* research program, we have identified 4 preferred tree and 4 shrub species that allow a robust comparison between different life histories (trees vs. shrubs; deciduous vs. evergreen) and contrasting canopy structures, heights and flowering characteristics (**Tables 1 and 2**).

Although these are our preferred tree and shrub species, we have an additional list of species that can be substituted and/or added into their respective categories (**Tables 1 and 2**). Alternative species can be substituted in where the preferred species is not appropriate for the planting site or the plant material is not available. We also encourage stakeholders to consider planting additional species to maximise the diversity of plants being tested in the *Living Lab*. Substitutions/additions should be undertaken in consultation with the WPW research team.

Table 1. Description of preferred and alternative tree species. Please use preferred species wherever possible; if alternative species are needed, select the corresponding replacement species from the column on the right.

Category	Species and attributes		Category	Species and attributes	
Tree 1			Tree 1		
Preferred	<i>Lagerstroemia indica</i> Crepe myrtle Lythraceae Deciduous 6-8 m Exotic		Alternative	<i>Pyrus calleryana</i> Callery pear Rosaceae Deciduous 5-8 m Exotic	
Tree 2			Tree 2		
Preferred	<i>Liriodendron tulipifera</i> Tuliptree magnolia Magnoliaceae Deciduous 20 m Exotic		Alternative	<i>Quercus robur</i> English oak Fagaceae Deciduous 10 m Exotic	
Tree 3			Tree 3*		
Preferred	<i>Elaeocarpus reticulatus</i> Blueberry ash Elaeocarpaceae Evergreen 15 m Native		Alternative	<i>Cupaniopsis anacardioides</i> Tuckeroo Elaeocarpaceae Evergreen 15 m Exotic	
Tree 4			Tree 4*		
Preferred	<i>Lophostemon confertus</i> Queensland brush box Myrtaceae Evergreen 20 m Native		Alternative	<i>Angophora costata</i> Rose gum Myrtaceae Evergreen 15 m Native	

* If native-only plantings are required at any particular site, please select both the preferred and alternative species for Trees 3 and 4. All eight tree species can be planted if space permits.

Table 2. Description of preferred and alternative shrub species. Please use preferred species where possible; if alternative species are needed, select the corresponding replacement species from the column on the right.

Category	Species and attributes		Category	Species and attributes	
Shrub 1			Shrub 1		
Preferred	<i>Melaleuca citrina</i> (synonym <i>Callistemon citrinus</i>) Red bottlebrush Myrtaceae 3 m Native		Alternative	<i>Westringia longifolia</i> Long-leaved westringia Lamiaceae 2 m Native	
Shrub 2			Shrub 2		
Preferred	<i>Westringia fruticosa</i> Coastal rosemary Lamiaceae 1.5 m Native		Alternative	<i>Zieria cytisoides</i> Downy zieria Rutaceae 1.5 m Native	
Shrub 3			Shrub 3		
Preferred	<i>Baeckea virgata</i> (synonym <i>Sannantha virgata</i>) Dwarf Baeckea Myrtaceae 1.5 m Native		Alternative	<i>Kunzea parvifolia</i> Violet kunzea Myrtaceae 1.5 m Native	
Shrub 4			Shrub 4		
Preferred	<i>Hibbertia obtusifolia</i> Hoary Guinea-flower Dilleniaceae 1 m Native		Alternative	<i>Grevillea juniperina</i> Juniper-leaf grevillea Proteaceae 0.6 m Native	

3.3. *Quality standards for planting material*

High quality and homogeneous planting material is required to ensure planting success and minimise confounding effects associated with variable plant material and the associated difficulties in interpretation of plant performance and benefits.

- Well-established (“advanced”) individuals are needed to be large enough to tolerate planting stress and avoid failure during establishment. The optimum pot size is 45 litres for trees and 400 ml for shrubs.

The quality of tree planting stock grown by commercial nurseries is extremely variable. To ensure consistency and quality of tree stock, all material should conform to Australian Standard AS 2303, “Tree Stock for Landscape Use.” The standard provides the above- and below-ground criteria for tree stock quality. Specifications for supply of shrub stock should employ similar standards (including plant health, branching structure and root formation). We recommend avoidance of plants with off-type characteristics, such as dwarfism, gigantism, mosaic-like, variegated, chlorotic or necrotic leaf patches, droopy leaves, or containers that are damaged or with loss of substrate. Plants without a properly developed root system should be discarded.

3.4. *Planting protocol*

3.4.1. Preparation for planting

At each site, consideration must be given to minimise the incidence of vandalism on the plantings (e.g. fencing, as appropriate). Information on the *WPWLL* should ideally be provided to local residents and stakeholders to outline the benefits of plantings. Sites should remain as undisturbed as possible for at least the establishment period of study (first 12 months). Trees and shrubs should be planted during the dormant season under well-watered conditions. The first phase of the *WPWLL* establishment should include plantings until mid-October 2018. Excavation of the sub-soil needs to be to a depth that allows the bottom of the root ball to sit on undisturbed material or uncompacted fill such that the top of the root ball remains at the proper finished grade.

3.4.2. Soil excavation

Excavation must be sufficiently deep as to prevent root damage. Excavation must not cause soil compaction in the root zone. Prevention of soil compaction - Soil compaction must be prevented within the drip line of the plant canopy. Planting should not take place during heavy precipitation events.

3.4.3. Site preparation

Weed removal and application of herbicides.

Where weed infestation occurs, the following action is advised:

- (a) for those species listed by the relevant local government authority as noxious categories W1, W2, W3, or W4 under the Noxious Weeds Act 1993, take action as required by the Act and the local Government Authority;
- (b) for all other species, physical removal or spraying with herbicide as appropriate to remove the impact of the weeds on the establishment and performance of the plant material.

Use an appropriate herbicide or pesticide for the intended purpose, subject to the specific requirements of the relevant local Government Authority. The choice of herbicide or pesticide used must be based on health and environmental considerations as appropriate. Use herbicides and pesticides in accordance with the manufacturer’s directions supplied with the product.

A biodegradable red dye should be included in the herbicide spray. The dye content used must be sufficient to ensure that the treated areas can be identified. Do not spray herbicide in windy weather (wind of 10 km/hr or greater) and allow enough distance from watercourses to prevent runoff of herbicide. Areas sprayed with herbicide must remain undisturbed for two weeks or as recommended by the manufacturer, whichever is the longer period.

Clearing for planting.

Clear the following areas by slashing to a height of not more than 100 mm:

- (a) for large-scale plantings in mulched beds, the areas of the mulched beds;
- (b) for individual plantings, the area of each planting, together with a perimeter area 1.5 m wide.

Remove, recycle or dispose of all slashings in a legally and environmentally responsible manner. Spray all planting areas with approved herbicide and leave for two weeks before commencing excavation.

3.4.4. Planting

Individuals must be planted randomly with respect to species. Council requirements vary as to the distance of street trees from the edge of the kerb, with distances of between 900 mm and 1.5 m typical in a standard 3.5 m verge. A 900 mm minimum is recommended to minimise any tree damage associated with the kerb-side operation of garbage trucks.

Street tree plantings are traditionally evenly spaced. The recommended distance between individual trees is a minimum of 8 m in tree-only plantings (level 1). For shrub-only plantings (level 2), the recommended planting density is one shrub per square meter. In tree + shrub plantings (level 3) trees should be planted at least 8 m apart, with shrubs (one of each shrub species per tree) planted 1-2 m away from the tree stems (**Figure 2**). As we are interested in assessing how trees and shrubs interact with each other, where possible we encourage planting trees no more than 12 m apart from each other and with a distance of no more than 2 m between trees and their co-planted shrubs.

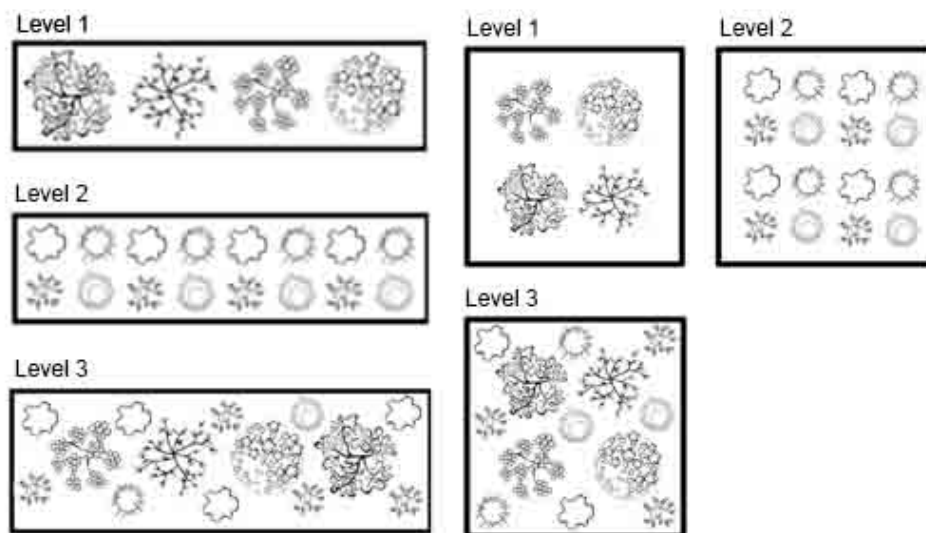


Figure 2. Planting layouts can be flexible, depending on space availability. Here we present an example of linear and non-linear plantings for each of the three levels of participation: level 1 (trees-only), level 2 (shrubs-only), level 3 (trees + shrubs). Four replicates of each level are required.

Where necessary, roots can be pruned and the root ball gently opened. If there is a chance of some settling after planting, the top of the root ball should be installed 2-4 cm above the surrounding grade. Wherever possible, the hole should be dug with sloping sides (preferred angle of 45 degrees). Plants should be positioned vertically. Planted trees should not require staking.

Soft plant ties support must be pushed back into the lower portion of the hole. A 10 cm raised saucer, of inside diameter equal to the outside diameter of the root ball, should be constructed around the perimeter of the root ball to enhance water infiltration (**Figure 3**). Plants should be immediately and adequately watered after planting.

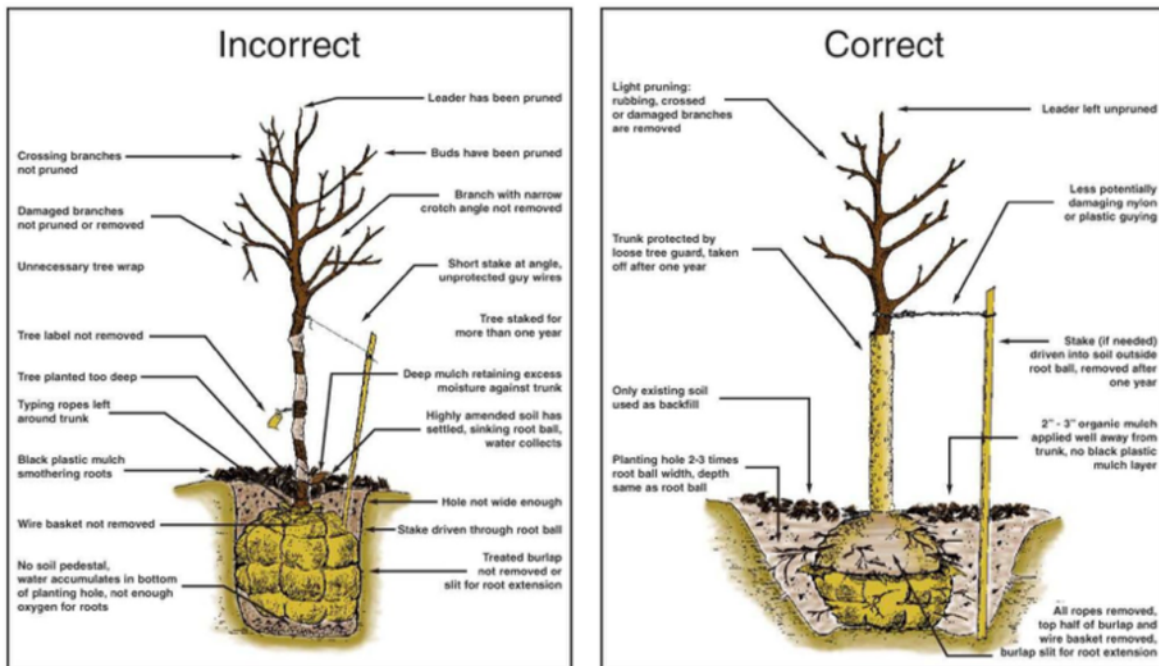


Figure 3. Illustration of an incorrect and a correct planting (Image source: treeologiceng.wordpress.com)

An organic mulch (e.g. composted materials or woodchip), should be applied to the surface after planting, to a thickness of between 50 to 75 mm in the surrounding area. Mulches should not be placed in direct contact with the plant stem. Top-up mulch application should be added, as required, to maintain target depth, using the same mulch material as specified at the original planting.

Fertilizer: Prior to application of fertilizers temporarily rake back the mulch to expose the topsoil. Supply and apply a 6-8 month-controlled release fertilizer on planting. The fertilizer should be a balanced formulation containing all essential macro-nutrients and trace elements for normal plant growth. Modify the formulation where required for phosphorus-sensitive (i.e. native) species. A slow-release formulation using micro-prill technology can be used. The fertilizer should be applied evenly to the root zone by hand broadcasting at the manufacturer’s recommended rate. Following fertilizer application, replace the mulch and replenish mulch cover as required.

3.4.5. Establishment and maintenance

Routine maintenance is required in order to ensure that the tree and shrub plantings maintain healthy and vigorous growth and development throughout the first 12 months.

- **Monitoring and inspection.** We recommend inspection from a qualified horticulturist on a regular basis to check for pest and disease infestation, signs of moisture stress, irregular growth patterns or similar problems. Where necessary, corrective action should be carried out promptly to minimise damage and avoid death or loss of plant material.
- **Watering.** Water plants on a regular basis throughout the first 12 months to ensure that they do not experience moisture stress. Regular monitoring of soil moisture levels should be carried out to ensure adequate soil moisture is maintained throughout the establishment period.
- **Weed control.** Control weed growth within the root zone area on a regular basis to minimise weed competition. Weeds should be eradicated before they reach 100 mm in height, either through manual removal or the use of herbicide (Glyphosate), sprayed directly onto the weeds at the manufacturers recommended rate. Spraying should only be undertaken when the weather conditions are fine and calm and there is no anticipated rainfall within the next 24 hours.
- **Pest and disease control.** Control pests and diseases as required to ensure that planted material is maintained in a healthy and vigorous condition and growth rate is not compromised.
- **Pruning.** Remove dead branches of greater than 10 mm in diameter as required. Selectively remove branches as required to promote proper form and branching habit, typical for the natural growth habit of the species. Ensure that no greater than 25% of the total foliage area is removed at any one time.

Prior to pruning, ensure compliance with the relevant Local Government Authority's Tree Preservation Order. All pruning should be carried out in accordance with the Australian Standard No 4373-2007 Pruning of Amenity Trees and the NSW WorkCover Authority Code of Practice for the Amenity Tree Industry (1998) to ensure works are carried out to acceptable safety standards in accordance with current best practice. All pruning should be carried out by a qualified arborist.

- **Replacement.** Plants that die due to improper or inadequate maintenance during the establishment maintenance period need to be replaced with the same species in accordance with the original planting specification, at the contractors cost.
- **Litter removal.** Remove litter and debris from the root zone as required. Dispose of all waste material at a licensed Waste Transfer facility.

4.5 Monitoring

One month after planting, the WPW research team will assess survival and measure plant traits related to performance. We will subsequently measure growth of individuals and monitor their condition at 6-12 month intervals, focussing on winter/summer periods and following any significant periods of climate stress. In addition to growth and performance traits, we will measure micro-climatic conditions including temperature, light (photosynthetic active radiation), wind and relative humidity. Biodiversity assessments will be carried out where tree (level 1), shrub (level 2) and tree + shrub (level 3) plantings have been undertaken at the same site.