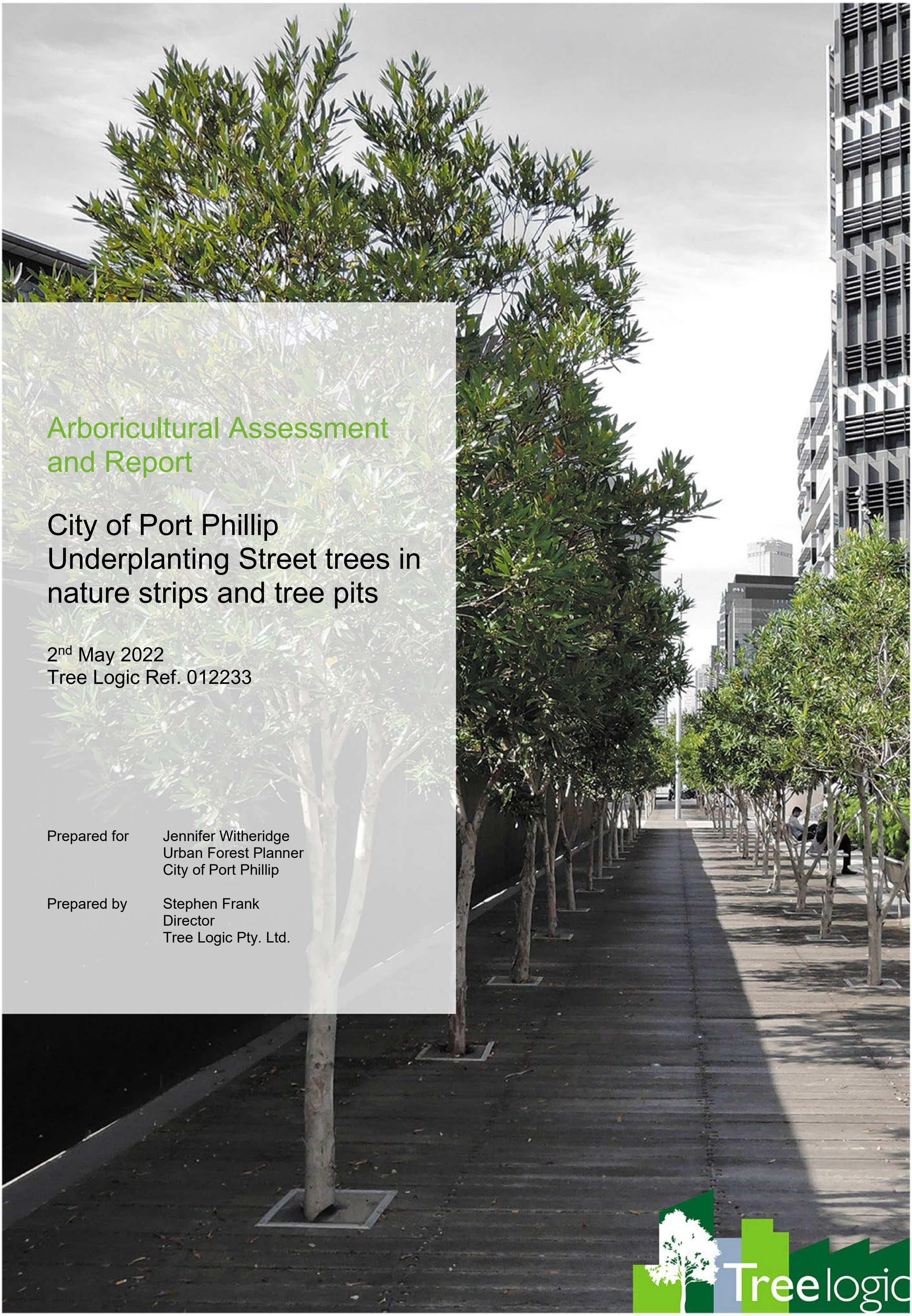

Arboricultural Assessment and Report

City of Port Phillip Underplanting Street trees in nature strips and tree pits

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Contents

Key points

Street trees are the dominant landscape elements in the streets of Port Phillip. They need careful consideration, rigorous management and protection in order to maintain them in a safe and aesthetically pleasing manner to achieve anticipated benefits.

Urban site constraints, primarily anthropogenic soils and reduced soil volumes, and adjacent hard surfaces constrain tree growth and reduce vitality.

Competition from understorey plants and grasses can compound drought induced stress on trees.

Due to climate change predictions and associated stress placed on trees, strategies and design elements for tree planting need to be considered. This includes the reduction in competition from understorey plantings and grass.

Impacts to tree's root systems must be avoided. In particular, the structural root zone (SRZ) of a tree, which comprises the major roots closer to the trunk, is of vital importance for the ongoing health and structural stability of a tree and must be protected.

There are advantages and disadvantages to incorporating verge plantings within a street. There is opportunity, with appropriate policy guidance and design solutions, for verge plantings to contribute to urban regreening, biodiversity, visual amenity and complexity of street greenery. However, this should not be to the detriment of the treed canopy.

Verge plantings have the potential to engage the community with public space, while also improving wellbeing and people-nature connections.

Key points and recommendations:

- The great majority of tree roots will be within 0.5-0.6 m of the soil surface so care must be used when digging underneath tree canopies.
- There is a risk potential that major roots close to the base of an established tree could be damaged when establishing or maintaining an understorey planting.
- The greatest risk to urban trees from climate change is the likely long-term change in soil moisture availability. Competition for moisture from additional understorey plants needs to be considered.
- In urban environments, the availability of water is negatively impacted upon by impermeable built urban infrastructure.
- As a general guideline, no understorey planting should occur within three times the trunk diameter (measured at 1.4 m above ground level) away from the edge of a trunk of a street tree.
- It is recommended that the root area of an establishing tree (considered three times the size of the root ball at planting) be left free of understorey plants and grasses for the duration of a 5-year establishment period or as otherwise approved by Council.
- Consideration needs to be given to the use of appropriate plants and planting techniques when planting under the canopy of trees.
- Do not build up verge gardens by raising soil levels around the trunks of street trees. This can introduce disease to the trees and predispose the tree to stress.

The importance and benefits of street trees

The street trees of Port Phillip are a vital component to achieve the vision for the greening of Port Phillip.

Port Phillip is committed to maintaining and enhancing streetscapes for improved amenity, liveability, character and sustainability through tree planting and implementing alternate greening options. Trees in streets, parks and private gardens are one of the most effective methods for reducing heat in urban areas and the adverse effects of climate change.

Trees are, because of seasonal changes and their size, shape, and colour, the most prominent elements of urban nature. Trees are important to people especially through symbolizing personal, local, community and cultural meanings. Their benefits and uses range from intangible psychological and aesthetic benefits to amelioration of urban climate and mitigation of air pollution. Historically the main benefits of urban trees relate to health, aesthetic and recreational benefits in industrialized cities (Tyrväinen, Pauleit, Seeland & de Vries, 2005).

Urban trees also contribute to an attractive green townscape and consequently communicate the image of a positive, nature-oriented city. Indirectly, urban trees can promote tourism and enhance economic development. At the local level trees contribute to the quality of housing and working environments and their benefits are reflected in property values. (Tyrväinen, Pauleit, Seeland & de Vries, 2005).

Some of the key benefits urban trees provide:

- reduce household cooling costs by more than 10%.
- attract birds and insects to your garden.
- provide wildlife habitats and linkages to other open space.
- provide shape, scale, form and seasonal changes to the landscape.
- improve air quality.
- mitigate stormwater runoff, holding it in the soil and taking it up by plant roots and stormwater is also better filtered by the soil.
- improve human health outcomes.
- increased property values.

What would be considered the ideal growing conditions for established street trees.

What trees need to not just grow but thrive?

Plants are living organisms. Like all living things, they have basic biological needs that must be met if that organism is to survive. If the plant is required to thrive, then those basic needs must be exceeded.

The six basic resources required for plant growth are water, light, oxygen, carbon dioxide, nutrients and appropriate temperatures. Four of these requirements are provided by the soil environment. Soils store water, provide and store nutrients, allow oxygen to diffuse to plant roots and buffer root zone temperatures (Bassuk, 2017).

Urban soils are often highly altered from their natural, or original, state. Urban soils generally have high vertical and spatial variability, meaning it is difficult to predict the soil conditions from one area to another. Compaction via human activity destroys soil structure, restricting aeration and water movement (in, through and out). This deoxygenation and droughting/saturation alter soil organism activity, exacerbating structural decline and leading to interrupted nutrient cycling. The presence of anthropogenic materials and other contaminants alters the soil chemistry, locking up some nutrients, making others too available, and potentially introducing elements toxic to plant growth. Restricted underground space alters the ability of the media to regulate (slow) temperature change. Wide fluctuations in temperature are experienced by roots not evolved to tolerate these extremes.

When plants are grown in such a compromised soil environment, their basic biological needs are barely met. This results in unhealthy (low vigour) growth which predisposes plants to other environmental and biological stresses.

Trees need significant soil volumes of low compacted soil with suitable pore space, drainage, nutrients, and organic matter to provide for their long-term growth. Restricted soil volumes result in low soil moisture that limits root development and consequently affects the vitality and longevity of urban trees. Providing an adequate volume of soil amended to mitigate the worst of these conditions is absolutely fundamental in enabling the success of landscape plantings.

Competition

Grass competes with trees for both water and minerals. It can out-compete tree roots by 30% for available soil moisture. Field tests have shown a decrease in leaf nitrogen concentration when trees are grown amongst grass swards. A potassium increase can be seen in the same leaves as a result of reduced growth, causing a concentration increase.

As an example, a 24-month fertilizer application increased a tree's nitrogen content by 0.15%, but a grass sward reduced it by 0.45% in a 2-year period (Kozlowski et al 1991).

The effect of competition from grasses appears conclusive, whereas competition from other plants, particularly if used in more naturalistic landscapes, has mixed effects on tree root growth.

In forestry research, exclusion of understory vegetation had resulted in biomass increases of all the components of three conifer species in a forest ecosystem (Chang, et al., 1996). Total tree height growth was significantly greater where understorey was removed.

All understorey plantings would compete for soil moisture and nutrients when planted under trees.

Conversely, Yingchun, et al. (2019) demonstrate that fine tree root biomass is significantly promoted and increased due to competition from understory vegetation where forest biomass is low, which would also typically be the case in dense urban areas. There are ecosystem benefits to understorey plants because they add a large variety and diversity of habitats and soil flora and fauna.

Discussion on tree roots

Roots supply 99% of water requirements of the tree and during the normal growing season they supply nutrients in solution to all parts of the tree. The roots also receive and store energy in the form of sugars and carbohydrates from the leaves which are supplied to the tree for growth and other energy intensive activities such as flowering.

In general:

- Roots do not mirror the above ground parts.
- Roots do not stop at the drip line of the canopy.
- Roots (generally) do not extend to great depths in the soil.
- Roots are opportunistic and go where the essentials of life take them.

- Occasionally finer roots may extend to depths of 5.0 m or more. However larger roots will not tend to be further than 1.0 m below the surface. The great majority of roots will be within 0.5-0.6 m of the surface.
- Radial spread of tree roots is not regular or symmetrical.
- Radial spread is dependent on soil conditions and site constraints.
- Roots of trees grown in the open can often extend two to three times the radius of the crown, while those growing in a close planting will be more confined.

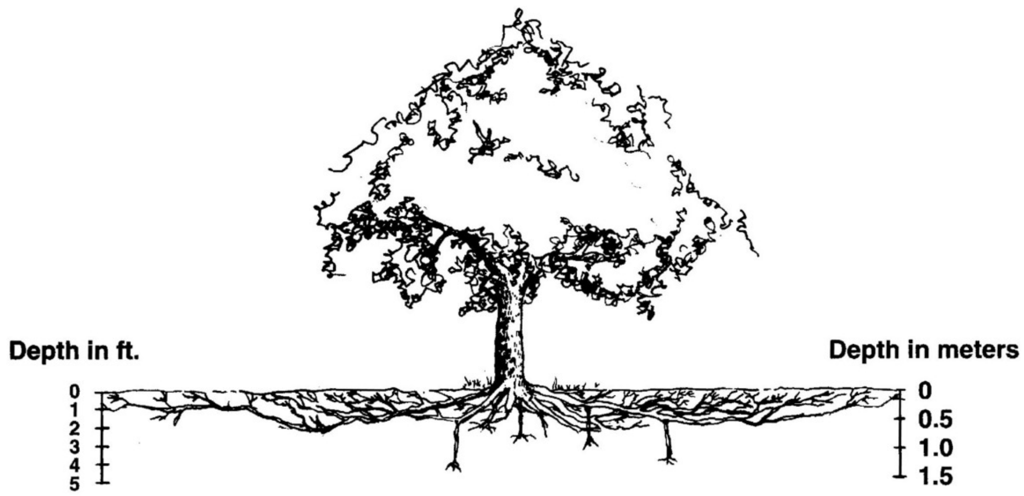

Figure 1. An appropriate representation of a tree root system. (From: Harris, Clark and Matheny, 2004)

There are also multiple physical constraints that dictate root exploration of the subterranean urban soil environment. These constraints can be broadly classified into two types: solid impediments such as building foundations, roads, and rocks; and permeable impediments, such as compacted soils. Root exploration of these physical obstructions may further depend upon moisture content.

Trees planted within linear street road reserves typically develop asymmetrical root systems because of the restricted rooting area and obstacles such as kerbs and pavements. Gilman (1997) identified that roots growing in a road reserve environment are frequently deflected by kerbs and grow parallel to the kerbing, creating a concentrated mass of roots in this area.

It is important to realise that root growth is opportunistic, occurring only where the soil environment can sustain it, with the presence of air and water being essential for growth. It is for this reason that the great majority of roots are found in the upper layers of a soil profile. However, if the opportunistic exploration of the soil encounters favourable conditions at any location, roots will proliferate.

Tree protection zone (TPZ).

The following is from Standards Australia, *AS4970 Protection of trees on development sites (Reconfirmed 2020)*. AS4970 provides guidelines that offer an understanding of how tree's root systems can be protected during development. It is stressed that AS4970 relates to the protection of trees during development. The perceived impact of planting or creating a verge garden within a tree protection zone would pose fewer potential tree impacts than that of development and construction.

According to AS4970 the most important consideration for the successful retention of trees during development is to allow appropriate above and below ground space for the trees to continue to grow. This requires the allocation of tree protection zones for retained trees.

The tree protection zone (TPZ) is a specified area above and below ground at a given distance from the trunk set aside for the protection of a tree's roots and crown to provide for the viability and protection of the tree to be retained.

The TPZ for individual trees is calculated based on trunk (stem) diameter (DBH), measured at 1.4 metres up from ground level. The radius of the TPZ is calculated by multiplying the trees DBH by 12. TPZ distances are measured as a radius from the centre of the trunk at (or near) ground level.

The method provides a TPZ that addresses both the stability and growing requirements of a tree. The TPZ incorporates the Structural Root Zone (SRZ).

There is a threshold as to how much root system can be lost without impacting tree health or creating a high-risk potential. Determining the specific size of this zone for an individual tree is dependent on several variable factors. These factors include tree species, age, condition, soil conditions and growing environment.

Of particular concern is the protection of structural roots, which are the major roots found closer to the base of the trunk. Damage to major roots can impact tree health and potentially tree stability.

Figure 2 illustrated to relationship between the TPZ and the SRZ and also indicates minor encroachment approaches as outlined in AS4970.

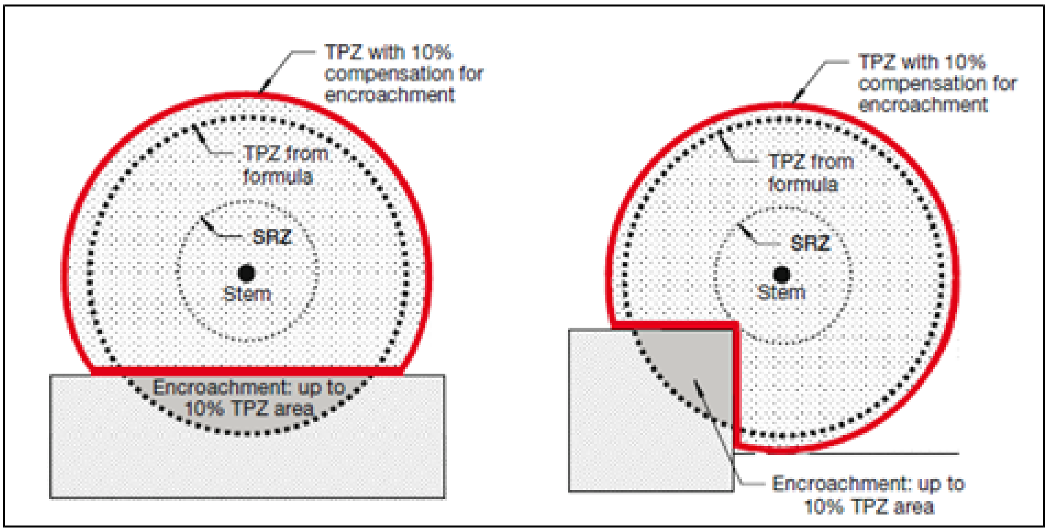

Figure 2. Examples of the TPZ and SRZ and minor encroachment into a TPZ. Extract from: AS4970-2009, Appendix D, p30 of 32

The structural root zone

There is a risk potential that major roots close to the base of an established tree could be damaged when establishing or maintaining a verge garden or understorey planting.

The greatest density of roots occurs within an area around the base of the tree's trunk. Root growth continues longer at the base of the trunk than further out (Hamilton, 1988). The pattern of root development can vary considerably, but generally, a tree has 5–15 (or more) primary structural roots that emanate from the root collar (base of the trunk) and descend obliquely into the soil before becoming horizontal within a short distance of the trunk. These major lateral roots account (act as a conduit) for 75% of the total root system (Gilman, 1997). Functionally, these roots are often referred to as structural roots with their primary role in anchoring the tree and creating a framework for the root system. In some tree species, horizontal structural roots near the trunk produce sinker roots that plunge vertically into the soil, providing supplemental anchorage (Day *et al*, 2010) (See Figure 1).

This zone of the root system is important when considering the management of the tree and implications around risk management, as tree stability depends heavily on both root system architecture and the anchorage of roots in the soil. Root/soil resistance gives rise to the characteristic mass of roots and soil seen on uprooted trees, known as the root plate. Uneven distribution, as is often the case with street trees, or large sections without roots reduces anchorage (Sundstrom and Keane, 1999).

A SRZ comprises the area around the base of a tree where structural roots required to maintain the tree's stability in the ground are typically located. This SRZ is of vital importance to sustaining a healthy and safe tree, however the research, again, is not particularly clear on how to attribute this zone to individual trees. The method outlined in *AS4970-2009* for calculating the SRZ is commonly used in Australia.

Dependent on the tree species, age, size and soil, encroachment and any associated root impacts into the SRZ may not result in the removal of a tree, it would however trigger other tree management, particularly crown reduction pruning, to mitigate the wind throw potential.

It is important to note that the SRZ primarily relates to a tree's structural stability, it does not include the finer, absorbing root system involved with maintaining the tree's vitality and long-term viability.

However, as smaller roots are connected to larger roots in a framework, there can be no doubt that if larger roots are severed, the smaller roots attached to them will die. Therefore, the larger the root, the more significant it may be.

There are other methods and research into what constitutes a structural root zone. According to Fraedrich and Smiley (2002) the following thresholds have been determined to allow decision making to mitigate hazard potential if too many tree roots are severed or damaged. Major buttress roots that were cut within a distance of three times the tree trunk diameter (DBH) are considered missing. If more than one-third of the major buttress roots are missing or severely decayed, the tree would be considered a high risk.

Most tree species can tolerate some root loss and damage. Some form of root disturbance has been occurring since trees were planted in streets. Different species, be they deciduous exotic or Australian native species, have different tolerances to root disturbance and site wide changes to their growing environments. Council's arborists should be able to inform the community about those species (as well as considering their age and health) that may be more tolerant of root disturbance.

Overseas research suggests that some trees can tolerate disturbance and root loss within the tree protection zone and SRZ. When trenches were dug for installation of new utilities 0.5 to 3.3 m from Hackberry (*Celtis occidentalis*), Sweetgum (*Liquidambar styraciflua*), Sugar Maple (*Acer saccharum*), and Honeylocust (*Gleditsia triacanthos*), only on hackberry, where the trench was only 0.5 m from the trunk (approximately 1.5 times the trunk diameter), was growth-reduced for all four growing seasons monitored following trenching. The trenching did not predispose the trees to readily evident disease or insect infestations (Miller and Neely, 1993). Miller and Neely (1993) found that if a trench was three times the trunk diameter away from the trunk, or more, no consistent growth reduction was measured.

When trenches were cut alongside trees, tree anchorage was compromised by trenches only when closer than 2.5 times the diameter of the trunk on the tension side (Bader 2000; Smiley 2008; Ghani et al. 2009). The surprisingly high anchorage of the trees with such severe root loss was thought to be because rooting depth close to the trunk was a major component of anchorage.

Over a 5-year period of measurement and assessment, no growth reduction or dieback was reported when pin oak (*Quercus palustris*) trees were trenched on one or two sides at a distance of three times the trunk diameter. However, moderate dieback was noted on trees that were trenched on three sides (Watson, 1998).

A study undertaken over four decades found that street or pavement construction at a distance of five to seven times the trunk diameter from the tree resulted in only a 4% increase in mortality and a 5% decrease in condition rating (Hauer et al. 1994).

Watson, Hewitt, Custic and Lo, (2014b) suggest that based on the research a vigorous tree with a trunk diameter less than 30 cm may be able to tolerate roots being severed on one side as close as three times the trunk diameter without a major loss in stability or crown decline.

The American National Standard ANSI A300 (Part 8)-2013 Root Management, states; Section 84.5.1 *When non-selective root cutting is necessary, roots shall be cut as far from the trunk as practical*. Section 84.5.5 - *When roots are damaged within six times the trunk diameter (DBH), mitigation shall be recommended*.

Research suggests that there is variation as to what minimum distance is required to sustain the structural integrity or health of a tree. Along with tree species, age, size, vitality and soil type, there's also the context around the type of encroachment of these distances. Typically, when managing retained trees in the context of a development site, then the minimum clearance distance required to simply provide confidence about a tree's stability should be determined by implementing the method outlined in AS 4970 to establish the SRZ.

As the research indicates, most healthy, vigorous trees can tolerate some root loss or damage and the planting of understorey plants should not present the same risk of root damage that could occur during development, such as construction of a structure or open trench excavation for underground services.

Because root injuries are common, even in nature, and injuries serve as sites of potential infection for root-rotting organisms roots have evolved to be able to wall off the spread of decay (strong compartmentalisers) (Watson, Hewitt, Custic, & Lo, 2014b). Research results suggest that dependent on size of root cut and location in relation to the trunk, decay development because of severing roots is not an immediate threat to the health or stability of a tree (Watson et al, 2014b).

Although root pruning is not recommended because it is a destructive management strategy, it can also be seen as a temporary measure because roots can regenerate, or adjacent roots can move in to exploit the newly vacant zones.

Many trees with adequate vitality can withstand severe root pruning and, in some instances, it can stimulate new root growth (Hamilton, 1988).

General guidelines for planting within the tree protection zone of an established street tree:

- As a general guideline, no understorey planting should occur within three times the trunk diameter (measured at 1.4 m above ground level) away from the edge of a trunk of a street tree.
- All roots equal to or greater than 30 mm in diameter must not be damaged or cut.

- The process of planting beneath the canopy of an established, maturing tree would entail the use of hand tools and generally smaller stock. Therefore, impacts to roots should be negligible to minor.

It should also be noted that leaving an area at the base of the tree free from additional plantings will help the tree capture storm water and recharge the soil moisture.

Care should always be exercised and just as people should use 'Dial Before You Dig' underground location services before planting in the verge, so to gardeners need to respect the roots of street trees.

Predicted broad changes to the Australian climate & effects on plant growth

Projected changes in climate present significant challenges for urban trees as they are already subject to high levels of physical change in their growing environment. The interaction of heat output from built infrastructure; climate-change related variability in rainfall and temperature regimes; and increasing urban drought severity and frequency is a principal concern for urban tree managers (Diamond Head Consulting Ltd., 2017).

CSIRO and the Bureau of Meteorology (2020) predict that over the coming decades Australia will experience the following changes that could impact on plant performance:

- Further increase in temperatures, with more extremely hot days and fewer extremely cool days.
- A decrease in cool-season rainfall across many regions of southern Australia, with more time spent in drought. Rainfall in Victoria has declined in most seasons over recent decades, with the greatest decreases in the cooler seasons.
- More intense heavy rainfall throughout Australia, particularly for short-duration extreme rainfall events.
- An increase in the number of high fire weather danger days and a longer fire season for southern and eastern Australia.

These predictions are dependent on the level of emissions. Higher ongoing emissions of greenhouse gases will lead to greater warming and associated impacts. Reduced emissions will lead to less warming and fewer associated impacts (CSIRO and Bureau of Meteorology, 2020). Temperatures are predicted to rise but these will happen at varying intensities across the different regions.

Importantly, the upper range of temperature results from the Victorian Climate Projections 2019 (VCP19) high-resolution modelling shows that a hotter future than that projected by the earlier Global Climate Model (GCM) data results is possible.

Effects of predicted climate change on plant growth

It is expected that reduced rainfall, increased temperatures and more extreme heat days (intensifying the urban heat island effect) will:

- Reduce volumes of soil water
- Reduce recharge of soil water
- Increase duration and frequency of water deficit conditions
- Increase plant demand for water.

The effect of warmer summers overall would be:

- More days exceeding 30 0C

- More daily temperatures exceeding species-specific growth optimums
- Increase in the experience of heat stress (exacerbated by reduced access to water during these events).

In urban areas this would potentially lead to widespread decline in tree growth for some species and an increase in tree mortality.

The increased frequency and duration of water stress conditions and dealing with higher temperatures appear to be determinant factors for plant performance under climate change scenarios.

Temperature is often identified as a key factor with regard to the performance of trees in urban environments (Jenerette et al., 2016; Kendal et al., 2018; Burley, et. al., 2019). Along with temperature, water and nitrogen are usually the most limiting environmental factors for plant growth. Where temperature and nutrients are optimal, the quantity and quality of growth depends primarily on water supply. Water is the single most limiting essential resource for tree survival and growth. Water shortages severely damage young and old trees alike and predispose healthy trees to other problems. Prolonged drought conditions can lead to tree decline, inciting pest problems, and non-recoverable damage.

Therefore, the greatest risk to urban trees from climate change is the likely long-term change in soil moisture availability. This one factor threatens tree vitality, establishment success, summer canopy cover and annual growth. Scientific literature agrees that less precipitation, particularly during winter and spring, warmer temperatures and intensified urban heat island effect will increase evaporation, reduce plant available soil moisture, and reduce reservoir water supplies (Diamond Head Consulting, 2017). The trees within our urban forests are vulnerable to this risk because supplying supplemental water to individual trees which can be expensive and difficult to organise.

Understorey plantings, albeit potentially irrigated by residents, will compete for available soil moisture.

A predicted increase in heat waves and associated heat loading (the length of time the temperature exceeds a threshold), exacerbated by increases in hard surfaces, will place greater water stress on street trees. Regardless of appropriate species selections, there may be times when supplemental irrigation will be required to sustain the trees over extended heat events.

In urban environments, the availability of water is negatively impacted upon by impermeable built urban infrastructure. Impermeable surfaces can create or intensify drought conditions simply through preventing infiltration of rainfall and increasing surface run-off. In addition, through vastly reducing total evapotranspiration, urban infrastructure increases vapour pressure deficit (the difference between the saturation of the leaf and ambient environment), significantly increasing plant water use, intensifying urban heat, and increasing water loss from the remaining vegetation. Each of these factors may contribute to increasing frequency, duration and severity of water deficit stress experienced in urban environments (Schneemann, et al. 2019, Xu, et al, 2010).

Climate adaptation strategies for improving soil management

The following guidelines focus on the most important soil management strategies for supporting the growth of a healthy urban forest:

Maximize soil volume: Provide sufficient soil volume in the rooting zone (upper 1 metre of soil) for healthy tree growth. The recommended volumes should be established from methods developed by James Urban (2008) or Leake and Haege (2014). Larger volumes may be required under warmer, drier climates to provide greater soil water storage for urban trees under climate change. Solutions for load bearing footpaths or parking areas, such as trenches to connect soil volume, suspended pavements supporting soil volume below, structural cells and structural soils, should be used to increase soil volume in hard surfaced landscapes. In an established landscape it is difficult and costly to retrofit soil. Wherever possible, optimal soil conditions should be designed into the construction of new landscapes (Leake and Haege, 2014).

Prevent compaction: Prevent soil compaction during construction in areas for future tree planting by fencing off planting areas or laying down materials like mulch or matting where machine access is needed. In areas that are already compacted, aerate, rip or deep till soils prior to planting.

Increase water storage capacity and reduce water loss: Protect native soils and soil structure. Where importing soil, follow Australian Standards (*AS 4419:2018 - Soils for landscaping and garden use. AS 4454-2012 Composts, soil conditioners and mulches*.) to select soils or amend soil properties to optimize water-holding capacity while still allowing adequate drainage. Avoid amendments to soil that will be backfilled into a planting hole if they cause the soil texture to vary from the surrounding soil. Apply mulch to the root zone of trees to reduce water loss in the soil through evaporation.

Minimize competition at planting sites: It is vital for tree establishment to reduce competition from understorey plants and grasses during the establishment period. Minimize competition for water in root zones. Roots of turf grass and other vegetation compete with tree roots for nutrients, light, oxygen, and water. Use mulch rather than turf grass below the drip-line of trees as far as is practicable. It is recommended that the root area of an establishing tree (considered three times the size of the root ball at planting) be left free of understorey plants and grasses for the duration of the 5-year establishment period or as otherwise approved by Council.

Minimize soil interfaces: Changes in soil texture create interfaces that can disrupt water flow and create waterlogged soils and perched water tables. Ensure that the entire root ball is within one soil type.

Preserve or improve soil quality: Understanding and improving site conditions is vital in order to support healthy growth and to encourage a diversity of species, some of which may not be ideally suited to urban environments (Watson and Himelick, 2013). Retain and protect native soils (and soil structure) where possible as they typically have higher organic content, nutrients, water storage capacity, porosity and microbial activity than modified urban soils.

What are the advantages and disadvantages of underplanting established street trees

Advantages

In a survey undertaken by Ligtermoet et al., (2021) respondents across all stakeholder groups recognized vegetated verges, including the use of predominantly native vegetation, had a significant role in providing a range of urban ecosystem services, including social, ecological and economic benefits.

- Understorey planting and verge gardens can contribute to urban regreening, biodiversity, visual amenity and complexity of street greenery.
- Increasing soil carbon (carbon sequestration in verge soils).
- Reduction of the urban heat island effect (particularly if used in hard paved areas where planting pit sizes have been increased).
- Developing social capital and civic engagement. New ways to engage with public space.
- Improving wellbeing and people-nature connections.
- Enhancing urban amenity.

- Increase opportunity for Council to educate the community about urban greening and develop consistency (policy development) in approach to verge planting in the city.

- Potential to incorporate new design initiatives in streets, such as WSUD and increasing sizes/areas of planting sites.

- Potential for additional irrigation to established tree root systems via watering understorey plantings and verge gardens. Long-term soil moisture levels affect the distribution of roots (Hamilton, 1988).

Disadvantages

- Root impacts at time of planting and during maintenance activities.

- Potential to impact tree stability through damaging structural roots or causing diseases at the base of the trunk via changes in soil levels.

- Competition for water and nutrients.

- Understorey plantings and verge gardens contributing to drought induced stress of some street trees.

- Reduced new tree establishment or prolonged establishment period.

- Abandoned, neglected or derelict gardens maintenance issues. Sites may need to be reinstated.

- Additional Council resources to assess and manage verge plantings and educate the community.

- Normative beliefs amongst residents causing uncertainty about community approval for verge gardening.

Discussion on when it is appropriate to plant underneath trees

Strategic considerations

Cities are struggling with a shortage of space as a result of increasing urban densification. The transformation and (re)distribution of space are an important basis for environmental improvement and social equality as we develop toward a more sustainable future (Lička & Furchtiehner, 2019).

Streets are ubiquitous in the urban fabric. They occupy a significant proportion of public space, which can amount to up to 90 percent. The street is crucial for everyday life as "*the basic unit of urban space through which people experience a city. … Streets are dynamic spaces that adapt over time to support environmental sustainability, public health, economic activity, and cultural significance.*" (National Association of City Transportation Officials, Global Designing Cities Initiative, 2016).

In dense urban areas, land-consuming urban densification is putting intense pressure on the remaining open spaces. In compensating for the loss of public spaces, streets can become a key factor in enhancing cities liveability and liveliness in the future (Lička & Furchtiehner, 2019).

Streets have a role in enhancing public open space and improving social balance in terms of accessible spaces for recreation and interaction. Surveys consistently highlight that trees and other plants are the most important attractors for streets, while their absence is perceived as the most negative aspect (Lička & Furchtiehner, 2019).

Despite the fact that a vast amount of public life takes place in these everyday urban spaces, until recently streets have scarcely been recognized as a public space that can cater to uses other than transportation or parking. The conviction that streets are truly public spaces is not yet prevalent in public discourse (Lička & Furchtiehner, 2019), or social norms, although the activity is gaining social momentum and acceptance (Marshall, et al. 2020).

The street is an intrinsic part of an urban network, suggesting its potential to create a connected green structure running through the city. As large linear open spaces, the cities' streets may form part of a green grid increasing the amount of accessible open green spaces. It is widely argued that such a greenery-based model can underpin improvements in environmental conditions and an increased quality of life, while also contributing to economic benefits, such as increased real estate values. (Lička & Furchtiehner, 2019).

Verge garden and understorey planting in Port Phillip streets

There are various street tree planting types in Port Phillip; the two main site types are nature strips (narrow to wide grassed areas out the front of properties) and hard surfaces, either tree pits in footpath or road pavement

Understorey planting in grassed nature strips

- Maintain clearance around the trunk of three times the trunk diameter measured from the edge of the trunk of an established tree.
- The following provides some guidance for the removal of grass underneath tree canopies:
    - Shovels, hoes, or trowels are all suitable for grass removal around tree roots making sure you don’t scrape or damage the tree roots (significant roots >30 mm in diameter). Any roots that are uncovered during the process can be buried with mulch or new topsoil to keep them healthy.
    - Herbicides should not be used underneath the canopy of a street tree.
    - Dig 50-100 mm deep to make sure you remove all the turf (roots and all).
    - If an area is hard to dig, don’t force it. A small root may be lying under that section of turf.
    - Once you’ve removed the grass, apply 50-75 mm depth of woodchip mulch in the area where turf has been removed.
    - Keep the mulch 150 mm away from the base of the trunk to avoid attracting pests and diseases.
    - Water the mulch thoroughly.

Understorey planting in planting pits or footpath cut-outs

Typically, the site constraints will dictate the available space available for planting under the canopy of street trees growing in planting pits or footpath cut-outs.

- No understorey planting is to occur within tree pits that have grates, crushed granite as a mulched surface, or are covered by porous paving. Understorey planting can occur in planter pits that are open, i.e. not covered by a grate, granitic gravel mulch or paving.
- Maintain clearance around the trunk of three times the trunk diameter measured from the edge of the trunk of an established tree. This may inhibit the ability to plant a verge garden in a tree pit (cut-out in hard paved surfaces). This could initiate discussion with Council to see if the tree pit could be extended. It may be possible to create a new verge garden by cutting out hard surfaces between street tree pits.
- Maintain applicable clearance distances to allow for free and clear passage of pedestrians on the footpath and adjacent portion of road.
- Provide for clear visibility of fire hydrants, driveway access, crosswalks, public transport stops, etc.

Understorey planting general considerations

The following should be considered when contemplating planting under the canopy of trees.

- The clearance area around the trunk of a tree must be three times the trunk diameter measured from the edge of the trunk of an established tree.
- Accessibility and access requirements along a footpath and accessing the road must be maintained at all times. Council will determine a minimum width of nature strip or footpath (road verge; property line to back of kerb) suitable for verge planting under tree canopies.
    - Maintain applicable clearance distances to allow for free and clear passage of pedestrians on the footpath and adjacent portion of road.
    - Provide for clear visibility of fire hydrants, driveway access, crosswalks, public transport stops, etc.
    - Ensure that understorey planting does not impact on lines of sight for traffic, including vehicles entering and exiting driveways
- Consider whether soil hydrology will be altered and how existing trees may be impacted and whether remaining permeable space will be sufficient to sustain the tree into the future, i.e. will the tree be able to access enough water.
- Understorey planting should only occur on established trees and not establishing trees. Establishment period is 5-years from planting.
- Most trees can tolerate a small amount of encroachment into their root zones (see section on structural roots). No tree roots greater than or equal to 30 mm in diameter are to be damaged or severed within the tree protection zone of a street tree.
- Soil levels must not be raised in the TPZ (12 x the trunk diameter) of a tree.
- No digging beyond what is required to remove existing weeds or turf or install plant stock is allowed (by hand only, no mechanical excavation permitted). See the section 'Understorey planting in grassed nature strips' on page 12 for a process for removing grass within the tree protection zone.
- Resolve whether maintenance requirements are achievable, and ongoing maintenance if current gardener moves away. Consider supplemental irrigation requirements (no irrigation systems are to be installed).
- Utility service providers and/or Council may upgrade and maintain their infrastructure within the road reserve, which may result in the excavation of part or all the understorey planting or garden. In these instances, there is no obligation from the utility service providers or Council to reinstate a verge garden after the work is undertaken (Adapted from the Wollongong City Council, Verge Garden Guidelines).

Look for a design response (a coordinated designed engineered response) in hard surfaces.

- Design can help create planting areas and tree pits by rearranging the available space. In restricted situations, the space can be enlarged by expanding long the back of kerbing or creating kerb outstands or extensions.
- In some cases roads could be narrowed (by up to 20% as noted in the Copenhagen Climate Adaptation Plan).
- Consider how outcomes for trees can be improved (i.e. whether water flow paths can be directed towards trees if drainage or soil nutrition can be improved).
- Increasing the size of planting pits would allow greater collection of rainfall with the understorey plantings transpiring the water creating a cooling effect.

- In some cases, it may be better to create a verge garden between street trees and allow access to the street between the end of the verge garden and the street trees.

Plants to use and planting techniques

Residents are encouraged to use native or water-wise plants where possible.

Use of suitable groundcovers, tufting grasses, wildflowers and/or low growing shrubs (refer to the City of Port Phillip Nature strip management guidelines - recommended species 2010).

Use small stock such as tube stock or up to 100 mm container size, annuals (from punnets) or bulbs (corms and tubers).

Council does not permit the planting of trees by residents on the verge or nature strip. Contact Council if you believe that the verge garden has a site for a tree. Council will assess the site to determine if it is suitable for a tree and program the planting of the right tree for the location if appropriate.

Plant selection guidelines (Adapted from the City of Sydney Footpath Gardening Policy):

- Use adaptable, heat and drought tolerant species.
- Select plants that are considered to be low maintenance.
- Ensure they are suitable for the site in which they are being planted, particularly the soils they'll be planted into and the amount of sun or shade they receive.
- There is a preference to use indigenous or Australian native groundcovers grasses or small shrubs and/or low growing exotic perennials.
- Selected plants are to be no more than 50 cm high at maturity (to maintain pedestrian and vehicle driver visibility).
- Select plants that are not environmental weeds or spread easily i.e. via suckers or the germination of seeds, prickly or spiky, poisonous or a common cause of allergies.
- Avoid groundcovers that spread very wide and grow quickly, to reduce the need regular prune to keep the footpath and kerb clear.
- Avoid fruit or vegetable crops. While there are benefits to using the road verge to grow fruit and vegetables, there are also risks.

Refer to the City of Port Phillip Nature strip management guidelines - Recommended species 2010.

Planting considerations:

- To minimise disturbance within the TPZ, keep under-planting to a minimum by reducing plant numbers and densities in order to reduce root disturbance and prevent excessive competition for water and soil nutrients. Use small stock such as, seedlings, tube stock or up to 100 mm containers.
- Hand tools only are to be used to excavate planting holes underneath canopies of trees. No motorised or power tools or equipment is to be used. If any significant roots (>30mm) are encountered, adjust planting location to nearest suitable position.
- Irrigation systems are not permitted.
- When hand watering, water must not flow on to the public footpath or into street drains.
- Mulch is recommended to retain soil moisture.
- Only use organic products rather than synthetic fertilisers, pesticides and other chemicals.

- Do not build up verge gardens by raising soil levels around the trunks of street trees. This has the potential to introduce disease to the base of the trunk (root collar) and can alter soil conditions that can predispose the tree to stress.

(Adapted from the City of Sydney Footpath Gardening Policy).

Discussion on changes to soil levels within root zones

When a significant amount of fill is added to a landscape, soil conditions will change, as will the root growth potential of existing trees. It has been estimated that 80-90% of all tree problems are related to soil and its effects on root growth potential and health of the trees' entire root systems (Smiley, et al, 1998).

Research has revealed that as little as 100 to 150 millimetres of fill placed over the roots of some tree species has caused serious deteriorating health conditions (Koetter & Johnson, 2014), yet two metres of fill placed over the roots of one tree caused no obvious damage (Costello, et al, 2004). Species and site conditions can vary and there can be other factors that impact on one tree and not another. Indications are however, that tree injury does not occur in all cases where fill is placed over root systems. Multiple factors most likely contribute to tree injury following placing fill within the root zone of a tree. The magnitude of the contribution of each varies with tree and site conditions and fill installation practices.

Although it is difficult to predict the ramifications of placing fill over the root zone of a tree it is generally not recommended.

The danger from soil stripping or lowering of grade in the root zone is root severance and removal of nutrient-rich soil layers, resulting in deficiencies, particularly for potassium and phosphorus (Craul, 1992; Harris et al, 2004). The lowering of soil levels with a tree protection zone is not recommended.

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