
# CREATING MORE SPACES FOR TREES

## University of Adelaide IEP Internship Project Report

Supported by the City of Adelaide and Resilient East

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# List of Acronyms:

| | |
|---|---|
| APA | Australian Pipeline Association |
| CoA | City of Adelaide |
| DBYD | Dial Before You Dig |
| DEW | Department of Environment and Water |
| DIT | Department of Infrastructure and Transport (from mid-2020) |
| DPTI | Department Planning Transport and Infrastructure (until mid-2020) |
| GDP | Gross Domestic Product |
| GIS | Geographical Information System |
| IEP | Industry Engaged PhD |
| LiDAR | Light detection and ranging |
| NDVI | Normalised difference vegetation index |
| PM | Particulate Matter |
| PVC | Polyvinyl Chloride |
| SA | South Australia |
| SAPN | South Australia Power Networks |
| UHI | Urban heat island |
| US | United States |
| USDA | US Department of Agriculture |
| WIR 2012 | Water Industry Regulations 2012 |
| WSUD | Water Sensitive Urban Design |

# List of Legislation Referenced

Australian Standard: AS4970-2009 Protection of Trees on Development Sites

Electricity Act 1996

Gas Act 1997

Gas Regulations 2012

Planning, Development and Infrastructure Act 2016

Planning, Development and Infrastructure (General) Regulations 2017

Telecommunications Act 1997

Water Industry Act 2012

Water Industry Regulations 2012

# Executive Summary

This report is the outcome of a University of Adelaide Industry Engaged PhD (IEP) Internship Project that was supported by the City of Adelaide and Resilient East and presents a study into the factors at play in determining underground space to plant urban trees. The information contained in this report is applicable to all of greater metropolitan Adelaide (Adelaide), with a particular focus on and examples from the City of Adelaide council area. The efforts to increase tree canopy in Adelaide have been hindered by inefficiencies with long-term planning for planting trees and collaborating with the multiple interests to find underground space to plant trees. The study aimed to provide insight into the broader issues and find opportunities relating to city and urban green infrastructure development within the context of utility services and planning regulations. The study involved a qualitative analysis of academic literature, government and utility policy and legislation, and stakeholder consultations to establish the overriding factors and ascertain possibilities for resolving the problems with the congested and contested underground space in city and urban spaces.

The literature review examined the broad values of trees in cities and urban spaces that inform government tree canopy plans and targets (e.g., their role in climate change mitigation, reduction of the urban heat island (UHI) effect, their role in urban ecology and biodiversity, and the health and economic benefits). The review also reflected the complexity of urban forest development by focusing on governance processes, the costs for infrastructure development, the consequences for tree health and survival, including examples of planning, development, and engineering solutions.

The report then presents the complex processes involved in putting trees into the ground in Adelaide. The processes for site determination, including negotiating approvals with utility authorities, costly site investigations and the consideration of the many development and utility related laws and regulations. These processes underscore the crowded and contested underground space that make finding the space available for trees challenging, if not impossible. To provide some clarity of this often-convoluted process, the report consolidates these processes into a series of steps and brings together the different industry and government protocols, acts and regulations that affect the decision-making processes and outcomes.

A series of stakeholder consultations, including with landscape architects in private business, academics working in engineering, horticulture, and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives, revealed eleven key subject themes relating to the issues in planting urban trees. They include: (i) that there is a problem; (ii) viewing trees as risk; (iii) the value of trees; (iv) inadequate knowledge in decision-making processes; (v) the prioritisation of assets; (vi) the old utility infrastructure in Adelaide; (vii) the costs of putting trees into the ground; (viii) community understanding; (ix) the political influence in decision-making; (x) the problems associated with tree planning, development, and management; and (xi) opportunities for tree planning, development, and management.

The qualitative data presented in this report underscores the difficult process of finding space to plant trees in a metropolis. Despite these issues, seven recommendations are made that reveal a range of opportunities for future decision-making and research regarding tree canopy targets to resolve some of the problems with finding space to plant trees in Adelaide. The recommendations include: (i) legislation to support the preservation of existing trees and urban forest development; (ii) decision-making standards for trees in Adelaide; (iii) research and development into urban forest development; (iv) collaborative and well-informed decision-making; (v) funding to support research and development and to cover the costs of planting and managing urban forests; (vi) planning for trees in the long-term; and (vii) expanding this study.

# Introduction

Trees provide metropolitan spaces a range of services, including, ecosystem services by mitigating the urban heat island (UHI) effect (Lanza & Stone 2016). Trees are also associated with providing social and economic services by creating beautiful spaces that people seek to live and work in, by increasing community cohesion and by reducing rates of crime (Kirkpatrick et al. 2013). As such, treed urban and metropolitan spaces symbolise the liveability and climate resilience of an urban space (Kirkpatrick et al. 2013). Because of this range of benefits, governments globally seek to increase the number of trees in cities and urban spaces.

Planting trees in urban and city environments, however, is not a simple task. The very nature of a tree means that they interact with a range of other planning considerations, above and underground, including utility services, human perceptions, and political dynamics (Elmendorf et al. 2003; Jim & Chan 2016; Kirkpatrick et al. 2013). Trees are also not governed by singular standards and rules like other services, such as, electricity, gas, water, and telecommunications. Therefore, finding places to plant trees is difficult because the spaces are often filled with these essential services and contested with often conflicting service and government policies and regulations (Jim & Chan 2016). Moreover, the harsh environment of many metropolitan spaces makes it difficult for trees to thrive and survive. The perceived risk in planting close to other infrastructure – house footings, local and State roads, footpaths, driveways, and underground and overhead services – frames rules and regulations about planting trees and limits plantable space (Slater & Chalmers 2020). Indeed, it is widely accepted that a lack of plantable space because of these constraints is a leading barrier to achieving canopy cover targets set by governments.

The City of Adelaide, other councils and Resilient East (with the support of the South Australian State Government through the 30 Year Plan for Greater Adelaide) are seeking to establish a way through all of these complexities to improve the conditions for planning and executing tree planting in urban spaces.

The City of Adelaide and Resilient East have developed this research project with the University of Adelaide's Industry Engaged Placement PhD internship scholarship program to start the process of researching, documenting and finding solutions for planting trees in city and urban spaces in order to create a greener and more liveable Adelaide. This internship project is the first part of this process and seeks to pull together the complex frameworks that influence tree planting. The result of this study is the documentation of the broader issues in relation to urban tree planting and the presentation of possibilities to work with the various stakeholders to increase the number of trees in Adelaide's urban areas.

Resilient East is a regional climate initiative between state and local government organisations in eastern Adelaide. It is about making sure the eastern region remains a vibrant, desirable and productive place to live, work and visit, and that our businesses, communities and environments can respond positively to the challenges and opportunities presented by a changing climate.

This partnership includes Campbelltown City Council, the Cities of Adelaide, Burnside, Norwood Payneham and St Peters, Prospect, Tea Tree Gully, Unley, the Town of Walkerville and the Government of South Australia.

Resilient East is one of 12 South Australian Regional Climate Partnerships.

## Project Background

This project sits within a range of government actions to improve Adelaide's sustainability and adaptability to the effects of climate change. Increasing the number of trees in Adelaide is a goal for most metropolitan councils, guided by the 30 Year Plan targets. For example, the City of Adelaide 2020-2024 Strategic Plan positions planting trees as a way to mitigate the urban heat island (UHI) effect and the effects of climate change more broadly:

> *Council and the South Australian Government have a joint commitment to make Adelaide one of the world's first carbon neutral cities. However, the achievement of carbon neutrality requires the efforts of citizens as well as governments.*
>
> *Climate change and increased frequency of adverse weather events calls for systems to prepare our city, community and businesses. Enhancing biodiversity in the City and Park Lands will help to mitigate some of the effects of climate change on the community and the environment. The planting of trees and other greenery increases canopy cover and reduces the urban heat island effect, which can potentially diminish the amenity of the City for its users (City of Adelaide 2020, p. 22).*

The South Australian State Government's 30 Year Plan target to make Adelaide a "green liveable city" (see Box 1) similarly sees planting trees as a key factor in mitigating climate change and to improve the liveability of metropolitan Adelaide. Increasing the city's tree canopy in all available spaces, including street verges and parklands is viewed to have a range of benefits, including to biodiversity, reducing heat island effect, management of air quality and storm water, and improve the visible amenity and public health within the region.

**Box 1: Target 5 of the South Australian State Government's 30-Year Plan for Greater Adelaide (DPTE 2017, p. 150)**

Urban tree cover refers to trees and shrubs located in street verges, parks and backyards. Such vegetation in urban landscapes is known to provide multiple economic, biophysical and social benefits including:

- maintenance of habitat for native fauna, which can include vulnerable or threatened species in fragmented urban landscapes
- reduction of the urban heat island effect
- air quality improvements
- stormwater management improvements through reductions in the extent of impervious surfaces
- provision of spaces for interaction, amenity and recreation, which improve community health and social well-being
- increased level of neighbourhood safety
- positive visual amenity for urban residents
- productive trees that can contribute to local food security.

Particular focus will be placed on ensuring that urban infill areas maintain appropriate levels of urban greenery.

This target will support the work being done by councils through their tree strategies which address biodiversity and quality of vegetation.

*How this target will be measured*

The target will be measured using software consistently applied to local council areas across the Adelaide metropolitan area. It is recognised that councils currently have varying amounts of tree canopy cover.

Therefore, the following is proposed:

- For council areas with less than 30% tree canopy cover currently, cover should be increased by 20% by 2045.
- For council areas with more than 30% tree canopy cover currently, this should be maintained to ensure no net loss by 2045.

In recent years the metropolitan Regional Climate Partnerships undertook land surface heat mapping which has highlighted hotspots of urban heat. These hotspots often correlate with low tree canopy and greenspace, as evident by tree canopy mapping using LiDAR (Light Detection and Ranging) and NDVI (normalised difference vegetation index). Councils are now referring to this evidence to plan and prioritise future planting programs.

There are a range of projects, research and initiatives being undertaken across metropolitan Adelaide at various scales that contribute to increasing the number of trees and addressing the challenges and barriers to putting this into action:

- City of Adelaide has worked with SA Water (water, sewer) and the Australian Pipeline Association (APA) (gas) to correlate tree information (location, species, height, width, age) and planting treatments against fault data to identify low-risk approaches.
- City of West Torrens received a Greener Neighbourhoods Grant to develop tree specifications for challenging spaces, this is close to completion.
- SA Power Networks (SAPN) produced an updated guide on planting under overhead powerlines and are still engaging with their stakeholder groups on this.

- Through the Planning Reforms, the Planning Commission made substantial efforts to improve standards on trees in proximity to house footings and driveways.
- Councils have trialled numerous treatments which enable trees to be closer to services and footpaths (e.g., root barriers), but there is not a standardised approach.
- Resilient East produced a report which looks at Monetised Benefits of water sensitive urban design (WSUD) treatments, including tree inlets, raingardens and wetlands.
- The Botanic Gardens Plant Selector tool is due for an update – there is an opportunity for information on species suitability in proximity to infrastructure to be included.

The City of Adelaide has adopted a 'green infrastructure' approach to the city's development. Green infrastructure refers to "greening elements that support a city such as street trees, community gardens and Water Sensitive Urban Design" (City of Adelaide 2016, p. 258). This policy requires increasing the number of trees planted in the city. To do so, however, also requires consideration of the underground service utilities that also accommodate the space.

The identified heat mapping 'hotspots' often correspond with highly developed spaces such as state and large main roads and within central business districts that also have little to no tree canopy. These spaces are contested with the range of utility services and policies that protect them above and underground. Finding space is in these areas is expensive because it involves substantially more background and on-the-ground work. Background work includes often extensive and time-consuming liaising and negotiating with utility service providers. It also requires substantial effort excavating sites to navigate spaces in amongst the utility services that conform with all of their policy requirements whilst at the same time ensuring the tree's survival. As a result, finding funding to fulfill the greening Adelaide policy is fraught because of complicated and expensive proposals.

Within this context there are a range of factors that need to be better understood. For example, the best suited tree species for Adelaide city/urban conditions, the influence of various soil types, and what treatments (e.g., root barriers, watering regimes/infrastructure) best mitigate any impacts. There are gaps in the coordination of research and its findings across service providers and the development of agreed standards (e.g., species lists, design standards under the *Planning, Development, and Infrastructure Act 2016*) that are recognised by relevant stakeholders across South Australia. As a result, long-term planning for planting trees is inefficient, particularly in relation to accommodating the requirements of utility services below ground. Addressing these inefficiencies and improving collaboration across sectors will reduce costs and time and increase opportunities to find spaces to plant trees for improved liveability.

## Research Aims

This study is the start of a larger research engaged by the City of Adelaide through Resilient East that seeks to increase the understanding of the broader issues, find opportunities, and establish best practice relating to green infrastructure and services, planning regulations and species diversity within the urban context, with a specific focus on service authorities. Within this context, the aim of this study is to determine the range of issues in relation to allocating spaces for trees in urban environments.

Specifically, this study seeks to:

i. Consolidate the range of regulations imposed by services that frame the planting of trees within the urban environment.
ii. Establish the range of design, physical and development issues that relate to planting trees within the urban environment.
iii. Ascertain a range of possibilities and solutions for creating space for planting trees within the urban environment.

## Project Scope

The scope of this project was to find insights into what modes may be available to ensure the planting and survival of more trees in a changing climate. To do so the study addresses and presents recommendations on one of the leading barriers – finding places to plant trees in the contestable space belowground.

The study includes an extensive literature review and consultation with Service Authorities, Councils, and other stakeholders to consider these issues. The literature review explores the academic and grey literature regarding the broader issues of planting trees in city and urban spaces. The study also consolidates the current service authority standards and guidelines, and the current legislative requirements.

Consultation with council staff provided insights into the processes and pathways, and barriers and opportunities for councils to plant trees. Consultation with other key stakeholders that work within this space also provided an understanding of the processes of working with various services.

This information will lay the groundwork and document what is happening on the ground in planning and implementing tree planting in Adelaide. This work will contribute to the overarching goal of developing central standards and guidelines for planting trees in Adelaide and provide some next steps towards achieve successful growth of more trees in proximity to infrastructure and create a greener and more liveable Adelaide.

## Research Method

The method of research included an extensive desktop study which analysed a range of secondary data including academic research, acts and legislation, and government and utility service documents. The academic literature provided the data for a comprehensive literature review, enabling an extensive understanding of the subject matter. The inclusion of acts and legislation and service utility policy documents provided the overarching legislated framework which frame decision-making around trees. All desktop searches related to planning and planting trees in cities and urban spaces and the benefits and challenges pertaining to trees within the contexts of planning and development. Analysis of City of Adelaide and Government of South Australian reports and strategic plans provided essential contextual information.

A range of stakeholders relevant to the study were also consulted through informal interviews. The stakeholders included landscape architects in private business, academics working in engineering, horticulture and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives. The data, summaries of each of these consultations, was thematically analysed using the NVivo qualitative analysis program. All data contributed to the overall analysis and findings of the report.

## Conclusion

This report documents the result of the internship study which seeks to find ways to improve tree planting in Adelaide. An analysis of the literature and other relevant documents, and insights from stakeholder consultation, document the processes and challenges and presents opportunities and recommendations for planting trees with consideration of underground utility service infrastructure. By improving the understanding of these realities and the opportunities the study establishes the next steps to enabling the goals for increasing the number of trees in metropolitan Adelaide and creating a greener and more liveable Adelaide.

# Literature Review

There is substantial evidence of the value of trees in relation to human wellbeing, economic benefits, and the positive environmental impacts. These understandings substantiate government policy agendas to increase the number of trees within city and urban spaces. However, the way these agendas are put into practice vary, as do the results. The literature reflects this complexity in a range of ways, including, with focuses on governance processes, the repercussions for infrastructure development and the implications for the survival and health of trees, planning development and engineering solutions for urban forests.

## The Value of Trees to Cities and Urban Environments

Trees hold a range of values to human and natural systems. For cities and urban spaces, trees provide a plethora of ecosystem services, such as, improved air quality, energy conservation and carbon storage, and changing climate conditions by reducing air temperature and providing shade to infrastructure and open spaces, all of which alleviate the impact of UHI effect (Lanza & Stone 2016). Trees also provide human and economic services. The social impact of trees in urban spaces include improved human wellbeing and public health as well as perceptions of a place's liveability (Beatley 2016). Economic values include improved property value (Donovan & Butry 2010) and energy saved by reducing heating and cooling costs from shading buildings and reduced wind speeds (Fisher 2016).

The term, urban forest, came from the US in the 1960s, and originally focused on woodlands close to urban areas, however, in recent decades, has come to include parklands, green spaces and even single tree or small groups of trees in city spaces (Sanesi et al. 2011). Representing this contemporary understanding, urban forest is defined in the Urban Forest of New York Report, 2018, as:

> *all trees in the city including street trees, trees in public parklands, as well as trees on private properties (Nowak et al. 2018).*

A narrative centred on sustainable cities emerged in the 1990s has brought the significance of the ecological integrity of urban environments into the centre of urban planning. This narrative considers urban development without deteriorating the quality of the environment, the effects on the quality of life for urban residents, and the impacts of urban development on the wider regional and even global environment (Sanesi et al. 2011). Consequently, urban policy has shifted to take into account externalities, such as climate change adaptation and mitigation, and our improved insights into the complex relationships between urban and natural environments (Sanesi et al. 2011).

Reflecting this trend, urban forest strategies are increasingly being developed by governments globally to improve tree populations in cities and urban spaces and demonstrate the growing recognition that increasing the number of trees have substantial benefit for the future of these spaces. The London Plan includes a policy to network London's green infrastructure because the benefits include:

> *biodiversity; natural and historic landscapes; culture; building a sense of place; the economy; sport; recreation; local food production; mitigating and adapting to climate change; water management; and the social benefits that promote individual and community health and well-being (Greater London Authority 2017).*

The UN's Food and Agriculture Organisation (FAO) similarly promotes trees within urban and city spaces because of the range of benefits trees offer (*Figure 1*). The range of benefits include filtering pollution in the air, providing food, improving physical and mental health, supporting building infrastructure energy efficiency, and providing vital habitat and biodiversity.


**Figure 1: The Benefits of Urban Trees produced by the UN Food and Agriculture Organization (FAO)**
http://www.fao.org/resources/infographics/infographics-details/en/c/411348/

Tyrväinen et al. (2005) similarly argue that benefits of trees in urban spaces is extensive and includes social, aesthetic, climate and physical, ecological, and economic (summarised in *Table 1*). Trees are also prominent features in urban landscapes because of their size, shape, colour and seasonal changes (Tyrväinen et al. 2005).

**Table 1: Benefits and uses of urban forests and trees taken from Tyrväinen et al. (2005, p. 82)**

| | |
|---|---|
| Social Benefits | Recreation opportunities, improvement of home and work environments, impacts on physical and mental health. Cultural and historical values of green areas |
| Aesthetic and architectural benefits | Landscape variation through different colours, textures, forms, and densities of plants. Growth of trees, seasonal dynamics and experiencing nature. Defining open space, framing, and screening views, landscaping buildings |
| Climatic and physical benefits | Cooling, wind control, impacts of urban climate through temperature and humidity control. Air pollution reduction, sound control, glare and reflection reduction, flood prevention and erosion control |
| Ecological benefits | Flora and fauna habitats in urban environments |
| Economic benefits | Value of market-priced benefits (timber, berries, mushrooms etc.), increased property values, tourism |

The literature demonstrates the examination of the broad-ranging benefits of trees in cities and urban spaces from varying research fields and are explored below.

### The Environmental Services Provided by Trees in City and Urban Spaces

There are a range of ways that trees provide environmental services to city and urban spaces, particularly in their capacity to store carbon, clean the air and mitigate the effects of climate change. However, various challenges in defining, classifying, and valuing ecosystem services impact decision-making (Bodnaruk et al. 2017). Predominantly, the studies about the value of trees and their ecosystem services demonstrate that trees in cities make a difference (Hecht et al. 2016). Nonetheless, despite this knowledge there continues to be a decline in urban tree numbers globally. Hecht et al. (2016) argue that this is because trees are more often viewed regarding their aesthetic or landscaping attributes and therefore overlooked in terms of their function as ecosystems and providing environmental services or calculated as carbon emission and sink entities. There is also a perception that because urban areas are heavily modified by humans that urban ecosystems have limited ecological value. However, with the growth of urbanisation, the ecology of towns and cities is increasingly relevant to urban planning and development (Davies et al. 2011).

The impacts of trees' ability to store and sequester carbon have been known for decades. Rowntree and Nowak (1991, p. 274), for example, documented the role trees have in reducing atmospheric carbon dioxide particularly by "maintaining existing trees and by planting and maintaining trees in the future" thirty years ago. Davies et al. (2011) quantified the above ground carbon storage capacity of vegetation in Leicester, UK, found Leicester demonstrated that cities are capable of storing a substantial amount of carbon, and that trees provided a 97.3% greater carbon pool than other forms of vegetation. Bjorkman et al. (2015), in a study of urban forests in Canada found that the estimated amount of $CO_2$ stored totalled 102,995,988 metric tonnes, that 7,225,191 metric tonnes of $CO_2$ were sequestered, and 1,300,883 metric tonnes of $CO_2$ were avoided annually. Similarly, Nowak et al. (2013) found that planting trees in potential available space in urban areas in the US could increase carbon storage capacity, whilst noting that the trends of declining tree cover in urban areas corresponded with a decline in carbon storage capacity.

Trees also provide environmental service through their role in removing air pollutants (Bodnaruk et al. 2017) and as a by-product of photosynthesis in their ability to absorb some gases, including Nitrogen Dioxide (NO2). Polluting particulate matter (PM) is captured in the process of dry deposition, on leaf and bark surfaces (Willis & Crabtree 2011). The particulate capture occurs when air passes and retains on the rough plant surfaces. This is dependent on both the density and leaf form of the foliage and the spacing and surface topography of trees (Willis & Crabtree 2011). Bark-shedding also give trees the ability to remove PM from the air (Willis & Petrokofsky 2017). Tree types differ in ability to capture air pollutants (Willis & Crabtree 2011) and as such specific species can be strategically planted in optimal locations to effectively manage locations with high levels of air pollution (Bodnaruk et al. 2017).

Trees, along with other vegetation, are also vital in providing the biodiversity required for habitat for wildlife (Beatley 2016). Trees are part of what is known as novel ecosystems:

> *human-modified ecosystems that have been irreversibly altered by intense impacts on abiotic conditions or biotic composition. … As such they include non-native vegetation assemblages, consisting of native, spontaneous, naturalized, and invasive species (Itani et al. 2020, p. 2).*

Despite the contrived nature of urban habitats, Itani et al. (2020) demonstrate that cities have the capacity to provide suitable habitats for species of conservation interest. For example, diversity of tree species and numbers and groupings provide important ecological value (Bell et al. 2005). Additionally, cities are spaces in which multiple species, flora and fauna have converged. Crawley (2011) explores this phenomenon in London which has seen the decline of native species since Roman occupation. He argues that it is important to note that this decline has been matched with the increase of alien species that have created new dynamic plant communities (Crawley 2011) which in turn support new ecological systems.

Trees also mitigate surface water runoff. One way they do this is by intercepting water flow during rain events from the disruption of tree leaves, branches, and bark. Another way is through the infrastructure that is put in place to plant the trees within can also capture and therefore passively water the trees, which results in savings for water treatment and runoff control costs (Nowak et al. 2018).

**Mitigation of the Urban Heat Island (UHI) Effect**

UHI is “the phenomenon through which cities are warmer than nearby rural areas” (Lanza & Stone 2016, p. 75). The problem of UHI has been demonstrated in US studies of large cities where their warming was found to be at twice the rate of adjoining rural districts (Lanza & Stone 2016). This trend is attributed to decreased vegetation, dark building materials, and the escalating waste heat emissions occurring in cities (Lanza & Stone 2016). Santamouris (2013, p. 225) argues that UHI is the most documented climate change related phenomenon and relates it to “positive thermal balance created in the urban environment because of the increased heat gains like the high absorption of solar radiation and the anthropogenic heat, and the decreased thermal losses”.

There are two ways in which trees provide cooling; (i) by providing shade on infrastructure, and (ii) through evaporation. The effect of these two impacts directly blocks solar radiation reducing the UHI intensity and removes heat from the urban environment (Speak et al. 2020; Willis & Petrokofsky 2017; Yuan et al. 2017). Transpiration converts water to vapour and reduces the air temperature within the trees canopy and cools the leaf surface temperatures (Speak et al. 2020). The tree canopy also intercepts sunlight (radiation) preventing it from reaching, and heating, adjacent urban surfaces as well as reducing reflected and re-radiated heat from urban surfaces (Speak et al. 2020). Nowak et al. (2018) found that these reductions in air temperature reduce building energy usage and subsequent emissions from power plants and other pollutant sources and latent heat from building air conditioners.

One of the approaches to mitigating UHI is by increasing localised albedo (surface reflectivity) of which urban forest strategies are a feature. Albedo is achieved by increasing the reflectivity of city surfaces to reduce the absorption of local radiation to offset local warming effects (Pearl 2019). Plants contribute to the albedo effect by both reflecting and absorbing the radiation through their process of photosynthesis (Pearl 2019). Lanza and Stone (2016) describe the significance of trees in mitigating UHI has been demonstrated in New York City where the Regional Heat Island Initiative (2006), in which urban forestry, living roofs and light reflective surfaces have effectively decreased urban temperatures.

Box 2 demonstrates how the City of Melbourne presents a range of environmental benefits from urban forests that reflect the examples from the literature above in their Urban Forest Strategy 2012-2032.

**Box 2: City of Melbourne Urban Forest Strategy 2012-2032, (2012, p. 12)**

Urban forests are described as the “engine room” for urban ecosystems in that they transformative and provide oxygen, clean air, shade and habitat. The environmental benefits of urban forests are that they:

- **Provide shade and cool our cities:** trees and other vegetation mitigate the urban heat island effect. Through the process of transpiration and by providing shade, trees help reduce urban temperatures. Whilst shading streets and footpaths, their leaves reflect more sunlight and absorb less heat than built materials, reducing the absorbed heat of the built environment. Transpiration releases moisture into the air from plant leaves.
- **Reduce stormwater flows and nutrient loads:** tree canopies and root systems reduce stormwater flows and nutrient loads in waterways. Tree canopies intercept and mitigate the impact of heavy rainfalls. Healthy tree roots help reduce the nitrogen, phosphorus, and heavy metal content in stormwater. Green roofs retain rainwater, filter the water that does run off, and delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods. Wetlands and raingardens trap stormwater, improve water quality, and reduce nutrient loads.
- **Reduce air pollution, air-borne particulates, and greenhouse gas emissions:** vegetation ameliorates air pollution and reduces greenhouse gases. Photosynthesis removes carbon dioxide, nitrous oxides, sulphur dioxide, carbon monoxide and ozone from the atmosphere. By reducing temperature, trees help improve air quality by reduced emission of pollutants that are temperature dependant. Trees sequester and store carbon and therefore mitigate atmospheric carbon dioxide. Studies show a typical mature tree can store as much as 10 tonnes of carbon.
- **Provide habitat and enhance levels of biodiversity:** a healthy urban forest contributes to biodiversity and habitat provision. Urban forests support a wide range of species, even endangered animals, and other species of high conservation value. By planting and managing different age strata, biodiversity and wildlife habitat values can be enhanced. Green roofs and walls can also provide habitat for wildlife.

### The Social and Human Value of Trees in Urban Spaces

A range of literature also demonstrates the ways in which urban forests have positive social and human wellbeing effects (Sander 2016). These range in terms of public health and well-being and the promotion of good social cohesion, even to the extent of reducing levels of crime. Poverty is often associated with higher levels of pollution, unhealthy living and unsafe neighbourhoods (Suzuki et al. 2008). Greening a city is one way in which to address issues of public well-being and create a safe and stable environment for its citizens, businesses, and urban ecological assets (Suzuki et al. 2008).

People are also more likely to be emotionally connected to spaces that have higher tree canopy (Tzoulas et al. 2007). Holtan et al. (2015, pp. 503-504) lists the ways in which green spaces benefit and are valued by society:

- decreased hospital patient recovery times
- increased feelings of peace
- escape from distraction
- neighbourhood satisfaction
- walking in forests reduce levels of stress hormones, heart rate, and blood pressure
- regulates the effects of environmental stress
- people are drawn to green space for mental health benefits
- meeting other people seeking the same relaxation and restoration
- creates space for social ties

Tree canopies also facilitate increased levels of social capital by a range of mechanisms. Social capital is associated with the way that trees make spaces more welcoming and hospitable, making them important features in shared public spaces, such as footpaths and parks (Kelcey & Müller 2011). Moreover, trees drive increased use of footpaths and outdoor spaces, in part because they create a feeling of freedom “that is essential to mental restoration or increase the sense of mystery that draws walkers around the corner to the next block to meet their neighbours” (Kelcey & Müller 2011, p. 517).

The way that trees affect the way that people feel about the spaces they are in is also described as *biophilia*. This term refers to the subconscious connection that people seek with other life and life-like systems (Van Herzele et al. 2011). The idea is that people have an inherent drive to connect with other forms of life such as plants, animals, and natural landscapes (Van Herzele et al. 2011). Trees provide these natural systems and allow the connection in urban spaces (Van Herzele et al. 2011). The elements of a biophilic city, according to Beatley (2016) include green alleys, parklets, footpath gardens, waterfront promenades, all of which create spaces that permit socialising, intermingling and strengthen social networks that enhance the publics resilience and cohesion.

These benefits can also be seen in term of positive public health outcomes. The greater levels of physical and outdoor activity in relation to proximity of green spaces are associated with improved public health and wellbeing (Maller et al. 2009; Nowak et al. 2018; Sanesi et al. 2011; Tzoulas et al. 2007). Trees are also associated with protection from the harmful effects of UV radiation. Trees absorb approximately ninety percent of UV radiation therefore reducing the amount that reaches the ground, protecting people from the harmful effects of sunshine (Nowak et al. 2018). Moreover, in their absorption of carbon dioxide and release of oxygen, trees also support overall public health (Suzuki et al. 2008). Connection with natural systems, such as with trees is also perceived to be fundamental to personal fulfilment and psychological wellbeing (Maller et al. 2009; Tzoulas et al. 2007). Moreover, in a recent citizen science study on connections between green spaces and public health in Adelaide, green spaces were attributed to community health and wellbeing because the spaces brought about a sense of calm and relaxation and desire to exercise (Barrie et al. 2020).

### The Economic Value of Trees in Urban Spaces

From an economic lens trees have a range of benefits in urban and city spaces. Indeed, many cities are quantifying the value of trees in economic terms to shift the focus of the value away from perceived ethereal or unfounded human values to sound and indisputable and more accepted economic values. These benefits summarised in Box 3, include: property value, the value of improved energy efficiency and lowering costs of power use, reduced costs because of improved water and storm water management, and the economic value of healthier and happier communities.

**Box 3: Economic wellbeing benefits arising from connection with nature in parklands (Maller et al. 2009, p. 69)**

- Views of nature from detention centres and prisons have the potential to reduce the incidence of illness (particularly stress related illness) in inmates, reducing health care costs in prisons.
- Views of nature from hospitals and other care facilities (such as nursing homes) have the potential to reduce recovery time (number of days spent in hospital). reduce the quantities of medication required to treat patients and reduce incidences of post-operative surgery in patients.
- Contact with nature improves job satisfaction, overall health, and reduces job stress in the workforce as well reducing number of sick days and employee absences.
- Parks and natural features attract businesses.
- Trees in urban streets attract consumers and tourists to business districts and are seen to increase appeal.
- Tourism is the third largest industry worldwide, with growth occurring particularly in wilderness or nature-based tourism.
- Parks and nature tourism generate employment in regional areas.
- Significant natural features, including parks and gardens, raise real estate values.
- Contact with nature can potentially reduce the burden of disease on the current health care system. For example, for pet ownership alone preliminary estimates of savings to the health care system are between AUD$790 million to AUD$1.5 billion annually (Headey and Anderson, 1995).
- Interaction with nature encourages a holistic/ecological approach to health, giving people a sense of control over their own health and wellbeing which may lead to less reliance on health care services.

In relation to property value, tree lined, or ‘leafy’ streets are known to increase the value of properties (Staats & Swain 2020). In 1988 Anderson and Cordell (1988), for example, found that house prices in Athens, Georgia in the US were increased by five percent when they were within treed, leafy streets. Donovan and Butry (2010) found in their research valuing the street trees in Portland in the US that street trees fronting properties positively influenced house sales price, on average, adding USD$8870. Pandit et al. (2013) similarly found that a broad-leafed street tree in Perth, Australia, but not on the property, increased the average house price by approximately AU$16,889 (4.27%). Plant et al. (2017) revealed that the homebuyer’s willingness to pay for leafy streetscapes demonstrates that there is strong support and informs a business case for local footpath tree canopy cover targets.

However, house prices are just one factor that is used to measure the economic benefit of street trees. The introduction of the i-Tree program integrated a range of economic benefits to quantify the benefits of trees into monetary value and has been used by researchers to assess the value of trees in cities across the globe. i-Tree is a peer-reviewed program developed in 2006 by the US Department of Agriculture Forest Service and quantifies urban and rural forestry benefits (USDA 2020). Measures are derived from calculations using the direction and distance of the tree from housing, as well as tree height and condition, and in conjunction with a range of state data, such as, savings in residential energy costs, State average costs for natural gas, heating season fuel costs, and residential costs for electricity and wood (Nowak et al. 2018).

McPherson et al. (2016) estimated the monetary value of street trees in California in the US, using measures on function and value (energy; carbon dioxide; air quality; rainfall interception; property values and other benefits; total annual benefits; replacement value):

> *Despite decreasing street tree densities in California, the state's street trees are an infrastructure asset valued at USD$2.49 billion. The annual value of all street tree services is USD$1.0 billion (USD$58.3 millions), or USD$110.63 per tree (USD$29.17 per capita). Given an average annual per tree management cost of USD$19, USD$5.82 in benefit is returned for every USD$1 spent. These findings indicate that investing in the long-term health of municipal forests can provide positive returns (McPherson et al. 2016, p. 113).*

In China, Wang et al. (2018, pp. 12-13) similarly found trees to be of significant economic value.

> *The structural value of Dalian's street trees was approximately USD$130 million, with a value of USD$4.5 million for carbon storage. The annual functional benefits of Dalian's street trees were USD$4.9 million (USD$85/tree). Street trees increased property value with an estimated annual value of USD$1.5 million (USD$25/tree). The annual energy saving benefits from all street trees in Dalian was USD$1.7 million (USD$29/tree). The net carbon dioxide reduction benefit was valued at USD$0.9 million (USD$16/tree). Smaller benefits resulted from air quality (USD$0.4 million or USD$7/tree) and stormwater runoff (USD$0.5 million or USD$8/tree). However, city managers should also consider the management costs of street trees. The municipality of Dalian spent approximately USD$1.5 million (USD$26/tree) annually on tree management. The annual net benefits were USD$3.4 million, an average of USD$59/tree. City residents received USD$3.2 in benefits from every USD$1 invested in management costs of street trees.*

Another consideration in relation to the economic value of street trees is via the improvement of citizen health through increased exercise and sense of wellbeing. Providing and maintaining nature spaces is considered a relatively cheap method to reduce the significant economic burden of the public health system (Goodenough & Waite 2019). Nature-based interventions, such as focusing on developing greener spaces within cities and urban spaces are estimated to contribute to significant savings (Goodenough & Waite 2019). The economic savings is through saving the public health system with more people engaging in increased physical activity and changing sedentary behaviour over the long term (Willis & Crabtree 2011).

## Underground Service Utility Infrastructure in Cities and the Conflicts About Trees – Varying Perceptions

The conflicts regarding the interaction between trees and underground service utility infrastructure are well known (Jim & Chan 2016; Randrup et al. 2001a; Slater & Chalmers 2020). Trees are seen as problems because their root systems are perceived as invasive, particularly with sewage, storm water drains, other water supplies, building infrastructure, footpaths, streets, curbs and parking lots (Randrup et al. 2001a). Much of the problems are framed around the species selection of street trees and infrastructure construction (Randrup et al. 2001a). Compounding the problem is the fact that trees have not been part of street and townscape planning leading to a lack of consideration and adequate planning for how trees interact with infrastructure (Randrup et al. 2001a).

In relation to tree function, their ability for supporting the tree roots to grow within the physical conditions available for street trees is a significant issue. Research into the geotechnical/physical specifications needed to prevent tree root extension has seen the development of a range of construction techniques and base materials that promote optimum growth responses within a confined urban context for street tree species (Jim 2012; Randrup et al. 2001a). Trials have assessed the interaction between tree roots and infrastructure, soil moisture regimes under a different paving systems and soils mixtures (Jim 2012; Randrup et al. 2001a).

One of the fundamental problems with this area of research is the language of arboriculturists and engineers is different and therefore they describe the conditions within tree root zones from different biases and using different terms and measures. As a result, trees fail to establish and thrive, and street and footpath paving fail to last (Blunt 2008). Blunt (2008) argues that the constraints put on tree selection (trees of small stature and considerable drought tolerance) are because of engineering design parameters that must be achieved. Additionally, most of the available information concerning planning and managing trees and underground utilities derives from industry standards and guidance, rather than targeted and independent research (Slater & Chalmers 2020).

One study by Kirkpatrick et al. (2013) explored the different attitudes of tree professionals in relation to trees and urban forestry in Australia, found that there were contrasting attitudes between those who work within and outside of government agencies. Those working in planning and strategy were more likely to regard trees as green infrastructure, whilst those working on-the-ground with tree management were more emotionally engaged with the trees (Kirkpatrick et al. 2013). Indeed, the range of biases and perceptions that exist in relation to trees (i.e., residents, planners and architects, tree professionals, engineers, and politicians) is at the heart of many of the conflicts and problems associated with urban trees (Kirkpatrick et al. 2012).

The varying biases and perceptions around trees have meant that conflicts relating to trees and underground services and urban infrastructure are well ingrained, even chronic, in urban development (Jim & Chan 2016). The utility infrastructure dominates urban and city underground spaces because cities have evolved with much of the utility services placed underground in direct competition with tree roots. In Hong Kong, they have reduced this problem as the service and redevelopment of the significant utility service lies underneath roads, not footpaths, resulting in the elimination of damage to existing trees (Jim & Chan 2016). The task of convincing governments to invest in common utility ducts requires building business cases demonstrating that it is cheaper than the substantial monetary and social costs of maintaining the existing systems (Jim & Chan 2016). For example, repeated trenching to reach or install underground utilities causes severe root damages reducing the lifespan of existing trees (Fini et al. 2020; Jim & Chan 2016; Slater & Chalmers 2020). In the UK, underground utilities consist of approximately 3.5 million kilometres of underground cables and pipes, of which, the highest density is in urban areas (Slater & Chalmers 2020). Excavation relating to management of utility trenches results in tree root damage and affects the trees lifespan (Fini et al. 2020; Slater & Chalmers 2020).

The impact of this type of tree root damage is substantial and Fini et al. (2020) suggests that root severance be reclassified from an inciting factor (a factor directly causing tree mortality) to a predisposing factor (a contributing, but indirect factor of tree mortality) in the Manion Mortality Spiral (*Figure 2*). The Manion Mortality Spiral is the result of research that found root damage from excavation for the installation and repair of belowground infrastructure reduces the long-term capacity of trees to survive the constrained and disrupted urban environments by decreasing carbon availability for growth and defence (Fini et al. 2020). The implication of this redefinition is that the management of utilities needs to take into consideration the long-term effects of damaging a tree's roots


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**Figure 2: Manion's spiral of tree decline (1981)** taken from Amoroso et al. 2017

The solutions for conflict are undoubtedly found in the way the different government, utility service agencies, and private developers interact and make priorities for urban tree planting and management. The review above demonstrates a clear need for trees to survive and thrive in cities, and it is therefore beholden upon constructive relationships to find solutions for this to happen (Slater & Chalmers 2020). Moreover, as Randrup et al. (2001a, p. 222) argues, rather than focusing on specific solutions, there "needs to be a broader spectrum and multi-disciplinary approach" with research that is site specific and uses methods of "controlled experiments and in situ testing".

## Trees Viewed in Relation to Risk

The evidence discussed so far demonstrates a range of perceptions about the value and function of trees in urban spaces from which urban greening strategies are framed. The range of benefits of having trees in cities drives the decision-making to promote greening strategies, but trees often struggle to thrive and coexist with the infrastructure which define urban spaces. This problem relates to the fact that trees are most often not part of the planning in urban development which means that the development and management of infrastructure and services utilities do not take into consideration their interaction with trees

(Randrup et al. 2001a; Ridgers et al. 2006). The result is that trees are viewed in terms of risk and the problems occurring because of the interactions between trees and infrastructure, with the tree being the problem.

Evidence of this viewpoint is found in the framing of research focused on the problems between trees and infrastructure. For example, there is much discussion in the literature about the problems associated with tree roots penetrating sewage pipes (known as root intrusion) because the substantial financial costs resulting from this problem are an ongoing concern for municipalities (Ridgers et al. 2006; Torres et al. 2017). This area of research focuses on the typical entry points for tree roots (the often “not completely tight” joints in pipes) and the ‘susceptibility’ of pipes to ‘root intrusion’ (Ridgers et al. 2006, p. 269). Kuliczkowska and Parka (2017) for example, explore the frequency and size of ‘root intrusion’ into sewers frequency as well as root size to develop methods for determining risks associated with root and the probability of structural defects. Östberg et al. (2012) examined data on ‘root intrusion’ to determine the ability of different plant species to intrude into urban sewer pipes. Torres et al. (2017) similarly identified pipe characteristics and tree species most responsible for ‘root intrusion’ to establish the characteristics that facilitate the damaging interfaces between pipes and tree roots.

Although root damage to sewer systems is likely to occur in old systems and cracked pipes (Randrup et al. 2001b), these studies describe trees as the problem. Indeed, tree root damage does present a considerable problem for service providers, with their underground utilities, particularly water and sewage. Problems associated with roots include partial and total flow blockages that cause leaks into the surrounding soil and groundwater, consequently contamination them (Kuliczkowska & Parka 2017). These flooding and pollution incidents can also occur in a range of places including residential housing and local communities (Kuliczkowska & Parka 2017). The blockages attributable to roots are estimated to represent about 50% of the total number of sewer blockages (Randrup et al. 2001b). *Table 2* shows the different types of sewer system failures found in an American study by (Randrup et al. 2001b).

**Table 2: Types of sewer system failures,** taken from Randrup et al. (2001b, p. 28)

| Sewer Failure Types | Reason for Failure |
|---|---|
| Collapse | • difficult ground conditions<br>• large wastewater flow<br>• adjacent utility impacts<br>• traffic congestion<br>• deep excavation |
| Structural | • roots<br>• corrosion<br>• soil movement<br>• inadequate construction combined |
| Blockage | • sediment<br>• roots<br>• intrusions (connections or foreign bodies)<br>• grease or encrustation or both |

It is also important to note that trees in urban spaces are expected to grow in conditions that are far from ideal and they are attracted to the moist and fertile environment existing from leakages from sewage pipes (Bühler et al. 2016; Grabosky 2001; Moore et al. 2019). The growing environment for urban trees is more often in compacted soils that have limited drainage and oxygen diffusion which limits tree root growth capacity (Moore et al. 2019). The opportunistic tree roots go to the more suitable environment provided by backfill around pipes which is often less compacted and provides opportunity for them to penetrate pipes where cracks are larger than the root tips (Moore et al. 2019).

The resulting conditions mean that sewers are not constructed in a way to prevent root intrusion and are therefore more susceptible to root intrusion compared to other types of urban infrastructure (Torres et al. 2017). The joints in pipes (whether they be old clay and concrete pipes which have joints every metre, or new PVC pipes which have joints up to 8 metres) continue to be the main entry point for roots (Moore et al. 2019; Östberg et al. 2012). However, root penetration also occurs because the infrastructure is old and not repaired (through breaks, loose joints, or failed rubber gaskets, and smaller pipes) and when the pipes are embedded in sandy soils (Moore et al. 2019).

Trees are also viewed in terms of risk in relation to powerlines, particularly in more forested areas. The primary cause of power outages is attributed to trees, principally from trees falling on powerlines during severe weather events (Fenrick & Getachew 2012; Freeman et al. 2019; Glass & Glass 2019). In the US, trees are estimated to cause approximately 25 percent of all electric service interruptions annually (Freeman et al. 2019). Fire is also a significant risk in particular where the climate is dry and warm (Ma et al. 2020). Given the considerable social, economic (the total annual cost of fire in Australia amounts to approximately 1.15% of GDP) and environmental costs of wildfires, the risks are substantial (Ma et al. 2020). Trees are managed to mitigate these risks. Right-of-ways and roadside tree pruning and removal have become the go-to forms of risk management.

There is a debate about placing power lines underground as a way of mitigating these risks. The arguments for and against undergrounding are framed around cost and risk. On one hand, putting these serviced underground shifts the risks away from trees above ground. However, the financial costs of doing so are considerable (Freeman et al. 2019). Freeman et al. (2019, p. 10) argue that the risks associated with weather are not eradicated by undergrounding: “flooding, insects, roots of trees, and decomposition are just a few issues that affect undergrounding”. However, the argument for and against undergrounding is more nuanced; the pros and cons of each relative situation needs to be considered to evaluate the costs and benefits (Fenrick & Getachew 2012). Glass and Glass (2019) argue that when you take into consideration the total costs of having powerlines above ground, including those not related to trees such as damage from wildlife, and fires caused by faults in the lines and transformers, there is a case for undergrounding those services.

However, there is little evidence in relation to trees’ interactions with underground powerlines. Despite this, service providers remain cautious and regulate tree planting space around the utilities. For example, the South Australian Power Network (SAPN) has regulated that if planting within three metres of an underground powerlines the tree must only have a mature height of less than 2 metres (South Australian Government 2020). In the UK, the British planting standards streamline the planting regulations for all underground services with drains (BSI 2005). As there is an absence of literature, particularly substantive empirical research regarding the effects of tree roots on underground powerlines, it appears that such regulations are not necessarily evidenced-based, but rather put in place through a risk-averse approach to decision-making.

## Engineering Solutions for Planting Trees in Urban Spaces

The risks explored above have been predominantly managed by either tree removal or increasing the zones around infrastructure that trees cannot be planted in. These approaches, however, have resulted in the depletion of the number of trees in urban areas as well as a reduction in the available space for planting trees. New research has shifted its focus away from seeing the tree as the problem, but rather finding ways to have both trees and utilities sharing the space. Much of this research has focused on finding engineering solutions for protecting underground utility services from ‘root invasion’. There is a growing area of research that incorporates engineering and arboricultural research to find ways to improve the growth conditions for trees in urban spaces so that they do not seek the nutritious moisture of leaking sewer pipes and utility trenches, including passively watering trees from rain runoff, and planting trees within contained spaces that provide them with all their growth needs. There is also research exploring measures to control stormwater aimed at reducing the environmental damage and financial costs caused by impervious runoff (Grey et al. 2018).

Grey et al. (2018), for example, explore the effects of water infiltration differences in various tree pit designs (*Figure 3*). This study found that street trees with access to stormwater runoff have the capacity to double their growth rates compared to conventional street tree planting techniques (Grey et al. 2018). However, the study also found that waterlogging was the key issue with the pits, thus measures to avoid waterlogging conditions is necessary to promote tree growth (Grey et al. 2018).

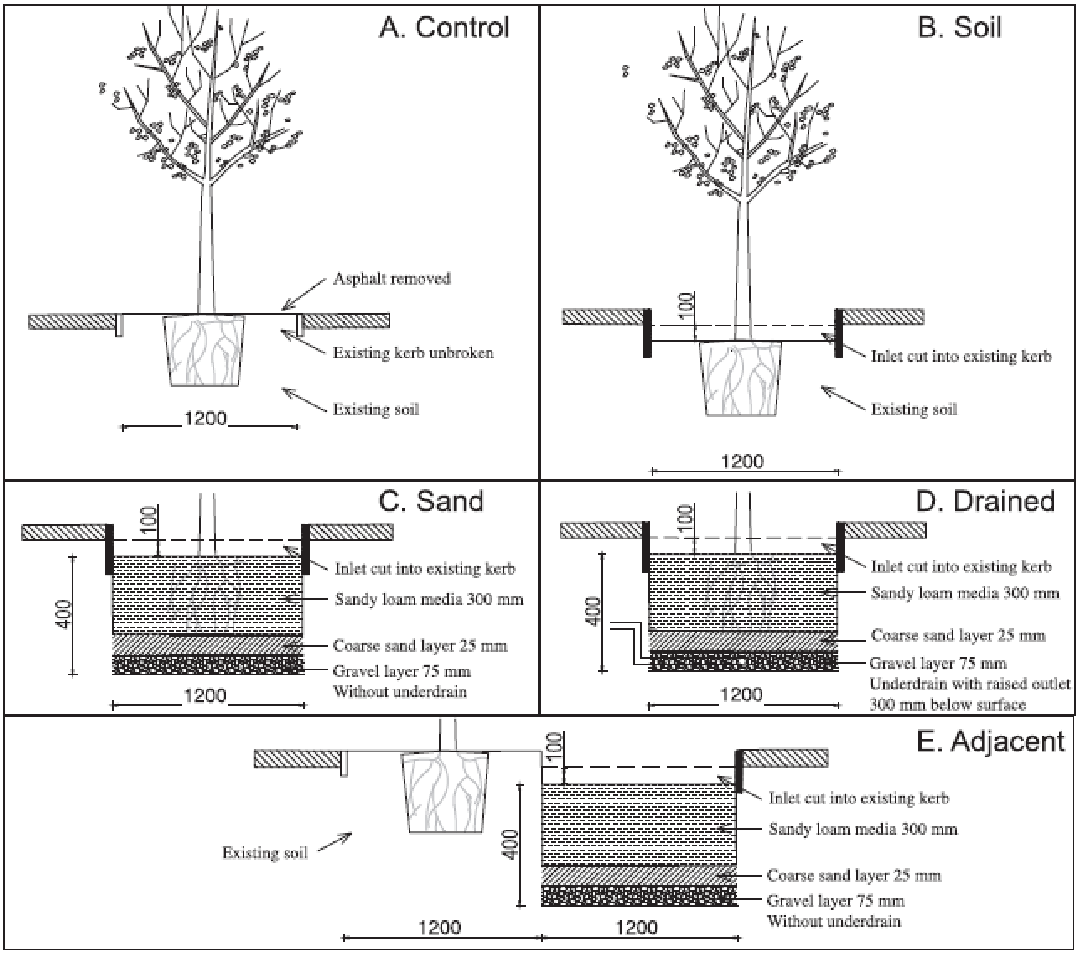


**Figure 3: Cross section drawings of study sites with different inlet locations, soil/substrate types, drainage connections and tree locations.** Image taken from (Grey et al. 2018)

Another area of research focuses on finding ways to reduce stormwater flows through pervious forms of paving (Beecham et al. 2012; Boogaard et al. 2014; Chandrappa & Biligiri 2016; Kuruppu et al. 2019). The problems associated with stormwater flows include flooding, erosion and pressure on sewer and drainage infrastructure capacity (Boogaard et al. 2014). This problem has been mitigated in the past through engineered infrastructure built to rapidly deliver the stormwater to collection points, but which was often inadequate to treat the quantities of water (Kuruppu et al. 2019). Permeable pavements reduce the pressure on stormwater infrastructure by enabling stormwater to infiltrate on site without disrupting aboveground land use, particularly pedestrian and vehicular traffic (Beecham et al. 2012). Research has found that there is no runoff from minor rainfall events and the peak flows from large rainfall events are substantially delayed and reduced (Johnson et al. 2020). Additionally, the in-situ infiltration effectively removes nutrients, suspended solids and some heavy metals (Beecham et al. 2012; Chandrappa & Biligiri 2016; Liu & Armitage 2020; Mullaney & Lucke 2014).

There are different systems of permeable paving (*Table 3*), monolithic (porous concrete/ asphalt), and modular types (interlocking porous pavers or grid systems) (Kuruppu et al. 2019).

**Table 3: Types of permeable pavements, taken from Kuruppu et al. (2019, p. 326)**

| Pavement type | Construction | Applications |
|---|---|---|
| Porous concrete/asphalt | Open-graded concrete or asphalt with no or reduced fines mixed with a special binder that create voids when cured to allow water to infiltrate | Commercial parking lots, perimeter/overflow parking, perimeter/light commercial, driveways, patios/other paved areas, sporting courts, industrial storage yards/loading zones |
| Interlocking concrete paving systems | Paving stones installed with keeping gaps between stones to allow water to infiltrate | Commercial parking lots, perimeter/overflow parking, perimeter/light commercial, driveways, patios/other paved areas, industrial storage yards/ loading zones, parking pads (e.g., caravan parks) |
| Grid systems/ reinforced turf | Plastic or concrete grids filled with aggregate, sand or grassed soil that water can infiltrate through | Commercial parking lots, perimeter/overflow parking, parking pads (e.g., caravan parks) |

Each of the permeable paver types are found to be high performing in relation to infiltration rates (Mullaney & Lucke 2014). All paving types will clog with sediment over time, however, can be managed with maintenance procedures, such as high-pressure hosing, sweeping and vacuuming (Mullaney & Lucke 2014). Much of the debate about permeable paving relates to the design, particularly in relation on whether or not to include geofabric between the aggregate layers (Mullaney & Lucke 2014). Research on permeable paving based in South Australia has included systems where geofabric has been used to line the sides and base of the gravel base layer but was not used between the base and bedding layers (see *Figure 4*). Johnson et al. (2020) argues that this type of design allows the water to freely drain into surrounding soil.

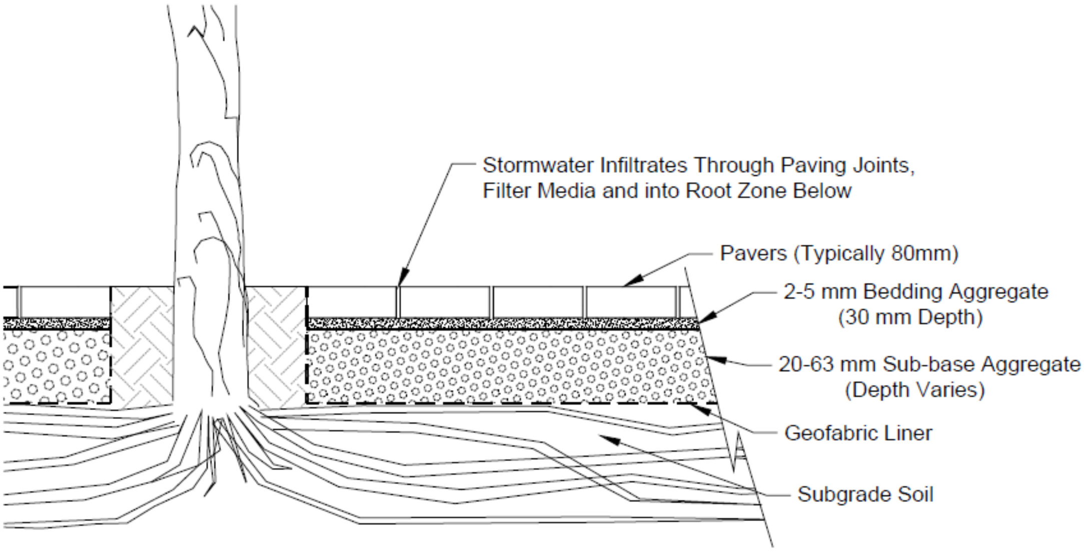


**Figure 4: Cross section of street tree with permeable paving design** (Beecham 2012)

*Figure 5* also shows the different base designs using gravel on a level uncompacted subgrade ('perm-level') and on uncompacted subgrade formed into a swale beneath the footpath ('perm-swale'). Existing impermeable paving laid on a coarse sand bedding layer on compacted subgrade served as the control.

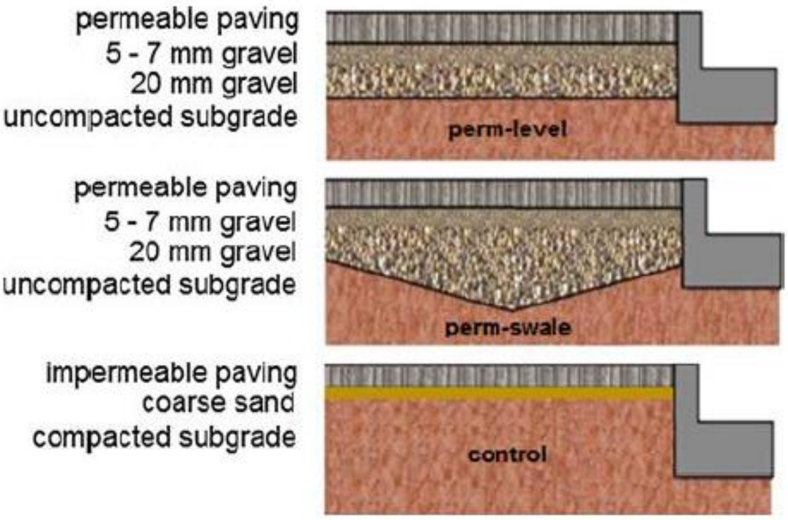


**Figure 5: Examples of permeable paving base designs**. Image taken from Johnson et al. (2019, p. 2)

As described above, impermeable surfaces that predominate city and urban spaces make it difficult for trees to get the required water they need to grow. Permeable paving has the added advantage of passively watering street trees which is vital to supporting better growth rates (Beecham 2012; Johnson et al. 2019). Permeable paving and passively watering trees also lead to reduced damage of other infrastructure damage, such as raising and cracking footpaths and roadways (Johnson et al. 2020) Trees instead provide soil stability when grown near pervious paving (Johnson et al. 2020). The uncompacted soils (*Figures 4 and 5*) also allow faster growing, deeper and healthier tree roots to grow compared to trees growing in streets where the traditional practice of compacting soils beneath paving has been used (Beecham 2012; Lucke & Beecham 2019). The aggregate layers prevent large roots from growing under the paving, providing a buffer to footpath damage (see *Figure 6*) (Beecham 2012; Johnson et al. 2019; Lucke & Beecham 2019)

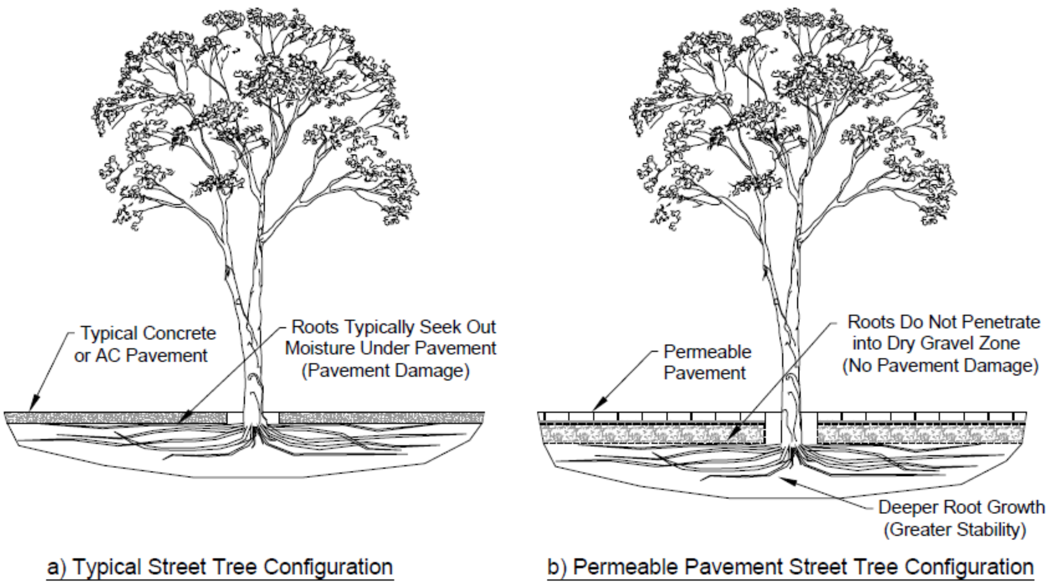


**Figure 6: Comparison of impermeable and permeable paving with street trees,**
Image taken from Beecham (2012, p. 3)

An example of permeable paving occurred at an intersection in an Adelaide suburb with a history of flooding during heavy rain events. Permeable paving was constructed at the intersection and used as a case study for research supported by TREENET, the University of South Australia and Mitcham Council. The project used 500 m$^2$ of permeable paving at the intersection (*Figure 7*) and also included the construction of soakage trenches to drain the runoff into nearby parkland where it irrigated existing River Red Gums (*Eucalyptus camaldulensis*) (*Figure 8*). The result of the project was that no ponding occurred at the intersection during heavy rain events. The cost for construction was one sixth of the cost of the alternative traditional pit and pipe drainage upgrade to increase the stormwater holding capacity (Lawry et al. 2017).

**Figure 7: Example of permeable paving at Mitcham Council, South Australia**.
Image taken from (Lawry et al. 2017)

**Figure 8: Example of permeable paving above underdrains that direct storm water into the adjacent reserve and into the road subgrade. The construction is laid close to mature trees with no damage to paving surface.** Image taken from Lawry et al. (2017, p.6)

Another emerging water sensitive urban street design to passively water trees is a cut kerb connected to a leaky well or trench. South Australian research has been conducted on a locally produced version of this system (Sapdhare et al. 2018; Sapdhare et al. 2019). The TREENET street kerb inlet (*Figure 9*) harvests road runoff for passive irrigation of street trees.


**Figure 9: TREENET Inlet.** Image taken from Johnson et al. (2016)

This inlet, coupled with a leaky well infiltration pit (*Figure 10*), is emerging as a system that can be installed into existing roadside infrastructure instead of directing stormwater flows into drainage, water is directed into the leaky well infiltration pits that filters water into the surrounding soils (Johnson et al. 2016). The leaky well infiltration pit is enclosed in filter media which acts to filter heavy metals, nutrients and organic matter to improve the quality of stormwater (Sapdhare et al. 2018).

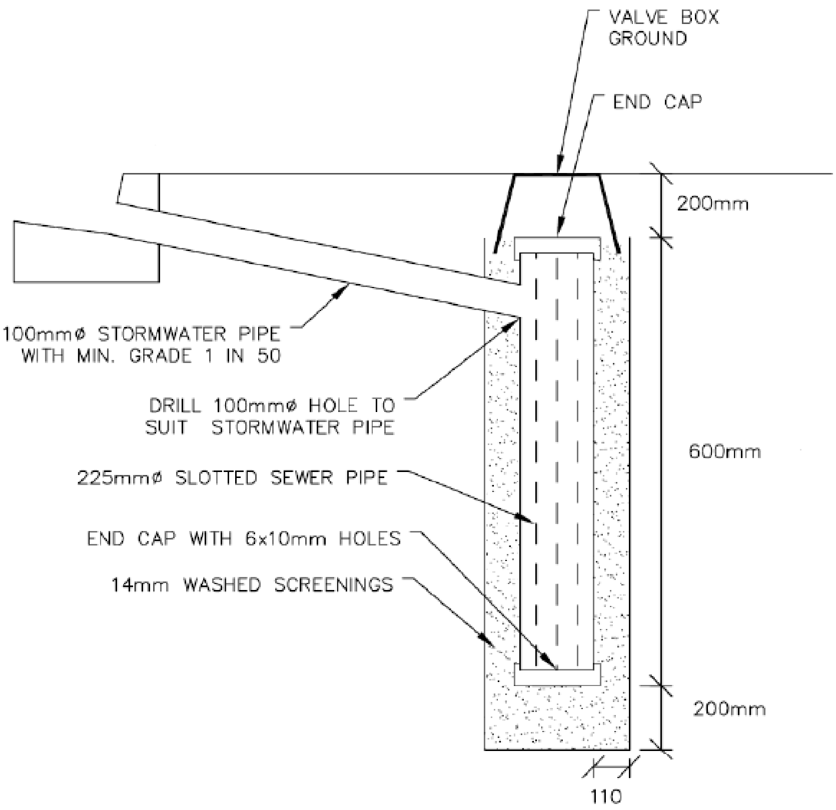


**Figure 10: Cross-section of a leaky well with a TREENET inlet.** Image taken from Johnson et al. (2016, p. 66)

Storm water harvesting systems are successfully functioning in local councils in metropolitan Adelaide with no operational failures or problems and provide a cost-effective opportunity to improve the conditions for trees in urban spaces (Johnson et al. 2016). In providing street trees with water, these systems also potentially provide systems for planting trees in otherwise difficult/ congested cityscapes through their ability to curb root growth (due to layers of gravel) in areas that protect and insulate service utilities. This is an area yet to be fully explored in the literature.

## Planning and Development for Urban and City Trees

The planning implications of all the considerations above, particularly in relation to the growing trend of governments to pursue urban greening and city tree planting programs is complex. This review demonstrates the challenges in finding space to plant trees because of the extent and complexity of underground utility networks in urban spaces and the constraints that they bring (Slater & Chalmers 2020). On one hand, changing the status quo and pursuing, or even facilitating, new and innovative approaches to roadside planning and development is a major challenge for decision-makers. On the other hand, divergent political interests and agendas, perceptions of risk, and operational standards and practices of different stakeholders make it difficult to find a shared vision for urban development (Elmendorf et al. 2003; Kirkpatrick et al. 2013). Needless to say, there is a case for improving government planning frameworks and decision-making regarding urban trees.

Improvements may include improvements to processes that incorporate broader regional strategies that protect trees and increase tree canopies (Kirkpatrick et al. 2012; Kirkpatrick et al. 2013; Pincetl 2010). Pincetl (2010) argues that it is important to resource and establish coordinated systems that sufficiently manage and maintain urban forests because of ecosystem services they provide, and because they are alive:

> *Nature's services infrastructure also suggests coordination and cooperation among traditionally separate departments such as planning, transportation, sanitation and other utility providers, and new biological knowledge about soils and microbes and their pollution filtration potential, which trees are the most appropriate for bioregion, climate, and desired function. Finally, unlike grey infrastructure that is generally hidden underground, in pipes, or else made inaccessible in concentrated facilities, nature's services infrastructure is in plain sight, it takes up real physical space, and if it is not regularly maintained, (gardened) it will look unattractive, may not work and/or it will die. This implies a different knowledge and maintenance regime from the networked modern city to one more akin to parks (Pincetl 2010, p. 47).*

Slater and Chalmers (2020) also found that a lack of coordination between stakeholders is a problem and contributes to the conflicts that evolve around urban trees which are now more highlighted because of the only very recent acknowledgement of the value of urban forest. They argue that better communication and collaboration and the facilitation of knowledge development and innovation would improve the chances of successful urban forest outcomes (Slater & Chalmers 2020).

The known attributes of thriving, long-lived trees that contribute the range of ecosystem services demonstrated above are in jeopardy when there is premature tree decline, physiological pressure and stunted growth (Fini et al. 2020). Conventional measures to address poor performance through maintenance and replanting regimes considerably reduces the benefit to cost ratio of urban trees (Fini et al. 2020). Continuous damage to trees because of the precedence given to utilities is a stress of increasing importance for trees in the urban environment (Fini et al. 2020; Jim 2003). Therefore, ensuring the conditions for trees is optimal, such as with the required soils, irrigation and space will ensure urban trees survive (Grabosky 2001; Jim 2012).

Jim (2001) lists a range of considerations for planning and managing trees in Hong Kong:

- the confined space of narrow pavements is keenly contested both above and below ground.
- the aboveground confinements that restrict trees performance (planting sites are often narrow, usually only 2–4 m) which limits the types of trees that will fit the space.
- safety clearance for pedestrians and vehicles (particularly double-decker buses and trucks) make for unyielding restrictions on roadside planting.
- the soil component is essential for the very fact that half of a tree dwells below the ground (from which water, nutrients, and anchorage are acquired), and that urban soils in most urban areas are inferior as a medium for plant growth.
- the high-density underground utilities located at shallow depth below the paving often congregate in the upper 2 m of the substrate; hence they are in direct conflict with tree roots.
- the lack of a separate conduit or tunnel to accommodate the profusion of service lines, and their placement is often haphazard, and there is little concern or awareness about their adverse impacts on trees, even though it is one of the most limiting physical constraints to tree planting in the city.

- the frequent trenching to repair defective utility lines, to install new ones, and to make connections or disconnections results in the repeated root damage and decline of trees.
- a lack of an official guideline on working with or near trees.
- community involvement is a way to connect residents with the open spaces they are otherwise divorced from.
- the unclear demarcation of responsibilities and authority concerning trees is unhelpful.
- recommendations include:
    - demonstrate the priority to greening by providing strong leadership and community and establish a coordinating body to oversee and integrate planting activities.
    - initiate in-depth, long-term, and visionary policy that is metropolitan-wide to effect widespread tree planting.
    - allocate adequate resources.
    - shift from a predevelopment to a sustainable-development strategy.
    - encourage private developers and citizens to participate.
    - raise the professional standard of urban forestry practice and readily adopt new techniques and materials.

Alternatively, Bell et al. (2005) offers a range of urban forest design principles:

- incorporate non-woodland habitats such as grassland, wetland, open water, or heath, where ecological values are important as well as recreational spaces, such as paths, picnic areas, play spaces or viewpoints.
- consideration should be given to the aspect of the trees (i.e., either on the sunny side or the shady side of the street, depending on species or desired design effect).
- considering different species but with care to maintain the design integrity.

## Conclusion

This review highlights that quality urban greening into the future lies in addressing the problems of, and making changes to, conventional measures for planning, and planting trees in city and urban spaces. However, the ecological pressures on urban forests are not always obvious to the public and politicians (Ottitsch & Krott 2005). Therefore, it is up to decision-makers and managers to make the case for innovation, research and development to ensure the greening and canopy targets are achieved. To do so new and innovative (and often more cost effective) processes, such as the ways of passively watering trees described above, will need to be incorporated into urban planning and development whilst simultaneously investing in the research and development of better systems. There is also opportunities for thinking outside the square to increase spaces to plant trees, such as developing brown sites (urban sites that are derelict, underused or contaminated and require intervention to be returned to beneficial use) can provide additional space to preserve existing and support new trees (Jim & Chan 2016). The costs for not addressing the issues today will only prolong the problems and financial costs into the future (Ottitsch & Krott 2005).

# The Planting Trees Framework in Adelaide

## Overview of the Process of Getting Trees into the Ground

Putting trees into the ground in metropolitan Adelaide, as with any metropolis, is a complex system of considerations and negotiations. Primarily there are a range of laws and regulations applying to state and local government development, and each utility service, that need to be taken into consideration. The city is a contested landscape as depicted in *Figure 11*.

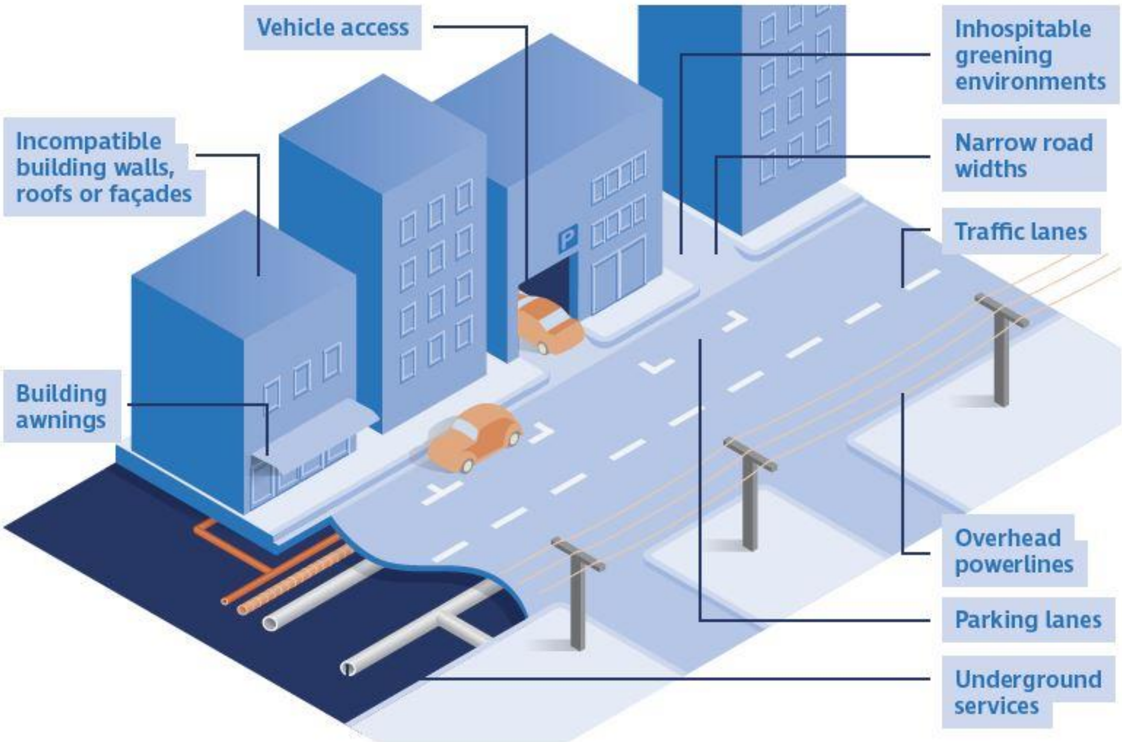


**Figure 11: A contested landscape creates barriers to greening in the urban environment**
(City of Adelaide)

Each of the utility services also need to be negotiated with independently, including the often-difficult process of establishing and documenting the location of their infrastructure and then attaining planning approvals before any form of construction/planting can take place. All of this occurs within the highly contested and overcrowded underground space (*Figures 12 and 13*) and finding the space available for trees is often difficult, if not impossible.

**Figure 12: Example 1 of the extent of services in a city underground space, Bank Street Adelaide.**

**Figure13: Example 2 of the extent of services in a city underground space, Bank Street Adelaide.**

The planning and implementation of planting trees on public land for local councils, therefore, is an extraordinarily convoluted process and includes a range of steps. *Figure 14* illustrates these steps and highlights this process is far from straight forward. At several stages through the process, obstacles are identified, negotiations are undertaken, and at times the site is found to be unviable which forces the process back to the beginning – identifying a possible location to plant trees. The jurisdiction of planning and development relating to planting trees and other vegetation in the city most often falls on local council. As such, they are responsible for the costs to identify the location of utilities and for any damage to utility infrastructure at all stages of a tree planting project and across the lifespan of the tree.

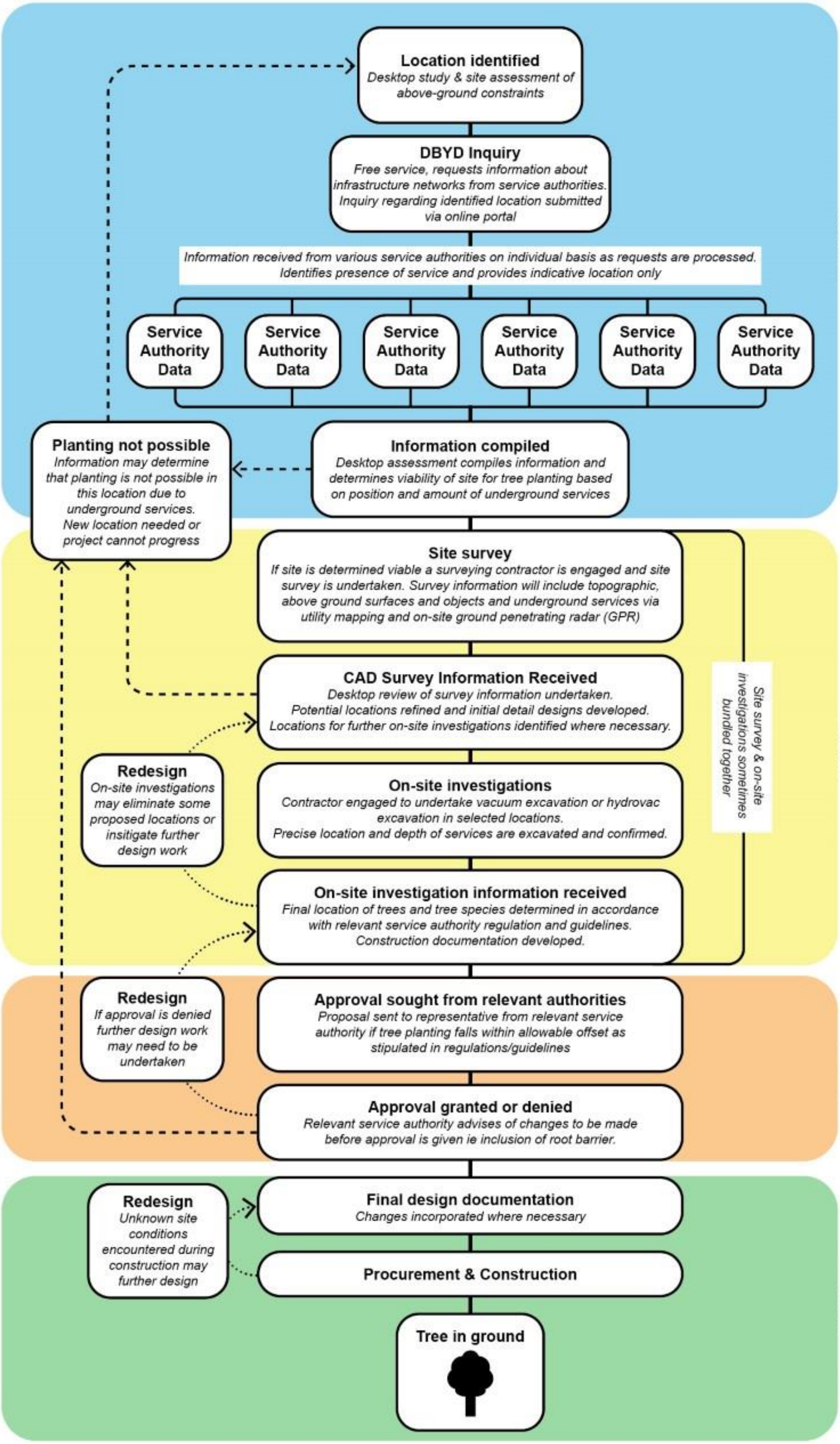


**Figure 14: Flow chart illustrating the process of planting tree in Adelaide**. (S.Rogers, B Meyer-Mclean) ** *Note, this figure number was incorrectly labelled and this is the only change in Version 3*

**Step 1. Establish site details**

Once a potential site is identified the process of establishing the details of the site begins. A desktop study establishes the aboveground constraints of the site. Lodging an inquiry to Dial Before You Dig (DBYD) initiates establishing the belowground constraints. Contact with the utilities from this point is then on an individual basis.

DBYD is a not-for-profit organisation that provides a free single point of contact to request information about the infrastructure networks at the planned project site without the need to contact utility organisations individually. The DBYD requested information is them provided from each service authority from their asset databases. This information generally comes with a disclaimer from each service authority, explaining that the location information provided about their assets is not guaranteed to be accurate, therefore necessitating that Council undertake their own verification of these assets before any works commence.

**Step 2. Site surveys and onsite investigations**

If the site is considered viable, site surveys are then undertaken by a surveying contractor. Information such as, topographic survey information, above and belowground surfaces, objects and services are located using utility mapping and onsite ground penetrating radar (GPR). Desktop investigations also review existing survey information in order to locate and refine detail drawings.

This is the time where more specific locations within the identified street are determined for onsite investigations to establish the precise location of underground utilities. To do so, **vacuum excavation** (*Figure 15*), otherwise known as 'pot holing', uses a high-pressure vacuum to remove soil to locate services under roadways, footpaths or areas that have limited access, removing the risk of damaging the infrastructure. **Hydrovaccing**, uses high-pressure water for the same purposes. These processes are also used to expose and determine the extent of tree roots around significant trees and to assess tree 'root intrusion' damage to utility infrastructure without damaging the tree or the infrastructure. Figures 15, 16 and 17 illustrate how vacuum excavation exposes utilities and tree roots without damage to the infrastructure or the trees.

**Figure 15: Vacuum excavation to expose utility services in the city.** Image: https://www.newcastlelocatingservices.com.au/vacuum-excavator-hire

**Figure 16: Utilities exposed by vacuum excavation.** Images: http://www.statewidehydrojet.com.au/sa/shj/main/hydro-excavation-adelaide/

**Figure 17: Vacuum excavation used to expose tree roots next to a footpath**. Image: https://southvac.com.au/hydro-excavation/

The process of vacuum excavation is expensive but vital because the utility infrastructure locations are not necessarily accurately documented on building or construction plans, making utility location a primary and expensive exercise for decision-making regarding where trees can be planted. Finding space in the often-congested space underground is further complicated when disused and unidentifiable infrastructure is found. This disused/unidentifiable infrastructure is unable to be removed because of the lack of knowledge about its potential network and the unidentifiable risks, such as leaks and contamination, therefore planting constraints continue to apply.

The information correlated in this step determines the site's suitability for planting trees ready for the next stage.

**Step 3. Negotiation and Approvals**

Proposals are developed with documentation of the accurate locality of utilities which are submitted to the appropriate utility authorities (i.e. up to 4 different utilities) where necessary. The process of negotiation with each utility authority begins. The section below outlines the different utility service requirements, demonstrating the complex environment in which these decisions and negotiations are determined. Whether proposals are approved or denied determines whether the process moves to the next step or goes back previous steps of onsite investigations or even ending the process altogether.

**Step 4. Final design and tree planting**

When there is approval from all the relevant service authorities, the final design is drawn, and the processes of procurement and construction are instigated.

## Overview of the Utilities and Development Regulations Relating to Trees*[1]

Each of the utility services have different legislated and non-legislated requirements for planting trees near their infrastructure. These differences summarised below, *Figure 18* and Table 4, highlight the complexity of the process for finding space to plant trees according to utility protocols. SA Water sewerage (wastewater) assets and SAPN have an associated legislated plant species list of approved trees if planted at a specified distance (See Appendix 1: Schedule 2 and 3). *Figure 18* illustrates the different required distances (offsets) measured from the different utility infrastructures and the centre of the tree trunk. When trees have multiple tree trunks the measurement is taken from the central trunk.

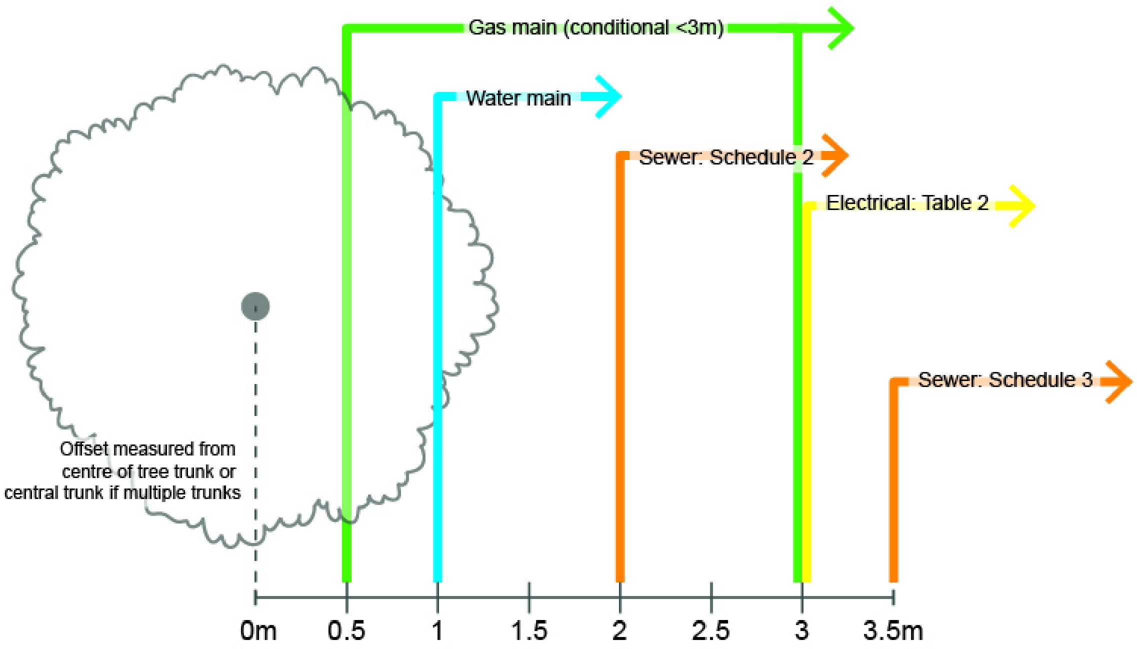


**Figure 18: Underground utility tree planting requirements – offset between tree and utility service.**
(S Rogers & B Meyer-Mclean 2021)

Table 4 provides details of the each of these utility requirements.

[1] **Note, this section has had minor reviews on 1 June 2021 to make this Version 2*

**Table 4: Utility tree planting regulations**

| Utility | Distance of utility from tree centre (m) | Regulations |
|---|---|---|
| Gas (APA Group) | No specific regulations regarding planting trees near their assets, however, this is their policy: | |
| | >3 | There are no restrictions |
| | 0.5 - 3 | Trees cannot be planted within 0.5 to 3 metres of a transmission pressure gas asset without approval.<br>Root barriers of robust permeable polyethylene or nylon sheeting or concrete cylinders are required and installed with specifications for approval |
| | Minimum 0.5 | No trees permitted to be planted |
| Water mains (SA Water) | Minimum 1 | Approval is required for any trees planted closer than 1 metre to water infrastructure |
| Sewerage (SA Water) | Written approval for any trees and shrubs (except those listed in Schedule 2 and Schedule 3) planted on public land that may affect any sewerage | |
| | Minimum 2 | Trees and shrubs listed in Schedule 2 in the Water Industry Regulations 2012 |
| | Minimum 3.5 | Trees and shrubs listed in Schedule 3 in the Water Industry Regulations 2012 |
| Underground Power Infrastructure (SAPN) | Any party intending to undertake civil works to a depth more than 300 mm below ground level shall contact Dial Before You Dig, and/or an equivalent on-site infrastructure location provider to have all cables and other infrastructure located | |
| | Minimum 3 | Species listed in Table 2 in the Electricity Act 1992 and exempt vegetation |
| | Near an underground power line of 66kV or more, only trees with a mature height of less than two metres can be planted within three metres of the centre of the underground power line | |
| Aboveground Power Infrastructure (SAPN) | There are no restrictions for planting distances from infrastructure. There are 2 zones with tree height requirements. In bushfire risk areas or areas where lines are uninsulated – trees can only have a mature height of 3 m or less. In non-bushfire risk areas or areas where lines are insulated – trees can only have a mature height of less than 6 m. | |
| Telecommunications (includes Telstra, Optus, Vocus Group, Nextgen Group, Primus Telecom, PIPE Networks, NBN) | No specific regulations regarding planting trees near their assets, however, decisions are made on individual risk assessments. | |

**APA Gas**

APA Group, Australia's largest natural gas company operations are underpinned by legislation that gives the utility the discretion to remove trees to protect or maintain their assets. This legislation effectively allows APA to remove or damage public trees without consent or assessment by a qualified arborist. According to the Gas Act 1997, APA can access and work on their infrastructure, including via excavation and removal of obstructions (including trees and vegetation) without prior notice or agreements for the purposes of an emergency or for maintenance, repairs, or minor extensions. Vegetation is viewed in terms of risk and the restrictions are based on the view that:

> *Vegetation may limit line of site, access and passage along an existing gas asset alignment, while the associated roots may damage existing buried pipe, coating or other ancillary equipment (e.g. cables). Above ground gas infrastructure may also be exposed to hazards from falling vegetation and increased fire risk (Gas Regulations 2012).*

**SA Water**

SA Water also requires approvals for planting trees within the vicinity of their infrastructure. In the case of water mains, tree or shrub planting within 1 metre of infrastructure is not permitted unless written approval are obtained prior. There are no planting restrictions for shrubs and trees planted more than 1 metre from water mains.

Sewage is more likely to encounter problems associated with tree roots finding joints and leaks and as a result have greater restrictions regarding planting near sewer infrastructure. There are two legislated tree and shrub species lists, the first (Schedule 2 in the *Water Industry Regulations 2012* – Appendix I) lists those species that can be planted minimum 2 metres from sewer infrastructure. The second list (Schedule 3 in the *Water Industry Regulations 2012*– Appendix II), lists those species that can be planted minimum 3.5 metres from sewerage infrastructure.

The *Water Industry Act 2012* similarly gives power to SA Water to excavate any land and remove or use any earth, stone, minerals, trees or other materials or things located on the land for the purposes of maintaining and developing their infrastructure. The *Water Industry Regulations 2012* also provide the framework for the planting restrictions on sewage infrastructure. The regulations are specific to the protection and use of infrastructure, equipment and water and gives powers in relation to installations and access to infrastructure and inhibits the planting of trees and shrubs on public land without approval.

**SA Power Networks**

SA Power Networks (SAPN) similarly requires approvals for planting within proximity of their infrastructure. For underground powerlines, planting trees is restricted to 3 metres offset. In relation to trees, the underground requirements only relate to their underground powerlines, however *The Electricity Act 1996* also legislates the power for the provider (SAPN) to acquire land and carry out work on public land for the purposes of installing, operating, maintaining, repairing, altering, adding to, removing, or replacing electricity infrastructure on public land and to carry out other work for the purposes of generation, transmission, distribution or supply of electricity. This includes excavation and the clearance of vegetation from and around powerlines.

For above ground powerlines they have restrictions associated with zones according to the fire risk of the area. In bushfire risk areas or in areas where the powerlines are uninsulated, trees can only have a mature height of 3 metres or less. In non-bushfire risk areas or areas where powerlines are insulated, trees can only have a mature height of less than 6 metres. SAPN has established the Appropriate Tree Species Lists which are focused on tree height and form and trees' responses to pruning (they are not at all related to the root systems). Each zone above has a tree species list.

**Telecommunications**

The *Telecommunications Act 1997* is not specific about tree, or vegetation planting within the vicinity of their infrastructure, however, provide guidelines on a case-by-case basis from the DBYD process. The *Act* does legislate utility carriers to do anything necessary or desirable on, over or under the land, for those purposes of accessing, installing, and maintaining facilities, including, felling, and lopping trees, clearing, and removing other vegetation and undergrowth, and clearing land. The *Act* also gives power to providers (carriers') access to enter on, and occupy, any land, and the right to remove and dispose of soil, vegetation, and other material for the purposes of installing and maintaining telecommunication facilities.

*Figure 19* depicts a plan view of the constraints that exist in relation to implementing trees in the urban context, where both above ground elements, such as footpaths, parking, roadways and street lighting, and the numerous underground utilities, and their required setbacks, must be considered.

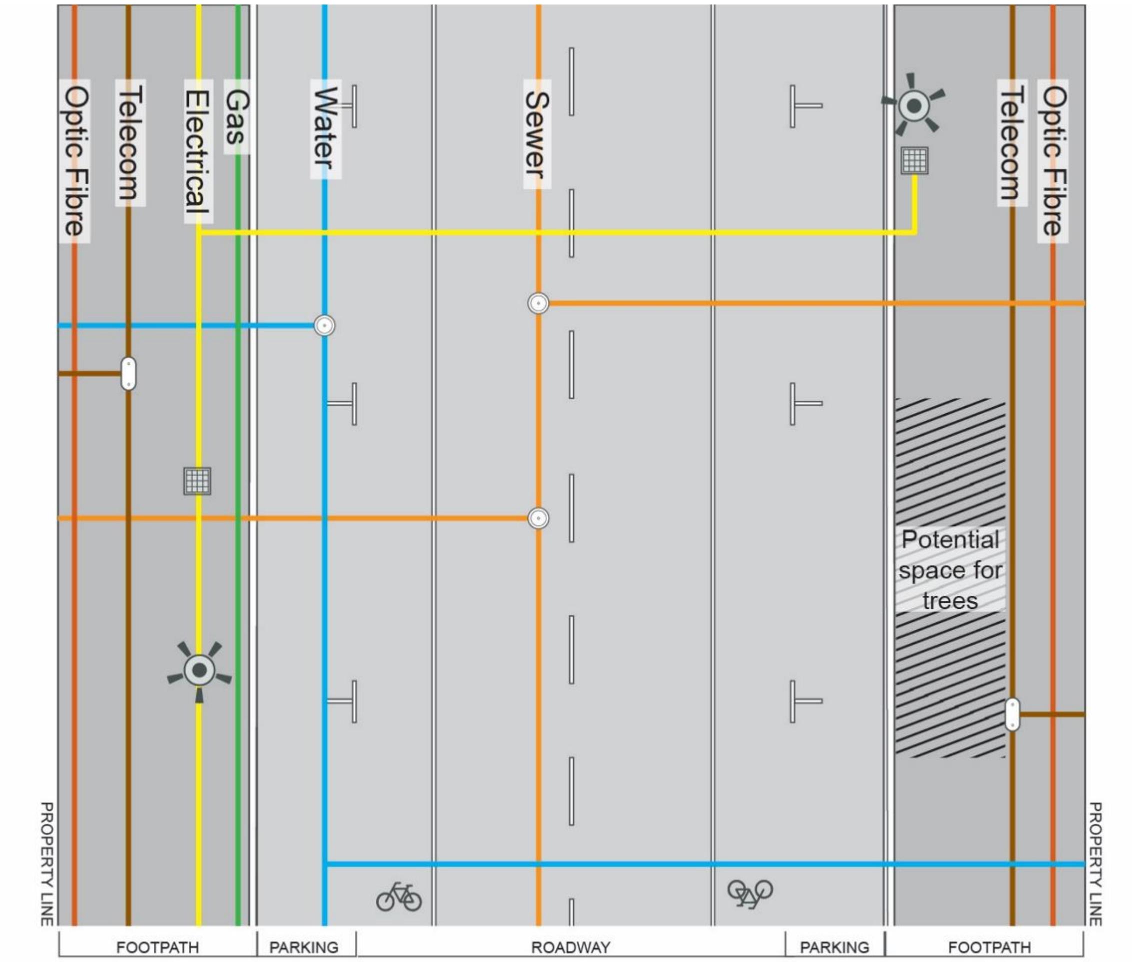


**Figure 19: Diagram of typical underground services arrangement in roadways and footpaths with potential space for tree planting highlighted after all service authority regulations and guidelines have been considered.**
(S Rogers & T Roe)

## Protection of Existing Trees

There is no specific legislated framework to fully protect all existing trees from development or utility activities, and urban/city tree planting ratios or quotas, or tree canopy ratios are also not legislated in South Australia. However, the *Planning, Development and Infrastructure Act 2016* does provide statutory provisions for the preservation of 'significant trees':

> *(i) it makes a significant contribution to the character or visual amenity of the local area; or*
>
> *(ii) it is indigenous to the local area, it is a rare or endangered species taking into account any criteria prescribed by the regulations, or it forms part of a remnant area of native vegetation; or*
>
> *(iii) it is an important habitat for native fauna taking into account any criteria prescribed by the regulations; or*
>
> *(iv) it satisfies any criteria prescribed by the regulations; or*

Or a significant stand of trees:

> *(i) as a group they make a significant contribution to the character or visual amenity of the local area; or*
>
> *(ii) they are indigenous to the local area, they are members of a rare or endangered species taking into account any criteria prescribed by the regulations, or they form, or form part of, a remnant area of native vegetation; or*
>
> *(iii) as a group they form an important habitat for native fauna taking into account any criteria prescribed by the regulations; or*
>
> *(iv) as a group they satisfy any criteria prescribed by the regulations,*
>
> *(and the declaration may be made on the basis that certain trees located at the same place are excluded from the relevant stand).*

The definition of a significant tree according to the *Planning, Development and Infrastructure (General) Regulations 2017* is a tree that:

> *has a trunk with a circumference of 3 m or more or, in the case of a tree with multiple trunks, has trunks with a total circumference of 3 m or more and an average circumference of 625 mm or more, measured at a point 1 m above natural ground level.*

The *Act* does, however, give power for the removal of any trees (including significant trees) to protect buildings and persons, so far as is reasonably practicable, be undertaken to cause the minimum amount of damage to the tree and have received the appropriate development authorisation. Also, the powers given to the developers and utility services to remove trees and vegetation, and excavate land for the purposes of development, and the development of utility services outlined above, are used to remove existing trees, including significant trees.

There is also the Australian Standard: AS4970-2009 Protection of Trees on Development Sites which:

> *provides guidance for arborists, architects, builders, engineers, land managers, landscape architects and contractors, planners, building surveyors, those concerned with the care and protection of trees, and all others interested in integration between trees and construction.*

This document provides best practice standard framework for planning and protection of significant and regulated trees on development sites and is an effective means of protecting space for trees in Australia. The document provides advice on planning and the tree management processes, including determining tree protection zones and other tree protection measures, and planning, construction, and post-construction tree protection strategies. This is not a compulsory standard and therefore is not consistently applied for all trees. For example, SA Water has adopted the standard for regulated trees, but not any other utility providers (to the knowledge of the authors at the time of writing).

## Summary of Stakeholder Consultations

Consultations were conducted with a comprehensive range of stakeholders. The stakeholders included landscape architects in private business, academics working in engineering, horticulture, and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives (SAPN, SA Water, APA gas). The stakeholder consultations showed a willingness to better understand the issues in finding underground space for trees in city and urban spaces. Table 5 presents eleven key subject themes produced from these discussions; (i) that there is a problem, (ii) viewing trees as risk, (iii) the value of trees, (iv) inadequate knowledge in decision-making processes (v) the prioritisation of assets, (vi) the old utility infrastructure in Adelaide, (vii) the costs of putting trees into the ground (viii) community understanding, (ix) the political influence in decision-making, (x) the problems associated with tree planning, development, and management, and (xi) opportunities for tree planning, development, and management.

Table 5: Key themes of discussion from stakeholder consultations

**There is a problem**

- All stakeholders identified that there is a problem with trees and utilities and planting urban trees. The divergences from this point of view related to each stakeholder's position.
- The utilities representatives saw trees as risk to their assets, and the problem therefore was the tree (and tree roots). They all commented on how City of Adelaide plants trees close to their assets without consultation and then there are problems, and the trees must then be managed. Council, therefore, causes the problem by planting the tree in the first place.
- Council representatives presented the problem as relating to the confusing and inconsistent restrictions for planting trees (navigating the approvals of multiple players), as well as the individualistic approach to utility development.
- Trees are primarily seen in terms of risk, therefore efforts to preserve and support planting of trees aims to minimise risk in planning and development rather than accommodate for existing and new trees.
- There is no foundational legislated framework to support an urban forest.
- Trees are not valued in the same way as other utilities.
- Arborists represented the problem from the trees point of view and saw the problem is more about the lack of consideration of trees in planning and development.
- Trees are seen as a way of solving problems and expected to perform in a space that is not meant for trees. The space needs to be made better for trees to survive and then they will perform – they will not solve the problem on their own. Urban, especially city spaces, are harsh environments for trees to survive in and so they are doomed because there is little investment into their survival and therefore their ability to perform. Given the harsh environments, trees will seek the nutrients and moisture to survive and that often coincides with utilities which consolidates the thinking that they are the problem.

**Trees viewed in terms of risk**

- Trees were often framed in terms of risk, or risk-related terminology, particularly that they cause damage.
    - Tree roots grow where they want and do significant damage to infrastructure.
- When the utilities go to fix/work on their infrastructure, they risk damage to trees (here the trees are in the way).

| |
|---|
| • Termites from nearby trees affect infrastructure (it has been found that termites are attracted to and have in some instances begun to eat through the poly coating around the steel pipelines and so exposing the pipes to the elements)<br>• A lack of diversity in street trees – smaller varieties or species creates risk of pest and disease – ideally there should be no one tree species over 10% of the total tree population. The risk is loss of a large number of trees at one time which would create a significant challenge to replace.<br>• Asset strike –when people start digging into a site and strike and damage a utility asset.<br>• Fundamentally, trees are a risk, but we need to put that into context – that we have risks all over the place. Tree risks, therefore, need to be put into perspective and we should work harder at saving trees and reducing those risks.<br>• There is a lack of evidence supported by data regarding infrastructure failure caused by tree roots. |
| **The value of trees**<br>• There was a consensus that trees are important. All stakeholders recognised the values of trees – particularly in relation to the UHI effect, habitat and biodiversity and water management.<br>• For the utility representatives, this level of importance, however, did not surpass the value of their assets.<br>• In contrast, one stakeholder argued that they are fundamental for life; if you do not have vegetation you do not have planet earth and that humans have evolved with a close association with plants (of which Indigenous people have a better understanding). We absolutely need them for the quality of life that we aspire to.<br>• Another comment (particularly those stakeholders that are speaking from a horticultural or arboriculture background) is that trees are not valued within the Australian culture like they are in other cultures. Two people used Spain, as an example of the way trees can be valued differently within cityscapes – for example, care and maintenance required to have them well pruned and looking great to enhance the cityscape whilst also performing as cooling agents within the city.<br>• Trees in the city and built-up areas have a greater impact because they affect a greater number of people. |
| **A perceived lack of knowledge about trees in decision-making**<br>• There is a lack of knowledge about trees and their interaction with infrastructure within the context of growing conditions in cities.<br>• Many of the problems associated with Adelaide's trees are because the trees are old as is the infrastructure. Any knowledge about trees in Adelaide is limited to the age of the tree within the urban spaces and there have been limited tree species used in Adelaide. Therefore, the knowledge is constrained to those tree species. As the trees grow older, so too the problems arise because of their interactions with services which gives rise to the views of certain species as problems. There is really no longitudinal research in Adelaide into the impacts of trees with infrastructure because you need to do that research over an extended timeframe – decades.<br>• A tree's expected performance is based on optimal growing conditions. However, urban and city tree growing conditions are principally below optimal and trees will therefore not perform in the same way. For this reason, species lists are not helpful, because they are all based on optimum growing conditions. Many examples of this exist within in Adelaide, such as Fraxinus trees (Ash) planted in North Adelaide. These trees are approximately 100 years old and if they had been planted in ideal conditions they would be double the size they are currently. |

- Multiple comments were made about the various levels of decision-making not having appropriate knowledge in relation to trees:
    - Many decisions about trees given to arborists are appropriate when the decision relates to a tree's biological/physical condition, however they are not necessarily qualified to make decisions based on their environmental/habitat/biodiversity impact.
    - Landscape architects don't necessarily have an in-depth knowledge of tree species, and their appropriateness within a certain space/conditions.
    - Overall decision-making needs to be flexible and adaptable, not require black and white answers (i.e., specific lists of species that are perfect for all conditions, as there'll be 0) (but more often than not it is not flexible)
    - Engineers are often the primary advisers behind utility asset requirements and arborists are not necessarily consulted at all – however, SA Water and SAPN have made improved.
    - The challenge for local governments is that it's often the number crunchers (accountants and business managers) that make the final decisions about trees, but they don't have the knowledge to be making the decisions.
- With proper expertise there can be the necessary understanding to be able to have some flexibility with decision-making so that good decisions about what trees/where can be made.
    - Some of the service provider representatives noted the benefits of expertise that have informed changes and improved their business operations.
- The representatives from SAPN and SA Water demonstrated their company's efforts to improve their business operations by consulting with a range of experts:
    - Over the past 7 years SAPN has engaged in efforts to improve public relations in terms of vegetation management. To do so they have set up advisory groups, the Arborists Advisory Group to bring expertise to improve the company's decision-making regarding trees, a Local Government Working Group to advise on improved relations with local councils, and a Customer Consultative Panel to improve customer and stakeholder relations.
    - To improve relations with local councils, SA Water has adopted the AS4970-2009 Protection of Trees on Development Sites and is investing in working trials with councils when the pits are open to put in root barriers and water inlets to protect their infrastructure, and trials where they are looking into tree species and how they interact with the pipes by cross-referencing species with the damaged pipes. They have also developed a tool to provide council planners a reference guide to their service locations to quickly choose locations for trees without needing specialised GIS experience or software.
- Trees are considered invasive by utility providers, but trees do not naturally grow in isolation and in compacted polluted soils. For a tree to survive in an urban (street) environment, it must be invasive. To plant less invasive trees there needs to be a more concerted effort to consider and provide more ideal space for them to grow in. Because of this, the idea then of suitable species lists is a misconception (either they need more nurturing/management to perform as expected, or they need to be 'invasive' to survive) and also highlights the importance of preserving and improving space for trees.
- Blanket rules regarding trees are a problem and are not a solution. There are so many variables and there is not enough knowledge about trees in Adelaide to be able to make long-term effective decisions.

| |
|---|
| • Trees are not the baddies! But trees go to the place of less resistance and there is a lot of sand and water to access in services trenches. Therefore, there is no one tree that is not going to be a problem. |
| **The prioritisation of assets**<br>• Each of the utility service provider representatives (gas, water, and electricity) spoke about the importance to them about protecting infrastructure, which they described as their assets. They approach each development/tree planting proposal from the perspective of protecting their assets. All of them expressed a keenness to work to improve working with councils and an extension of this project if it means they can help to protect their assets.<br>• At this point Dial Before You Dig is regarded as the go-to for asset protection for utilities.<br>• Council representatives were frustrated that the utilities are not necessarily adequately restoring work sites, the cost of which is placed on Council; a principal that also applies to trees. When trees are damaged/removed by the utilities, it is still up to Council to replace that tree, which is often impossible.<br>• The guidelines regarding trees are written by the Institute of Public Works Engineers Australia which only see trees as risks. Therefore, with the asset management systems, the trees are not valued as other infrastructure is, and all the other range of values from trees are not measured when considering them as assets.<br>• There is no obligation for the utilities to consider or put in infrastructure to protect their services – the expectation is that Council will pay for it all.<br>• It is a one-way street – services only looking after their own assets; however, council must consider it all (i.e., all the assets underground, above ground, water runoff, pedestrian access, creating public amenity, greening, lighting, safety etc).<br>• Trees were also described as assets by City of Adelaide representatives; they are costed and viewed as an attribute to the city (i.e., trees are used to draw people to spaces – particularly in 'target spaces' where people can move in amongst them). Notable, although trees are spoken of as assets, they are not thought of in the same regard as hard infrastructure assets. |
| **Old infrastructure in Adelaide**<br>• The old and often failing infrastructure is seen as a problem across the board. This is particularly so with sewage, there has not been a consistent and cohesive system for the placement of utilities, therefore the utility infrastructure in Adelaide is dense and complicated. The cost to address this problem is viewed as incomprehensible. |
| **The costs of putting trees into the ground in the city**<br>• You can't just dig a hole in the city. The cost of putting trees into the ground is a principal issue that applies to the city - the fact is that it is more costly to plant trees in the city, predominantly because of the processes involved in establishing the space availability at any given site (finding, negotiating, and actually physically getting the space that caters for all of the requirements and considerations within that space, including the expensive and often numerous onsite investigations and onsite surveys) but that makes it hard to find funding to plant trees (a lot less trees for a lot more money).<br>• People don't necessarily fully understand these costs in relation to planting a tree in the city or reconcile that cost with the full value of the tree.<br>• Councils always have problems with tree maintenance – irrigation, filters, pruning, regulation assessments – all of these create points of opposition that are driven by finance. The economic benefit and the long-term benefit and costs are lost in these points of opposition because they are not as quantifiable. |
| **Community understanding about trees** |

- There are reasons for making decisions around trees and the development of tree species lists (massive trees under a powerline is not going to work) however, people need to understand why certain decisions/management approaches are made and they need to have access to that information. Getting that information out to the community is really important to gain public acceptance about tree management.
- People oppose trees for a range of reasons but often it's generally a situation of yes, we want more trees, just not in my street/back yard. Humans respond to trees from their own biases, and therefore, trees will be a problem from a range of different perspectives.

**The political influence in tree-related decision-making**

- Politically, there is motivation to plant the trees, but then it is all too hard because it is so difficult and expensive. There is no funding through the acts and regulation spent on R&D but there is a lot that can be developed in this space, if there was that would improve the longevity of infrastructure, management of storm water, and greening cities.
- Principally, there is nothing that will protect trees in the long-term because of the political nature that trees exist in. The governing and decision-making is often political and also often driven by public opinion.
- The issues around trees become political and whoever is making the decisions at the time determine the outcomes.
- Trees are impacted by humans and the problems with trees are framed by humans.

**Problems associated with planning, development, and management**

- The management of utility services is inefficient and there should be an effort to converge and manage our services underground. In this context, the use of trenching was also referred to as archaic and instead, existing tunnelling technology could be used to tunnel underneath tree roots. Therefore we should be able to pull together all services in a common utility box or tunnel. Hindering this progression is an attitude about using the trenching from the engineering infrastructure side– that it has always been done this way.
- It is astonishing that development projects still engineer with the assumption that there are no trees. Engineering standards need to evolve. There are different approaches being developed and so there are ways forward.
- Drought management is a problem because trees are not looked after during extreme and long dry periods – such as the millennium drought, where many street trees were cut down because there was a perceived concern about water requirements and that they would be a strain on water supplies, which was argued to be a misperception.
- A key reason street trees are lost is due to the increase of subdivision within urban spaces (such as dual occupancies) which means that street trees are cut down to make way for the increased number of driveways.
- Utilities felt that their assets are not thought of initially in development designs and that developers/designers are less inclined to allow for their spatial requirements and as a result, problems occur with the trees – hence the need for their removal. Considering the requirements in the planning phase reduces the need for the utilities to step in and manage the situation.
- Trees are not necessarily considered in the development of utilities.
- Infrastructure is built to fail, especially when trees aren't taken into account in the planning, but trees are blamed for it. Trees go where the water is and that is often

where the sewer chokes (blockages) are – work needs to be done to work out solutions for these problems, not just blame trees.

- Utility services rarely collaborate, and are rarely on site at the same time, instead work independently.
- Asset management timelines are not coordinated. For example, the NBN know when they are rolling out their asset operations – but that information is not necessarily shared with council to be able to coordinate other operations in line with those timelines.
- When coordination does occur, utilities may contract the work out to private companies and undertake work that go against agreed plans (private contractors are not necessarily informed) and changes may be made onsite without informing council.
    - There are no consequences for these irregularities and therefore the utilities do not care.
- Council planners/designers are willing to design around all of the utility infrastructure and make sure that everyone is happy but feel that services are always the complexity in any situation, and that it is up to council to fit in with everyone else.
- Designing to fit in with utility requirements is often expensive.
- The rapidity of development and the influence of developers has led to trees being at risk.
- The focus is wrong – trees are not seen as something to be preserved for the long term and are therefore dispensable. Trees should be seen as part of the project that needs to be worked around (a given) and therefore the problems around trees will be worked out because you have to. When they are dispensable, they are not taken into consideration.
- Growing canopy and achieving targets first requires the protection of existing trees due to high mortality rates and the recognition of their conservation value to protect intergenerational assets. Large, long lived trees provide the greatest environmental services and carbon sequestration, but they are being replaced by smaller trees with a life expectancy of less than 30 years – the replacement value is uneven.
- Many projects are approached by landscape architects and developers with a mindset that trees are replaceable – North Terrace and Adelaide Oval are good examples. Landscape architects decide to remove 100+ year old trees from projects because of their aesthetic (looking scrappy).
- Trees affect every government department, and in that way, they are a wicked problem.

**Opportunities for planning, development, and management**

- The use of plant boxes that raise the level of the planting space above the road/path surface, something that is not done so much anymore, but used to be used much more in Adelaide. This increases the amount of medium, increasing the space available for trees to grow in.
- Using climbing plants on buildings, which has been found to not cause structural issues in buildings but have the same cooling effect on buildings.
- Incorporate, or incentivise the incorporation of passive watering systems into road/footpath infrastructure. Using alternative forms of paving and passive watering, storm water flows, and the effects of flooding are reduced because water is taken away from floodways, as well as the benefit of improving groundwater levels and providing water for trees.

- Using gravel medium as a buffer/ barrier for tree roots – new research
- The use of pruning trees, such as espaliering, pleaching or pollarding[2] so that they fit in the confined spaces, but still provide the cooling effect needed. The problem with these approaches is they require a higher level of management with regular pruning.
- Rooftop gardens. A critical note regarding rooftop gardens in Adelaide is that there is no incentive for developers to design buildings in the city that accommodate rooftop gardens and then retrofitting is expensive, so they do not get done.
- Being innovative/experimental with tree selection. This will increase the number of tree species in the city, but also increase the understanding of what species do and do not work.
- Watering systems for trees to establish in the first few years.
- Use the Waite Arboretum as a resource for trees in Adelaide. The trees here are not watered and live in relatively difficult conditions.
- Ensure collaborative process are used – don't make decisions in a hurry. Time should be taken to make decision and discussions with those that have the knowledge should happen before decisions are made. Tree planting and removal decisions are often made in haste without consultation.
- Council landscape architects seek dispensations with the utilities so that they can design systems to protect the utility, and at the same time, create more space for the tree to grow successfully. The idea is that with individual projects, some flexibility can enable the creation of space.
- If the tree is given the right conditions, they are not likely to cause problems. Service authorities see the tree roots as 'out of control', but we can control them by giving the tree the right conditions to grow.
- An Adelaide Tree Advisory Board which would provide the required expertise for decision-making about trees in Adelaide. It would provide an informed view and an unbiased view and consist of tree professionals, horticulturalists, arborists.
- City of Melbourne is doing particularly well because there is good leadership and great quality of staff. The urban forest strategy is good and influential with other metropolitan councils. The Council has a strong position because the land they manage is significant and they are not scared to take on the utilities which sometimes leads them to going to court. The importance of that is that although they do not always win, the issues they are bringing to the fore become public issues which is a good thing.
- Places that have embedded strategies for trees have increased tree canopies. New York and Vancouver are good examples of cities with good policies in place

[2] Pollarding, pleaching, and espaliering: pruning systems used widely in Europe that promote the growth of a dense tree canopy foliage and shape branches and to maintain trees at a determined height and frame and which enable a range of trees to be grown in more contained spaces.


Pleaching


Pollarding


Espaliering

regarding trees. New York has costed each tree in the city which has meant that each tree has a monetised value (in terms of all the benefits) which then affects development decisions regarding trees in that city. Vancouver has a tree strategy that involves a mandated volume of soil per tree so that each tree that is planted has sufficient soil for it to survive in which has been complied with well by developers etc and it seems to work well.

- Need to consider what is real in terms of long-term benefits, not just in terms of budgets, because that will always result in cheaper, short-term outcomes.
- There was an expressed willingness by the utility providers to work with councils in a positive way to make sure that trees get planted and collaborate to work out how trees can be planted when near their infrastructure rather than just plant and then have a problem later down the track. SA Water for example, is in the process of rolling out an online tool to help planners establish where their assets are. They are also starting trialling working with councils when the pits are open to put in infrastructure to protect their infrastructure by putting in root guards and inlets to passively water the trees, and other research into tree species and how they interact with the pipes – cross referencing species with the damaged pipes.
- Add trees to the DBYD process – i.e., contact the council and see if they had earmarked a streetscape for new/replacement trees, and looking at existing trees

# Discussion: The Challenges and Opportunities for Finding Spaces for Trees

The challenges related to planting trees in Adelaide's urban and city spaces listed by the stakeholders in this project are testament to the extent of the problem. Many of the problems relating to trees and infrastructure identified are widely known and anticipated in metropolitan developments worldwide (Jim 2003; Jim & Chan 2016; Randrup et al. 2001a; Randrup et al. 2001b; Slater & Chalmers 2020), such as tree roots interactions with sewer pipes (Kuliczkowska & Parka 2017; Randrup et al. 2001b; Ridgers et al. 2006; Torres et al. 2017). However, many of the problems are site specific (Randrup et al. 2001a), and using the example of Adelaide, is an opportunity to highlight specific problems to achieve local tree canopy targets.

Examining South Australia's legislative framework highlighted the complex landscape shaping any planning for an urban forest in Adelaide. Despite the policy goals and targets, backed up by the well-understood values of trees in cities (demonstrated in the literature review), it is evident that there is no robust framework to specifically support those goals and targets coming into fruition. The value of the utility services, fundamental to supporting expectations of contemporary society, is underpinned by the strong legislated frameworks which support their management and development. However, within those legislations, there is little to consider trees outside of them as a risk concern. Furthermore, because trees are framed as ultimately expendable, there is no incentive for the utility providers to either protect or consider trees within their development or management operations. Any work by the utilities to consider the protection of trees is driven by their own motivations to protect their assets, not because there is a need or that they are required to by law to support the planting of trees in the city/urban public spaces. Moreover, the policy targets and goals have no regulatory provision for the development of tree planting in Adelaide.

Without robust regulation the policy targets and goals can be seen as tokenistic, because with no such framework, putting them into action is a very difficult exercise, and as such, a disincentive. For example, the convoluted process of finding space to plant trees in Adelaide, illustrated above (*Figure 14*), is a central challenge for the City of Adelaide (and other similar built-up local government areas) meeting the canopy targets. The fact that so much time, effort and cost go into establishing a site's viability is a real barrier to getting trees into the ground. The excessively high costs involved in finding spaces to plant trees in the city compared to metropolitan councils is a hard sell in grant applications and adds to the financial strain on council to meet targets. Also, the vast range of problems identified in the stakeholder consultations underscore the multifaceted scale of why the tree canopy in Adelaide is at risk, and why reaching the canopy targets is increasingly challenging.

Needless to say, trees have risk associated with them, which not only require consideration, but as highlighted strongly in the stakeholder consultations, require better understanding, particularly in the Adelaide context. This project has revealed a concern that decision-making systems do not sufficiently use existing knowledge or seek to expand what is known. The recent work by SA Water and SAPN, driven by their own business bottom-lines, emphasise that having adequate understanding and expertise about trees makes business sense. In this way, the utility providers are demonstrating a concerted effort to improve their knowledge, and thus their operations concerning trees. The problem here lies with the fact that knowledge building is framed by industry desire to preserve their assets rather than focus on solving the problems of preserving trees and supporting tree canopy growth within city and urban spaces per se.

At the moment, in South Australia, there is no overarching research initiative or funding to develop a better understanding of how to find ways to support the preservation of existing trees and increase the tree canopy in Adelaide. Any research progress, such as the vital work exploring engineering solutions for passive watering trees being undertaken in Adelaide, is supported in an ad hoc way by individual local councils and university research institutes. There are therefore missed opportunities impacting the broader metropolitan area more comprehensively. The limited literature demonstrating working governance mechanisms and planning, and design possibilities resolving existing underground spatial and contested interest issues further highlights that there is no silver bullet to roll out city/metropolitan tree canopy targets.

This project also highlights that there is a highly political aspect to planting trees in cities and urban spaces. Trees are at the centre of decision-making that is based on a range of perceptions and biases. In general terms, governments focus on cost, engineers on hard structures, utilities are biased towards their assets, landscape architects focus on public amenity, and arborists on a tree's biological and physical attributes. Public opinions vary between appreciation of the aesthetic of trees, fears of risk and the mess they make, conservation of indigenous species, and urban biodiversity. Moreover, there is an overarching view that trees are dispensable which has meant that many trees have unnecessarily been cut down.

The decision-making that affects trees often fails to consider appropriate species that suit the limited space. In regards to preservation of existing trees especially, it can often fail to consider the full range of their value and benefits, such as carbon sinks, habitat value, or public health benefits. Despite some protections for significant and regulated trees, these can be overridden, and there is nothing in place to protect trees under a 200 mm trunk circumference, with only certain species capable of reaching this size. Therefore, it would be beneficial to review who is making and why decisions are made regarding trees, and whether those decisions support or inhibit Adelaide's urban forest.

But despite the long list of problems, the consensus that there is a problem and the willing participation by a wide range of stakeholders in this project denotes that there is interest to engage in and find solutions. Importantly too, the stakeholder consultations also presented a range of possibilities to address those problems and find ways and means to increase Adelaide's tree canopy.

Fundamentally, many of the problems presented above have foundations in the fact that the tree canopy targets have no legislated backing. Trees as a legitimate urban structure / asset is also not legislated. The only legislated protection for trees relates to 'significant trees in the *Planning, Development and Infrastructure Act 2016.* Although an important legislation, it affects a limited number of trees and there are ways that can be found around it to still cut down and remove significant trees for urban development and utility related projects. There are examples of successful legislated structures which could inform ways in which to put in such a framework. The limited timeframe of this study meant that case studies of other examples of city's tree canopy efforts were not analysed. Further study into case studies, such as the examples highlighted in the stakeholder consultations, New York, and Vancouver, would provide a range of possible strategic frameworks that could incentivise problem solving abound finding space in which to plant trees.

The issues around knowledge highlighted in the stakeholder consultations related to decision-making systems and community understanding, but above all, there was a strong perception that there is not enough known about trees specific to Adelaide. The perceived need to improve knowledge extends to all aspects of putting trees into the ground, including developing systems to allow for and support trees within hard infrastructure and to include trees within utility development. Creating incentives to problem solve leads to significant opportunities in research and development to create new and improved ways and means to support urban tree planting. These opportunities lie in both new and existing understandings. The existing research and development into passive watering and water management development described above is a great example of what could be supported by a legislated framework and fostered more broadly across metropolitan Adelaide. Existing planning and design possibilities already adopted in Adelaide and in cities worldwide also provide a plethora of options to inform decision-making.

# Conclusions and Recommendations

The qualitative data presented above demonstrates that finding space to plant trees in a metropolis is a difficult undertaking. This report provides an opportunity to present the multifarious issues at play in undertaking planting trees in the city and broader metropolitan Adelaide. For the city, the space underground is physically congested and contested by numerous and often conflicting interests. Moreover, the number of factors that inhibit and complicate decision-making are made more difficult because of a lack of overarching frameworks that support the planting of trees. In presenting these issues, the opportunities are also highlighted and provide potential ways to resolve the problems at hand. The following recommendations provide ways to consider the range of issues raised in this study in future decision-making regarding tree canopy targets to resolve some of the problems with finding space to plant trees in Adelaide.

## Key Recommendations

### Legislation supporting the preservation of existing trees and urban forest development

It is recommended that the tree canopy targets be strengthened by legislation. Legislation that places trees as assets and specifically directs urban tree protection and planting trees in urban public space would provide a foundation to protect and promote urban forest development in Adelaide. Legislation would also provide the impetus for urban and utility development to include measures for trees and incentivise research into solutions that enable planning and development that takes trees into account.

### Decision-making standards for trees in Adelaide

Another recommendation is for the development of standards for decision-making concerning all trees within the city/urban public spaces that can be universally adopted by councils, developers, and utilities. The standards would guide decision-making in relation to city and urban development, and utility management and development. Moreover, establishing a site-specific framework for Adelaide would not only give substance to the tree canopy targets in place, but also be an exemplar for successful rollouts of those targets. These standards should be a coordinated and collaborative effort, informed by all key stakeholders, including, tree experts proficient in horticulture, arboriculture, and conservation and biodiversity; hard structure experts (engineers, architects, landscape architects, planners); representatives from all utilities and developers; and government (state and local).

### Research and development into urban forest development

Support for multi-disciplinary local research and development into the range of issues relating to trees is imperative to ensuring strong frameworks can be put in place, decision-making is properly informed, and trees can grow and perform in the way intended when they are planted. The success of planting trees hinges on their planting environments and so it is important to support research into how to better provide adequate water, nutrients, and enough space for them to grow within the Adelaide environment.

Other important research areas include:

- Creating best practice standards for urban planning and design that considers trees.
- How to improve engineering and architectural design to consider trees.
- Engineering solutions for utility development that considers trees and retrofitted solutions to protect existing infrastructure.

### Collaborative and well-informed decision-making

Decision-making should reflect the range of stakeholders that affect and are affected by decisions made regarding trees. This report shows that the range of issues related to trees tap into different stakeholder interests and knowledge. The many different voices that affect trees calls for a multidisciplinary collaborative approach to tree management. The stakeholder consultations revealed a range of methods undertaken by the utilities to improve their dialogue with councils, demonstrated that maintaining productive, collaborative dialogue between stakeholders results in better outcomes for all parties. However, it is important that decisions about trees are not driven by one agenda. Equally, it is important that decisions are appropriately and expertly informed. Protecting and managing existing trees and planting trees that will thrive and perform requires specific knowledge capabilities. Moreover, problems solving around issues between trees and infrastructure requires certain knowledge and capabilities. The idea of an Adelaide Tree Advisory Board broached in the consultations is one way that may provide unbiased tree related expertise into decision-making. Whatever approach, adopting a more consultative and informed approach to decision-making allows for those broad spectra of ideas and expertise to be considered in planning and development.

### Funding to support research and development and to cover the costs of planting and managing urban forests

The above recommendations require funding. If urban forests are to be valued, they need to be invested in. This includes funding management and development of city and urban treescapes and in research and development. This project identified many of areas relating to trees that should be better understood, but for a concerted effort to fill those knowledge gaps (particularly to finetune these understandings to Adelaide) they will need to be funded. Moreover, anecdotal evidence has been given that suggests that the City of Adelaide requires substantially more funding than the metropolitan councils.

### Planning for trees in the long-term

Long-term planning for trees is an imperative. Preserving what exists and looking to the future when planting new trees will address the risks to tree canopy in Adelaide. Many of Adelaide's street trees are relatively short lived (30 years), contingency plans will need to take the renewal of these trees into account.

### Expanding this study

This study was a small step towards better understanding the issues relating to putting tree canopy targets into action by exploring the spatial problems for planting urban/city trees. The small scope of the study had several limitations, particularly, that there was not time to undertake case study analyses of other cities that have successfully rolled out tree canopy targets, and/or put into place legislation for trees. Another limitation to this study, is that there was no scope to examine the value and culture relating to urban trees in Adelaide. Such an examination would help to inform tree canopy strategies and areas to shift cultural expectations to support urban forest development. The first three recommendations also provide an opportunity to expand this study into possible legislative frameworks and the collaborative development of an Adelaide specific standard for urban forest development.

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# Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines Protocol

| Latin name | Common name | WIR 2012 Tree List Schedule 2 | WIR 2012 Tree List Schedule 3 | Bushfire Risk Zone Tree List 1 | Bushfire Risk Zone Tree List 2 |
|---|---|---|---|---|---|
| ***Abelia*** **species** | | | | v | |
| ***Abutilon*** **species** | | | | v | |
| ***Acacia acinacea*** | Gold Dust Wattle | | | v | |
| ***Acacia acuminata*** | Raspberry Jam Wattle | | v | | v |
| ***Acacia anceps*** | | | | v | |
| ***Acacia aneura*** | Mulga | | | | v |
| ***Acacia argyrophylla*** | Golden Grey Mulga | | | | v |
| ***Acacia brachybotrya*** | Grey Mulga | | | v | |
| ***Acacia calamifolia*** | Wallowa Wattle | | | | v |
| ***Acacia cardiophylla*** | Wyalong Wattle | | | v | |
| ***Acacia cultriformis*** | Knife Leaf Wattle | v | | | v |
| ***Acacia cyanophylla*** | Orange Wattle | | v | | |
| ***Acacia cyclops*** | Western Coastal Wattle | v | | | v |
| ***Acacia dodonaeifolia*** | Hop-leaved Wattle | | | | v |
| ***Acacia drummundii*** | Drummond Wattle | | | v | |
| ***Acacia glandulicarpa*** | Hairy Pod Wattle | | | v | |
| ***Acacia glaucoptera*** | Flat Wattle | | | v | |
| ***Acacia gracilifolia*** | | | | | v |
| ***Acacia hakeoides*** | Hakea Leaved Wattle | | | | v |
| ***Acacia howitii*** | Sticky Wattle | v | | | |
| ***Acacia iteaphylla*** | Flinders Range Wattle | v | | | v |
| ***Acacia ligulata*** | Umbrella Bush | | | | v |
| ***Acacia longifolia*** | Sallow Wattle | | | | v |
| ***Acacia microbotrya*** | | v | | | |
| ***Acacia microcarpa*** | Manna Wattle | | | v | |
| ***Acacia myrtifolia*** | Myrtle Wattle | | | v | |
| ***Acacia notabilis*** | Notable Wattle | | | | v |
| ***Acacia oswaldii*** | Umbrella Wattle | | | | v |
| ***Acacia pendula*** | Weeping Myall | | v | | |
| ***Acacia pycnantha*** | Golden Wattle | | | | v |
| ***Acacia retinodes*** | Wirilda | v | | | |
| ***Acacia rigens*** | Nealie | | | | v |
| ***Acacia rotundifolia*** | Round Leaf Wattle | | | v | |
| ***Acacia salicina*** | Broughton Willow or Wattle | | v | | |
| ***Acacia sclerophylla*** | Hard-leaf Wattle | | | v | |
| ***Acacia sophorae*** | Coastal Wattle | v | | | v |
| ***Acacia sowdenii*** | Western Myall | v | | | |
| ***Acacia spectabilis*** | Mudgee Wattle | | | | v |

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|---|---|---|---|---|---|
| ***Acacia suaveolens*** | Sweet Wattle | | | | v |
| ***Acacia terminalis (A. elata)*** | Cedar Wattle | | v | | |
| ***Acacia trineura*** | Hindmash Wattle | v | | | v |
| ***Acacia verniciflua*** | Varnished Wattle | v | | | v |
| ***Acacia vestita*** | Hairy Wattle | | | | v |
| ***Acacia victoriae*** | Elegant Wattle | v | | | v |
| ***Acer buergerianum*** | Trident Maple | | | | v |
| ***Acer ginnala*** | Amur Maple | | | | v |
| ***Acer grosseri*** | | | | | v |
| ***Acer japonicum*** | Full-moon Maple | | | | v |
| ***Acer negundo*** | Box Elder | | v | | |
| ***Acer palmatum*** | Japanese Maple | | | | v |
| ***Acer pennsylvanicum*** | Striped Maple | | | | v |
| ***Acer sieboldianum*** | | | | | v |
| ***Acokanthera oblongifolia*** | | | | v | |
| ***Actinostrobus pyramidalis*** | Swan River Cypress | v | | v | |
| ***Aesculus pavia*** | Red Buckeye | | | | v |
| ***Agonis Flexuosa*** | W.A. Willow Myrtle or Peppermint | | v | | |
| ***Alberta magna*** | | | | | v |
| ***Albizia julibrissin*** | Silk Tree | | v | | |
| ***Aleurites fordii*** | Tung-oil Tree | | | | v |
| ***Allocasuarina muelleriana*** | | | | v | |
| ***Allocasuarina nana*** | Stunted Sheoak | | | v | |
| ***Allocasuarina paludosa*** | Scrub Sheoak | | | | v |
| ***Aloysia triphylla*** | Lemon-scented Verbena | | | | v |
| ***Alyogyne species*** | Desert Rose | | | v | |
| ***Alyxia buxifolia*** | Sea Box | | | v | |
| ***Amelanchier andrachne*** | | | | | v |
| ***Amelanchier asiatica*** | | | | | v |
| ***Amelanchier laevis*** | | | | | v |
| ***Amelanchier sanguinea*** | | | | v | |
| ***Amygdalus pollardii*** | Flowering Almond | | v | | |
| ***Angophora cordata*** | Dwarf or Scrub Apply Myrtle | | v | | |
| ***Angophora cordifolia (syn. A. hispida)*** | Dwarf Apple-Myrtle | | | | v |
| ***Angophora costata*** | Smooth-barked Apply Myrtle | | v | | |
| ***Anigozanthos species*** | Kangaroo Paw | | | v | |
| ***Annona species*** | Custard Apple | | | | v |
| ***Anopterus glandulosus*** | Tasmanian Laurel | | | | v |
| ***Arbutus unedo*** | Strawberry Tree | | v | | v |
| ***Aristotelia serrata*** | Makomako | | | | v |
| ***Arundinaria* (cultivars) (except those in List 2)** | Ornamental Bamboos | | | v | |
| ***Arundinaria hindsii*** | Kanzan-Chiku | | | | v |
| ***Arundinaria japonica*** | Metake | | | | v |
| ***Arundinaria linearis*** | Narrow-leaf Bamboo | | | | v |
| ***Arundo donax*** | Danubian Reed | | | | v |

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|---|---|---|---|---|---|
| ***Atriplex species*** | Saltbush | | | v | |
| ***Azara lanceolata*** | | | | | v |
| ***Azara microphylla*** | Box-leaf Azara | | | | v |
| ***Baccharis halimifolia*** | | | | | v |
| ***Bambusa multiplex*** | Hedge Bamboo | | | | v |
| ***Banksia ashbyi*** | Ashby's Banksia | | | | v |
| ***Banksia baueri*** | Possum Banksia | | | | v |
| ***Banksia baxteri*** | Birds-nest Banksia | | | | v |
| ***Banksia brownii*** | Brown's Banksia | | | | v |
| ***Banksia burdettii*** | Burdett's Banksia | | | | v |
| ***Banksia caleyi*** | Caley's Banksia | | | v | |
| ***Banksia collina*** | Hill Banksia | | | | v |
| ***Banksia dryandroides*** | Dryandra-leaved Banksia | | | v | |
| ***Banksia hookeriana*** | Hooker's Banksia | | | v | |
| ***Banksia media*** | Golden Stalk | | | | v |
| ***Banksia nutans*** | Nodding Banksia | | | v | |
| ***Banksia ornata*** | Desert Banksia | | | v | |
| ***Banksia speciosa*** | Showy Banksia | | | | v |
| ***Banksia sphaerocarpa*** | Round-fruited Banksia | | | v | |
| ***Bauhinia carronii*** | Queensland Bean or Ebony Tree | | v | | |
| ***Bauhinia species*** | eg Orchid Tree | | | | v |
| ***Bauhinia variegata*** **and forms** | Orchid Tree, Bauhinia | v | | | |
| ***Beaufortia sparsa*** | Swamp Bottlebrush | | | v | |
| ***Berberis species*** | Barberry, Berberis | | v | | |
| ***Betula pendula (B. alba)*** | Silver Birch | | v | | |
| ***Betula pendula 'Youngii'*** | Weeping Birch | | | | v |
| ***Boronia muelleri*** | Tree Boronia | | | | v |
| ***Boronia species*** **(except** ***B. muelleri)*** | | | | v | |
| ***Brachychiton acerifolium*** | Flame Tree | | v | | |
| ***Brachychiton acerifolium x populneum (B. Hydridum)*** | Hybrid Flame Tree | | v | | |
| ***Brachychiton discolor*** | Queensland Lace Bark | | v | | |
| ***Brachychiton populneum*** | Kurrajong | | v | | |
| ***Brachyglottis repanda 'Purpurea'*** | | | | | v |
| ***Brahea armata*** | Blue Palm | | | | v |
| ***Buddleja colvilei*** | | | | | v |
| ***Buddleja davidii*** | Butterfly Bush | | | | v |
| ***Buddleja madagascariensis*** | | | | | v |
| ***Butia capitata*** | Wine Palm | | | | v |
| ***Butia yatay*** | | | | | v |
| ***Buxus sempervirens*** **(cultivars)** | | | | v | |
| ***Calliandra portoricensis*** | | | | | v |
| ***Callistemon "Harkness"*** | Gawler Hybrid Bottlebrush | v | | | |
| ***Callistemon 'Burgundy'*** | | | | | v |
| ***Callistemon cirtrinus (C. Lanceolatus)*** | Crimson Bottlebrush | v | | | |

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|---|---|---|---|---|---|
| ***Callistemon citrinus*** | Red Bottlebrush | | | | v |
| ***Callistemon 'Harkness'*** | | | | | v |
| ***Callistemon lilacinus (C. violaceus)*** | Lilac Bottlebrush | v | | | |
| ***Callistemon macropunctatus (C. rugulosus)*** | S.A. Red Bottlebrush | v | | | |
| ***Callistemon phoeniceus*** | Fiery Bottlebrush | v | | | v |
| ***Callistemon polandii*** | | | | | v |
| ***Callistemon rigidus*** | Stiff-leaved Bottlebrush | v | | | v |
| ***Callistemon salignus*** | Willow Bottlebrush | v | | | |
| ***Callistemon species* (except those in List 2 and *C. salignus)*** | Bottlebrush | | | v | |
| ***Callistemon viminalis*** | Weeping Bottlebrush | v | | | v |
| ***Callitris columellaris*** | White Cypress Pine | | v | | |
| ***Callitris drummondii*** | | | | | v |
| ***Callitris oblonga*** | Tasmanian Cypress Pine | | | | v |
| ***Callitris preissii*** | Slender Cypress Pine | | v | | |
| ***Callitris verrucosa*** | Mallee Pine | | | | v |
| ***Calothamnus aspera*** | Rough-leaved Net Bush | v | | | |
| ***Calothamnus* species** | Netbush | | | v | |
| ***Calpurnia aurea*** | African Laburnum | | | | v |
| ***Calytrix* species** | eg Snow Myrtle, Fringe Myrtle | | | v | |
| ***Camellia sasanqua*** | | | | v | |
| ***Camellia* species** | Camellias | | | | v |
| ***Carissa bispinosa*** | | | | v | |
| ***Carissa grandiflora*** | Natal Plum | | | v | |
| ***Caryota mitis*** | Fish Tail Palm | | | | v |
| ***Casuarina cristata*** | Black Oak, Belah | | v | | |
| ***Casuarina stricta*** | Weeping Sheoak | | v | | |
| ***Casuarina torulosa*** | Rose Sheoak | | v | | |
| ***Ceanothus* species** | Californian Lilac | v | | | v |
| ***Celtis australis*** | Southern Hackberry, Celtis | | v | | |
| ***Celtis occidentalis*** | American Hackberry, Celtis | | v | | |
| ***Cephalotaxus harringtonia*** | Japanese Plum-Yew | | | v | |
| ***Cercis siliquastrum*** | Judas Tree | | v | | |
| ***Chamaecyparis lawsoniana 'Allumii'*** | | | | | v |
| ***Chamaecyparis lawsoniana 'Darleyensis'*** | | | | | v |
| ***Chamaecyparis lawsoniana 'Ellwoodii'*** | | | | v | |
| ***Chamaecyparis lawsoniana 'Fletcheri'*** | | | | | v |
| ***Chamaecyparis lawsoniana 'Lutea'*** | Golden Lawson Cypress | | | | v |
| ***Chamaecyparis lawsoniana 'Olbrichi'*** | | | | v | |
| ***Chamaecyparis lawsoniana 'Pottenii'*** | | | | v | |
| ***Chamaecyparis lawsoniana 'Stewartii'*** | | | | | v |

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|---|---|---|---|---|---|
| ***Chamaecyparis lawsoniana 'Tamariscifolia'*** | | | | v | |
| ***Chamaecyparis lawsoniana 'Westermanii'*** | | | | | v |
| ***Chamaecyparis obtusa* (except dwarf cultivars)** | | | | | v |
| ***Chamaecyparis obtusa 'Aurea'* (and other dwarf cultivars)** | | | | v | |
| ***Chamaecyparis pisifera 'Argentea'*** | | | | | v |
| ***Chamaecyparis pisifera 'Filifera'* (and other dwarf cultivars)** | | | | v | |
| ***Chamaecyparis pisifera 'Squarrosa'*** | | | | | v |
| ***Chamaecyparis thyoides 'Glauca'*** | | | | | v |
| ***Chamaecytisus proliferus*** | False Tree Lucerne | | | | v |
| ***Chamaerops humilis*** | Mediterranean Palm | | | v | |
| ***Chamelaucium species*** | Esperance Wax | | | v | |
| ***Chamelaucium uncinatum*** | Geraldton Wax | | | | v |
| ***Chionanthus retusa*** | | | | | v |
| ***Citharexylum fruticosum*** | Florida Fiddlewood | | | | v |
| ***Citharexylum species*** | Fiddlewood | | v | | |
| ***Citriobatus pauciflorus*** | | | | v | |
| ***Citrus aurantifolia*** | Sweet Lime | | | | v |
| ***Citrus limon*** | Wild Lemon | | | | v |
| ***Citrus limon 'Variegata'*** | Variegated Lemon | | | v | |
| ***Citrus medica*** | Citron | | | | v |
| ***Citrus reticulata*** | Mandarin Orange | | | | v |
| ***Colletia paradoxa*** | | | | v | |
| ***Coprosma repens*** | Mirror Bush | | | v | |
| ***Cordyline stricta*** | Erect Palm-Lily | | | v | |
| ***Cordyline terminalis*** | Ti-Port | | | | v |
| ***Cornus mas*** | | | | | v |
| ***Corokia macrocarpa*** | | | | | v |
| ***Cortaderia rudiuscula*** | N.Z. Pink Pampass-Grass | | | v | |
| ***Corylus avellana*** | European Hazelnut | | | | v |
| ***Corymbia ficifolia* 'Dwarf'** | 'Summertime' Grafted Red Flowering Gum | | | | v |
| ***Cotinus coggygria*** | Smoke Tree | | | | v |
| ***Cotinus obovatus*** | | | | | v |
| ***Cotoneaster 'Cornubia'*** | | | | | v |
| ***Cotoneaster Frigida*** | Himalayan Cotoneaster | v | | v | |
| ***Cotoneaster glaucophyllus (C. serotinus)*** | | | | | v |
| ***Cotoneaster serotina*** | Cotoneaster | | v | | |
| ***Cotoneaster 'Watereri'*** | | | | | v |
| ***Crataegus chrysocarpa*** | | | | | v |
| ***Crataegus coccineoides*** | Kansas Hawthorn | | | | v |
| ***Crataegus crus-galli*** | Cockspur Thorn | | | | v |

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|---|---|---|---|---|---|
| ***Crataegus durobrivensis*** | | | | | v |
| ***Crataegus ellwangeriana*** | | | | | v |
| ***Crataegus lavallei (C. carrieri)*** | Lavalle Hawthorn | v | | | |
| ***Crataegus orientalis*** | Silver Hawthorn | | | | v |
| ***Crataegus oxyacantha*** **and forms** | Hawthorn, May Tree | v | | | |
| ***Crataegus phaenopyrum*** | Washington Thorn | v | | | v |
| ***Crataegus pinnatifida*** **var. major** | | | | | v |
| ***Crataegus prunifolia*** | Plumleaf Hawthorn | | | | v |
| ***Crataegus pubescens (C. mexicana)*** | Mexican Hawthorn | v | | | |
| ***Crataegus x grignonensis*** | | | | | v |
| ***Crataegus x lavallei*** | French Hawthorn | | | | v |
| ***Crinodendron hookeranum*** | Red Lantern Tree | | | | v |
| ***Cupressus glabra*** | Arizona Cypress | | v | | |
| ***Cupressus glabra 'Hodginsii'*** | | | | | v |
| ***Cussonia spicata*** | | | | | v |
| ***Cuttsia viburnea*** | | | | | v |
| ***Cycas media*** | Baveu | | | | v |
| ***Cycas revoluta*** | Sago-Plum | | | v | |
| ***Cyperus papyrus*** | Papyrus | | | v | |
| ***Cyphomandra betacea*** | Tree Tomato | | | v | |
| ***Cytisus battandieri*** | | | | | v |
| ***Cytisus multiflorus*** | | | | | v |
| ***Cytisus species*** **(except those in List 2 and** ***C. scoparius)*** | | | | v | |
| ***Dahlia imperialis*** | | | | v | |
| ***Dais cotinifolia*** | Pompon Tree | | | | v |
| ***Datura arborea*** | | | | | v |
| ***Datura cornigera (Brugmansia knightii)*** | | | | v | |
| ***Datura sanguinea*** | | | | v | |
| ***Datura suaveolens (Burgmansia)*** | Angels Trumpet | | | | v |
| ***Deutzia species*** | | | | v | |
| ***Dicksonia antarctica*** | Soft Tree-Fern | | | | v |
| ***Dodonaea species*** **(except** ***D. viscosa)*** | Hop Bushes | | | v | |
| ***Dodonea viscosa*** | Hop Bush | | | | v |
| ***Dombeya natalensis*** | | | | v | |
| ***Dombeya tiliacea*** | | | | v | |
| ***Doryanthes species*** | Spear Lily | | | v | |
| ***Dracaena species*** | eg Dragon Tree | | | | v |
| ***Dracaena umbraculifera*** | | | | v | |
| ***Dryandra formosa*** | | | | | v |
| ***Duboisia hopwoodii*** | Pituri | | | v | |
| ***Duranta repens*** | Sky Flower, Duranta | v | | | |
| ***Duranta species*** | Sky Flower | | | | v |
| ***Elaeagnus species*** | Russian Olive | | | | v |
| ***Elaeodendron australe*** | Scarlet Olive-Wood | | | | v |

Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines protocol

| | | | | | |
|---|---|---|---|---|---|
| ***Entelea arborescens*** | Whau | | | | v |
| ***Eremophila fraseri*** | Turpentine Bush | | | v | |
| ***Eremophila mackinlayi*** | Desert Pride | | | v | |
| ***Eremophila maculata*** | Spotted Emu Bush | | | v | |
| ***Eremophila species*** | Emu Bush | | | | v |
| ***Erica arborea*** | Tree Heath | | | | v |
| ***Erica species (except E. arborea)*** | Heath | | | v | |
| ***Eriostemon species*** | Native Daphne, Waxflower | | | v | |
| ***Erythrina "Indica"*** | Hybrid Indian Coral Tree | | v | | |
| ***Erythrina acanthocarpa*** | Tambookie Thorn Tree | | | v | |
| ***Erythrina 'Blakei'*** | Coral Tree | | | v | |
| ***Erythrina fusca*** | | | | | v |
| ***Erythrina hendersonii*** | | | | v | |
| ***Erythrina humeana*** | Coral Tree | | | | v |
| ***Erythrina parcellii*** | Variegated Coral Tree | | | | v |
| ***Erythrina phlebocarpa*** | Veined-pod Coral Tree | | | | v |
| ***Erythrina senegalensis*** | | | | | v |
| ***Erythrina speciosa*** | | | | | v |
| ***Erythrina x bidwillii*** | | | | | v |
| ***Escallonia 'C F Ball'*** | | | | v | |
| ***Escallonia 'Edinburgh'*** | | | | v | |
| ***Escallonia 'Fretheyi'*** | | | | v | |
| ***Escallonia 'Iveyi'*** | | | | v | |
| ***Escallonia macrantha*** | | | | v | |
| ***Escallonia 'Slieve Donard'*** | | | | v | |
| ***Escallonia species*** | | | | | v |
| ***Escallonia x langleyensis*** | | | | v | |
| ***Eucalyptus "Augusta Wonder"*** | | v | | | |
| ***Eucalyptus "Ericoides"*** | | | v | | |
| ***Eucalyptus "Pterocarpa"*** | | | v | | |
| ***Eucalyptus "Torwood"*** | Hybrid Coral gum | | v | | |
| ***Eucalyptus "Urrbrae Gum"*** | | | v | | |
| ***Eucalyptus angulosa*** | Ridge Fruited Mallee | | | | v |
| ***Eucalyptus behriana*** | Broad-leaved Box | | v | | |
| ***Eucalyptus brachycalyx*** | Gilja or Chindoo Mallee | | | | v |
| ***Eucalyptus caesia*** | Gungunnu | v | | | |
| ***Eucalyptus caesia 'Silver Princess'*** | | | | | v |
| ***Eucalyptus calycogona*** | Square-fruited Mallee | v | | | |
| ***Eucalyptus calycogona 'Jubilee'*** | Jubilee Gum | | | | v |
| ***Eucalyptus campaspe*** | Silver Gimlet | | v | | |
| ***Eucalyptus Cinerea*** | Mealy Stringybark, Argyle Apple | | v | | |
| ***Eucalyptus cneorifolia*** | Kangaroo Island Narrow-leaved Gum | | v | | |
| ***Eucalyptus conglobata*** | S.A. Coastal Gum | | v | | |
| ***Eucalyptus cosmophylla*** | Cup Gum | v | | | v |
| ***Eucalyptus crucis*** | Southern Cross Mallee | v | | | v |

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|---|---|---|---|---|---|
| ***Eucalyptus decipiens*** | Limestone Marlock | | | | v |
| ***Eucalyptus dielsii*** | Cap-fruited Mallee | v | | | v |
| ***Eucalyptus diversifolia*** | S.A. Coastal Mallee | v | | | |
| ***Eucalyptus dumosa*** | White Mallee | | | | v |
| ***Eucalyptus dundasii*** | Dundas Blackbutt | | v | | |
| ***Eucalyptus eremophila*** | Tall Sand Mallee | v | | | |
| ***Eucalyptus erythrocorys*** | Red-capped Gum | v | | | |
| ***Eucalyptus erythronema*** | Lindsay Gum | v | | | v |
| ***Eucalyptus Ficifolia*** | W.A. Scarlet Flowering Gum | | v | | |
| ***Eucalyptus flocktoniae*** | Merrit | | v | | |
| ***Eucalyptus foecunda (E. lepto-phylla)*** | Slender-leaved Mallee | v | | | |
| ***Eucalyptus forrestiana*** | Fuchsia Gum | v | | | v |
| ***Eucalyptus gardneri*** | Blue Mallett | | v | | |
| ***Eucalyptus gillii*** | Curly Mallee | | | | v |
| ***Eucalyptus gracilis*** | Yorrell | | v | | |
| ***Eucalyptus grossa*** | Coarse-leaved Mallee | | | | v |
| ***Eucalyptus incrassata*** | Ridge-fruited Mallee | | v | | |
| ***Eucalyptus intertexta*** | Smooth-barked Coolibah | | v | | |
| ***Eucalyptus kingsmillii*** | Kingsmill Mallee | | | | v |
| ***Eucalyptus kruseana*** | Bookleaf Mallee | | | v | |
| ***Eucalyptus lansdowneana*** | Pt. Lincoln Gum & Crimson Mallee | | v | | v |
| ***Eucalyptus lansdowneana albopurpurea*** | Port Lincoln Gum | | | | v |
| ***Eucalyptus lansdowneana lansdowneana*** | Crimson Mallee | | | | v |
| ***Eucalyptus le souefii*** | Le Souef's Blackbutt | | v | | |
| ***Eucalyptus lehmanni*** | Bushy Yate | | v | | |
| ***Eucalyptus leucoxylon "Rosea"*** | Pink-flowering Blue Gum | | v | | |
| ***Eucalyptus leucoxylon 'Magnet'*** | 'Euky Dwarf' | | | | v |
| ***Eucalyptus macrandra*** | Longflowered Marlock | | | | v |
| ***Eucalyptus macrocarpa*** | Mottlecah | | | | v |
| ***Eucalyptus megacornuta*** | Warty Yate | | v | | |
| ***Eucalyptus nutans*** | Red-flowered Moort | | v | v | |
| ***Eucalyptus oleosa*** | Red Mallee | | v | | |
| ***Eucalyptus orbifolia*** | Round-leaved Mallee | v | | | v |
| ***Eucalyptus pachyphylla*** | Thick—leaved Mallee | | | v | |
| ***Eucalyptus pauciflora 'Frosty'*** | Edna Walling 'Little Snowman' | | | | v |
| ***Eucalyptus pileata*** | Ravensthorpe Mallee | | v | | |
| ***Eucalyptus platypus*** | Round-leaved Moort | | v | | |
| ***Eucalyptus preissiana*** | Bell-fruited Mallee | v | | v | |
| ***Eucalyptus pulverulenta*** | Silver-leaved Mountain Gum | | v | | |
| ***Eucalyptus pyriformis* (not *E.p.youngiana)*** | Pear-fruited Mallee | | | | v |
| ***Eucalyptus pyriformis* subspecies *youngiana*** | Ooldea Mallee | v | | | |
| ***Eucalyptus redunca*** | Black Marlock | | | | v |
| ***Eucalyptus rhodantha*** | Rose Mallee | v | | v | |
| ***Eucalyptus rugosa*** | Kingscote Mallee | v | | | v |

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|---|---|---|---|---|---|
| ***Eucalyptus salubris*** | Gimlet Gum | | v | | |
| ***Eucalyptus sargentii*** | Salt or Sargent's Mallet | | v | | |
| ***Eucalyptus sideroxylon*** | Manna Red Ironbark, Mugga | | v | | |
| ***Eucalyptus socialis*** | Red Mallee, Morrel | v | | | |
| ***Eucalyptus spathulata*** | Swamp Mallee | | v | | |
| ***Eucalyptus steedmanii*** | Steedman's Gum | | v | | |
| ***Eucalyptus stoatei*** | Scarlet Pear Gum | v | | | v |
| ***Eucalyptus stricklandii*** | Yellow-flowering Gum | | v | | |
| ***Eucalyptus tetragona*** | Tallerack | | | | v |
| ***Eucalyptus tetraptera*** | Four-winged Mallee | v | | | v |
| ***Eucalyptus torquata*** | Coral or Coolgardie Gum | | v | | |
| ***Eucalyptus viridis*** | Green Mallee | | v | | v |
| ***Eucalyptus websterana*** | Webster's Mallee | v | | | v |
| ***Eucalyptus woodwardii*** | Lemon-flowering Gum | | v | | |
| ***Eucryphia glutinosa*** | | | | | v |
| ***Eugenia aggregata*** | Rio Grande Cherry | | | | v |
| ***Eugenia smithii (Acmena smithii)*** | Lilly Pilly | | v | | |
| ***Eugenia uniflora*** | Surinam Cherry | | | | v |
| ***Euonymus alata*** | Cork Tree | | | v | |
| ***Euonymus fortunei*** | Spindle Tree | | | | v |
| ***Euonymus hamiltoniana*** **var** ***yedeonsis*** | | | | v | |
| ***Euonymus japonicus*** | Evergreen Spindle Tree | v | | | v |
| ***Euonymus latifolia*** | | | | | v |
| ***Euonymus pendula*** | | | | | v |
| ***Euphorbia species*** **(except** ***E. candelabra)*** | | | | v | |
| ***Eupomatia laurina*** | Copper Laurel | | | | v |
| ***Exochorda*** **species** | Pearl Bush | | | | v |
| ***Feijoa sellowiana*** **and forms** | Pineapple Guava | v | | | v |
| ***Ficus rubiginosa "Variegata"*** | Variegated Rusty Fig | | v | | |
| ***Fortunella*** **species** | Cumquat | | | v | |
| ***Fraxinus excelsior "Aurea"*** | Golden Ash | | v | | |
| ***Fraxinus ornus*** | Manna Ash | | v | | v |
| ***Fraxinus 'Raywood'*** **on ornus root stock** | Dwarf Claret Ash | | | | v |
| ***Fremontodendron californicum*** | Flannel Bush | | | | v |
| ***Garrya elliptica*** | | | | | v |
| ***Gastrolobium bilobum*** | Poison Pea | | | | v |
| ***Geijera linearifolia*** | Sheep Bush | | | v | |
| ***Geijera parviflora*** | Wilga | v | | | v |
| ***Genista aethnensis*** | Mt. Etna Broom | | | | v |
| ***Genista species*** **(except** ***G. aethnensis, G. virgata*** **and** ***G. monspessulanus)*** | | | | v | |
| ***Goodia lotifolia*** | Golden Tip | | | v | |
| ***Gordonia axillaris*** | | | | v | |
| ***Gossypium barbadense*** | Sea Island Cotton | | | v | |
| ***Grevillea nematophylla*** | Silver Leaved Water Bush | | | | v |

Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines protocol

| | | | | | |
|---|---|---|---|---|---|
| ***Grevillea species (*****except those in List 2 and *****G. robusta, G. hilliana*** **and** ***G. striata)*** | | | | v | |
| ***Hakea elliptica*** | Oval-leaved Hakea | v | | | |
| ***Hakea francisiana*** | Bottlebrush Hakea | | | v | |
| ***Hakea kippistiana*** | | | v | | |
| ***Hakea laurina*** | Pincushion Hakea | v | | | |
| ***Hakea leucoptera*** | Needle Bush | | | v | |
| ***Hakea muelleriana*** | Muller's Hakea | | | v | |
| ***Hakea nodosa*** | Yellow Hakea | | | v | |
| ***Hakea orthorrhyncha*** | | | | v | |
| ***Hakea petiolaris*** | Broad-leaf Sea Urchin | v | | | |
| ***Hakea salicifolia (H. saligna)*** | Willow Hakea | v | | | |
| ***Hakea sericea*** | Silky Hakea | | | v | |
| ***Hakea*** **species** | eg Oval-leaved Hakea | | | | v |
| ***Hakea suaveolens*** | Sweet Hakea | | v | | |
| ***Hakea sulcata*** | Furrowed Hakea | v | | v | |
| ***Hakea undulata*** | Wavy-leaved Hakea | v | | v | |
| ***Hamamelis*** **species** | eg Witch Hazel | | | | v |
| ***Harpephyllum caffrum*** | Kaffir Plum | | v | | |
| ***Hebe diosmaefolia*** | | | | | v |
| ***Hedycarya angustifolia*** | Austral Mulberry | | | | v |
| ***Hesperoyucca whipplei*** | | | | v | |
| ***Hibbertia*** **species** | Guinea Flower | | | v | |
| ***Hibiscus*** **species** | Hibiscus | v | | v | |
| ***Hoheria lyallii*** | Ribbonwood | | | | v |
| ***Homalanthus populifolius*** | Queenslander Poplar, Bleeding-Heart Tree | v | | | |
| ***Hovea species*** | | | | v | |
| ***Hovenia dulcis*** | Japanese Raisin Tree | | | | v |
| ***Howea belmoreana*** | Curly Palm | | | | v |
| ***Howea forsterana*** | Kentia Palm | | | | v |
| ***Howittea trilocularis*** | Native Hibiscus | | | v | |
| ***Hydrangea*** **species** | | | | v | |
| ***Hymenosporum flavum*** | Woolum, Native Frangipani | | v | | |
| ***Ilex cornuta*** | Chinese Holly | | | v | |
| ***Ilex crenata*** | Japanese Holly | | | | v |
| ***Ilex paraguariensis*** | Paraguay Tree | | | | v |
| ***Ilex purpurea*** | Java Holly | | | | v |
| ***Ilex verticillata*** | Black Alder | | | v | |
| ***Illicium anisatum*** | Japanese Staranise | | | | v |
| ***Illicium floridanum*** | Purple Anise | | | v | |
| ***Indigoferaspecies*** | | | | v | |
| ***Itea ilicifolia*** | | | | | v |
| ***J. x media (hybrids)*** | | | | v | |
| ***Jacaranda*** **species** | Jacaranda | | v | | |
| ***Jasminum fruticans*** | | | | v | |
| ***Jasminum mesnyi*** | Primrose Jasmin | | | | v |

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|---|---|---|---|---|---|
| ***Jasminum multiflorum*** | Hairy Jasmine | | | v | |
| ***Jasminum nudiflorum*** | Winter Jasmin | | | | v |
| ***Juniperus chinensis 'Aurea'*** | Golden Chinese Juniper | | | | v |
| ***Juniperus communis 'Hibernica'*** | Irish Juniper | | | v | |
| ***Juniperus communis var. suecica*** | Swedish Juniper | | | | v |
| ***Juniperus sabina*** | Savin Juniper | | | v | |
| ***Juniperus sheppardii var. pyramidalis ("J.africans")*** | Juniper | | v | | |
| ***Kalmia latifolia*** | Calico Bush | | | v | |
| ***Kerria japonica*** | | | | v | |
| ***Koelreuteria paniculata*** | Golden Rain Tree | | v | | v |
| ***Kolkwitzia amabilis*** | Beauty Bush | | | v | |
| ***Kunzea ambigua*** | White Kunzea | | | | v |
| ***Kunzea* species (except *K. ambigua)*** | | | | v | |
| ***Laburnum species*** | Laburnum | | v | | v |
| ***Lagerstoemia indica all varieties*** | Crepe Myrtle | | | | v |
| ***Lagerstroemia "Eavesii"*** | Mauve Crepe-Myrtle | v | | | |
| ***Lagerstroemia indica*** | Pink Crepe-Myrtle | v | | | |
| ***Lagunaria patersonii*** | Pyramid Tree | | v | | |
| ***Lantana camara*** | Common Lantana | | | | v |
| ***Lantana camara 'cultivars' (except Common Lantana)*** | | | | v | |
| ***Lavatera* species** | | | | v | |
| ***Lawsonia inermis*** | Henna | | | | v |
| ***Leptospermum laevigatum*** | Victoria Coastal Tea Tree | v | | | |
| ***Leptospermum nitidum 'Copper Sheen'*** | | | | v | |
| ***Leptospermum rotundifolium*** | | | | v | |
| ***Leptospermum scoparium* (dwarf varieties)** | | | | v | |
| ***Leptospermum sericeum*** | Silver Tea Tree | | | v | |
| ***Leptospermum* species** | Tea Tree | | | | v |
| ***Leptospermum squarrosum*** | Pink Tea Tree | | | v | |
| ***Leucadendron argenteum*** | Silver Tree | | | | v |
| ***Leucadendron salignum*** | | | | v | |
| ***Leucopogon parviflorus*** | Coast Beard-Heath | | | | v |
| ***Ligastrum ovalifolium 'Aureum'*** | Golden Hedge Privet | | | v | |
| ***Ligustrum amurense*** | Amur Privet | | | v | |
| ***Ligustrum delavayanum*** | | | | v | |
| ***Ligustrum japonicum* and forms** | Japanese Tree Privet | | v | | v |
| ***Ligustrum japonicum* var. *rotundifolium*** | | | | v | |
| ***Ligustrum japonicum 'Variegatum'*** | | | | | v |
| ***Ligustrum ludidum* and forms** | Glossy Privet | | v | | v |
| ***Ligustrum ovalifolium*** | Californian Privet | | | | v |
| ***Ligustrum sinense*** | Chinese Privet | | | | v |
| ***Ligustrum undulatum*** | New Guinea Privet | | | v | |

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|---|---|---|---|---|---|
| ***Ligustrum vulgare*** | European Privet | | | v | |
| ***Linospadix monostachus*** | Walking-stick Palm | | | v | |
| ***Liquidambar styraciflua*** | Liquidambar | | v | | |
| ***Livistona chinensis*** | | | | | v |
| ***Lonicera*** **species** | Honeysuckle | | | v | |
| ***Lophomyrtus bullata*** | Ramarama | | | | v |
| ***Lophomyrtus obcordata*** | | | | | v |
| ***Luculia grandifolia*** | | | | | v |
| ***Macrozamia*** **species** | eg Pineapple Palm | | | v | |
| ***Magnolia liliiflora*** | | | | | v |
| ***Magnolia salicifolia*** | | | | | v |
| ***Magnolia sieboldii*** | | | | | v |
| ***Magnolia stellata*** | Star Magnolia | | | v | |
| ***Magnolia x soulangeana (cultivars)*** | Saucer Magnolia | | | | v |
| ***Mahonia lomariifolia*** | | | | | v |
| ***Maireana*** **species *(Syn. Kochia)*** | eg Blue Bush | | | v | |
| ***Malus 'Aldenhamensis'*** | | | | | v |
| ***Malus angustifolia*** | | | | | v |
| ***Malus 'Echtermeyer'*** | | | | v | |
| ***Malus 'Gorgeous'*** | | | | v | |
| ***Malus halliana 'Parkmanii'*** | | | | | v |
| ***Malus ioensis 'Plena'*** | Bechtel Crab | | | | v |
| ***Malus 'John Downie'*** | | | | | v |
| ***Malus 'Robert Nairn'*** | | | | | v |
| ***Malus sargentii*** | | | | v | |
| ***Malus sieboldii*** | Toringo Crab | | | | v |
| ***Malus*** **species** | Flowering Crabs and Apples | v | | | |
| ***Malus 'Veitch's Scarlet'*** | | | | | v |
| ***Malus x atrosanguinea*** | Red Japanese Crab Apple | | | | v |
| ***Malvaviscus arboreus*** | | | | v | |
| ***Maytenus boaria*** | | | | | v |
| ***Melaleuca acuminata*** | Mallee Honey Myrtle | | | | v |
| ***Melaleuca alternifolia*** | | | v | | v |
| ***Melaleuca armillaris*** | Bracelet Honey Myrtle | | v | | |
| ***Melaleuca bracteata*** | White Cloud Tree | | | | v |
| ***Melaleuca brevifolia*** | White-flowered Paperbark | | | v | |
| ***Melaleuca coccinea*** | Goldfield's Bottlebrush | | | v | |
| ***Melaleuca decussata*** | | | | v | |
| ***Melaleuca diosmifolia*** | | | | | v |
| ***Melaleuca elachophylla*** | | | | v | |
| ***Melaleuca elliptica*** | Granite Honey Myrtle | v | | v | |
| ***Melaleuca ericifolia*** | Swamp Paperbark | | | | v |
| ***Melaleuca fulgens*** | Scarlet Honey Myrtle | v | | v | |
| ***Melaleuca gibbosa*** | | | | v | |
| ***Melaleuca glomerata*** | Inland Paperbark | | | | v |
| ***Melaleuca Glomerata*** | | v | | | |

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|---|---|---|---|---|---|
| ***Melaleuca halmaturorum*** | Coastal Paperbark | | v | | v |
| ***Melaleuca hamulosa*** | | | | v | |
| ***Melaleuca huegelii*** | Chenile Honey Myrtle | | v | | v |
| ***Melaleuca hypericifolia*** | Hillock Honey Myrtle | v | | v | |
| ***Melaleuca incana*** | Yellow-Flowered Grey Honey Myrtle | v | | v | |
| ***Melaleuca Lanceloata (M. pubescens)*** | Dry Land Tea Tree | | v | | |
| ***Melaleuca lateritia*** | Robin Redbreast Bush | v | | v | |
| ***Melaleuca linariifolia*** | Flax-leaved Honey Myrtle | | v | | |
| ***Melaleuca megacephala*** | | | | v | |
| ***Melaleuca micromera*** | | | | v | |
| ***Melaleuca microphylla*** | | | | v | |
| ***Melaleuca nematophylla*** | Wiry Honey Myrtle | | | v | |
| ***Melaleuca nesophila*** | Western Honey Myrtle | v | | | v |
| ***Melaleuca oraria*** | White-flowered Paperbark | | | v | |
| ***Melaleuca pentagona*** | | v | | v | |
| ***Melaleuca preissiana*** | | | | | v |
| ***Melaleuca pulchella*** | Claw Flower | | | v | |
| ***Melaleuca quadrifaria*** | Limestone Honey Myrtle | | | v | |
| ***Melaleuca radula*** | | v | | v | |
| ***Melaleuca scabra*** | Rough Honey Myrtle | | | v | |
| ***Melaleuca spathulata*** | | | | v | |
| ***Melaleuca squamea*** | | v | | v | |
| ***Melaleuca steedmanii*** | Steedman's Honey Myrtle | | | v | |
| ***Melaleuca styphelioides*** | Prickly Paperbark | | v | | |
| ***Melaleuca thymifolia*** | Thyme Honey Myrtle | | | v | |
| ***Melaleuca trichophylla*** | | | | v | |
| ***Melaleuca uncinata*** | Broombush Honey Myrtle | | | v | |
| ***Melaleuca wilsonii*** | Wilson's Honey Myrtle | | | v | |
| ***Melia axedarach*** | White Cedar | | v | | |
| ***Meryta sinclairii*** | | | | | v |
| ***Mespilus germanica*** | Medlar | | | | v |
| ***Metrosideros excelsa (M. tomentosa)*** | New Zealand Christmas Tree | | v | | |
| ***Michelia figo*** | Port Wine Magnolia | | | v | |
| ***Microcitrus australasica*** | Native Finger-Lime | | | | v |
| ***Mirbelia* species** | | | | v | |
| ***Miscanthus sinensis*** | | | | v | |
| ***Montanoa* species** | eg Mexican Tree Daisy | | | v | |
| ***Murraya paniculata*** | | | | v | |
| ***Musa basjoo*** | | | | | v |
| ***Myoporum acuminatum (syn.M.montanum)*** | Water Bush | | | | v |
| ***Myoporum floribundum*** | | | | v | |
| ***Myoporum insulare*** | Boobialla | | v | | v |
| ***Myoporum laetum*** | Ngaio | | | | v |
| ***Myoproum montanum*** | Water Bush | | v | | |
| ***Myrsine australis*** | Mapou | | | | v |

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|---|---|---|---|---|---|
| ***Myrtus* species** | eg Common Myrtle | | | | v |
| ***Neopanax arboreus*** | Five-Fingers | | | | v |
| ***Neopanax colensoi*** | Orihou | | | | v |
| ***Nerium oleander*** | Oleander | | v | | v |
| ***Nolina recurvata*** | | | | v | |
| ***Ochlandra maculata*** | Mottled Bamboo | | | | v |
| ***Olearia species*** | Daisy Bush | | | v | |
| ***Omalanthus populifolius*** | Queensland Poplar | | | | v |
| ***Osmanthus aurantiacus*** | | | | v | |
| ***Osmanthus 'Fortunei'*** | | | | v | |
| ***Osmanthus heterophyllus (varieties except 'Ilicifolius')*** | | | | v | |
| ***Osmanthus* species** | | | | | v |
| ***Oxydendrum arboreum*** | Sourwood | | | | v |
| ***Parkinsonia aculeata*** | Jerusalem Thorn | | v | | |
| ***Parrotia persica*** | Persian Witch Hazel | | | | v |
| ***Philadelphus* species** | | | | v | |
| ***Phormium tenax*** | N.Z. Flax | | | v | |
| ***Photinia beauverdiana*** | | | | | v |
| ***Photinia glabra*** | | | | | v |
| ***Photinia glabra 'Rubens'*** | Red-leaf Photinia | | | v | |
| ***Photinia 'Robusta'*** | | | | v | |
| ***Photinia serrulata*** | Chinese Hawthorn | v | | | |
| ***Photinia villosa*** | | | | | v |
| ***Phyllostachys castillonis*** | | | | | v |
| ***Phyllostachys nigra*** | Black Bamboo | | | | v |
| ***Phyllostachys pubescens*** | Noble Bamboo | | | | v |
| ***Picea glauca var. albertiana 'Conica'*** | | | | v | |
| ***Pimelea* species** | Rice Flower | | | v | |
| ***Pisonia umbellifera 'Variegata'*** | | | | | v |
| ***Pittosporum crassifolium and variegated form*** | Karo | v | | | v |
| ***Pittosporum eugeniodes 'Variegatum'*** | Silver Tarata | | | | v |
| ***Pittosporum phylliraeoides*** | Native Apricot, Weeping Pittosporum | v | | | v |
| ***Pittosporum ralphii*** | | | | | v |
| ***Pittosporum revolutum*** | Brisbane Laurel | | | | v |
| ***Pittosporum rhombifolium*** | Queensland Pittosporum | | v | | |
| ***Pittosporum tenuifolium*** | New Zealand Kohuhu | v | | | |
| ***Pittosporum tenuifolium "Pirpureum"*** | | v | | | |
| ***Pittosporum tobira*** | Tobira | | | | v |
| ***Pittosporum undulatum*** | Sweet Pittosporum | | v | | |
| ***Pittosporum undulatum "Variegatum"*** | Variegated Sweet Pittosporum | | v | | |
| ***Plumbago auriculata*** | | | | v | |
| ***Plumeria rubra*** | Frangipani | | | | v |
| ***Podocarpus lawrencei*** | Mountain Plum Pine | | | v | |
| ***Polygala species*** | | | | v | |

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|---|---|---|---|---|---|
| ***Polyscias balfouriana*** | | | | | v |
| ***Polyscias guilfoylei*** | Wild Coffee | | | | v |
| ***Pomaderris* species** | | | | | v |
| ***Poncirus trifoliata*** | | | | | v |
| ***Populus x pseudo-grandidentata*** | Weeping Large-tooth Aspen | | | | v |
| ***Prostanthera lasianthos*** | Victorian Christmas Bush | | | | v |
| ***Prostanthera* species** | Mint Bush | | | v | |
| ***Protea* species** | | | | v | |
| ***Prunus amygdalus*** | Almond | | | | v |
| ***Prunus avium 'Pendula'*** | Weeping Gean | | | v | |
| ***Prunus cerasifera 'Nigra'*** | | | | | v |
| ***Prunus cerasus*** | Kentish Cherry | | | | v |
| ***Prunus 'Elvins'*** | | | | | v |
| ***Prunus glandulosa 'Alboplena'*** | Bush Cherry | | | v | |
| ***Prunus ilicifolia*** | Islay | | | | v |
| ***Prunus incisa*** | Fuji Cherry | | | | v |
| ***Prunus japonica*** | Chinese Cherry | | | v | |
| ***Prunus lustianica*** | Portugal Laurel | | | | v |
| ***Prunus mume 'Alboplena'*** | Flowering Apricot | | | | v |
| ***Prunus mume 'Alphandii'*** | Flowering Apricot | | | | v |
| ***Prunus persica (cultivars)*** | Peach | | | | v |
| ***Prunus* species** | Flowering Almonds, Plums, Apricots, Cherries, Peaches | v | | | |
| ***Prunus spinosa 'Purpurea'*** | Purple-leaf Blackthorn | | | v | |
| ***Prunus tenella* var. *gesslerana*** | Dwarf Russian Almond | | | v | |
| ***Prunus triloba*** | Bush Almond | | | | v |
| ***Prunus triloba 'Plena'*** | | | | v | |
| ***Prunus x blireiana*** | Cherry-Plum | | | | v |
| ***Pseudocydonia oblonga*** | Quince | | | | v |
| ***Pseudocydonia sinensis*** | | | | | v |
| ***Psidium guajava*** | Common Guava | | | | v |
| ***Psidium littorale*** | Strawberry Guava | | | v | |
| ***Psoralea pinnata*** | | | | v | |
| ***Ptelea trifoliata*** | Hop-Tree | | | | v |
| ***Punica* species** | Pomegranate | | | | v |
| ***Pyracantha angustifolia*** | Orange Firethorn | | | v | |
| ***Pyracantha atalantioides*** | Firethorn | | | | v |
| ***Pyracantha coccinea*** | | | | v | |
| ***Pyracantha coccines "Lalandei"*** | Lalande Firethorn | v | | | |
| ***Pyracantha crenulata*** | Nepal Firethorn | v | | v | |
| ***Pyracantha fortuneana*** | | | | v | |
| ***Pyracantha rodgersiana*** | Yellow-Berry Firethorn | v | | | |
| ***Pyracantha rogersiana*** | | | | v | |
| ***Pyrus calleryana*** | Chinese Pear | | | | v |
| ***Pyrus salicifolia*** | Silver Pear | | | | v |
| ***Quercus ilex*** | Holm Oak | | v | | |

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|---|---|---|---|---|---|
| ***Rhamnus alaternus 'Argenteovariegata'*** | | | | v | |
| ***Rhaphiolepsis umbellata*** | | | | v | |
| ***Rhaphiolepsis x delacourii*** | | | | v | |
| ***Rhododendron*** **species** | | | | | v |
| ***Ribes*** **species** | Currant | | | v | |
| ***Robinia hillierii*** | | | | | v |
| ***Robinia kelseyi*** | | | | v | |
| ***Robinia pseudoacacia 'Umbraculisera'*** | Robinia Mop Top | | | | v |
| ***Sambucus nigra*** | European Elder | | | | v |
| ***Santalum*** **species** | | | | | v |
| ***Senna brewsteri*** | | | | | v |
| ***Senna species (except S. brewsteri)*** | eg Desert Cassia | | | v | |
| ***Sesbania grandiflora*** | Agati | | | | v |
| ***Sophora japonica*** | Pagoda Tree | | v | | |
| ***Sophora tetraptera*** | Yellow Kowhai | v | | | |
| ***Sorbus aucuparia*** | Rowan, Mountain Ash | | v | | |
| ***Sorbus vilmorinii*** | | | | | v |
| ***Sparmannia*** **species** | | | | v | |
| ***Spartium junceum*** | Spanish Broom | v | | | v |
| ***Stenolobium alatum (Tecoma smithii)*** | Winged Yellow-Trumpet | v | | | |
| ***Stenolobium stans (Tecoma stans)*** | Florida Yellow-Trumpet | v | | | v |
| ***Stewartia sinensis*** | | | | | v |
| ***Styrax japonica*** | Snowbell | | | | v |
| ***Syzygium Coolminianum*** | Blue Lilly Pilly | v | | | |
| ***Syzygium paniculatum*** | Brush Cherry | | v | | |
| ***Tamarix juniperina*** | Flowering Tamarisk | | v | | |
| ***Tamarix*** **species (except *T. aphylla)*** | | | | | v |
| ***Taxus baccata*** **'cultivars' (except Common Yew)** | | | | v | |
| ***Telopea mongaensis*** | | | | v | |
| ***Telopea species*** | eg Tasmanian Waratah | | | | v |
| ***Telopea speciosissima*** | | | | v | |
| ***Templetonia retusa*** | | | | v | |
| ***Thevetia peruviana*** | Lucky Nut | | | | v |
| ***Thryptomene species*** | | | | v | |
| ***Thuja orientalis*** **(cultivars)** | | | | | v |
| ***Thujopsis dolabrata 'Variegata'*** | | | | | v |
| ***Tieghemopanax sambucifolius*** | Elderberry Panax | | | | v |
| ***Tristania conferta*** | Brush Box | | v | | |
| ***Tristaniopsis laurina (Tristania laurina)*** | Water Gum | | | | v |
| ***Ulmus glabra 'Pendula'*** | Weeping Scotch Elm | | | | v |
| ***Viburnum tinus*** | Laurestinus | v | | v | |
| ***Virgilia divaricata*** | | | | | v |
| ***Vitex agnus-castus*** | Lilac Chaste Tree | | | | v |

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|---|---|---|---|---|---|
| ***Vitex agnus-castus*** | Lilac Chaste Tree | v | | | |
| ***Xylomelum angustifolium*** | Sandplain Woody Pear | | | v | |
| ***Yucca species*** | Yucca | | | v | |