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economics
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Living Melbourne: our metropolitan urban forest

Value analysis of trees on private land

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About Us

Established in 1996, Marsden Jacob Associates has grown to be Australia's leading dedicated natural resource economics, policy, and strategy advisory. We employ talented economists and policy advisors who specialise in solving practical, real-world problems relating to water, energy, environment, natural resources, agriculture, earth resources, public policy, and transport. We work with a wide range of cross-disciplinary partner firms to deliver best project outcomes for our clients.

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1. Introduction

Why do we need to understand the monetary benefits that urban trees on private property provides to their owners and the broader community in Greater Melbourne?

More than ever before, we need nature in our cities. Melbourne is expected to grow to be a city of nine million people by 2056, which would make it the largest city in one of the world's most urbanised nations. Greenfield development in Melbourne's west, and to a lesser extent in the southwest, will accommodate much of this growth (Figure 1). Infill development in the middle ring suburbs and inner Melbourne will change urban structure and form [1].

This growth brings opportunities for innovation and economic development. It also threatens Melbourne's urban forest and the many services it provides to Melburnians. These 'ecosystem services' include things like air purification, local cooling during summer, and flood protection. There are also broader benefits, such as opportunities for better physical and mental health and wellbeing.

Living Melbourne Action 2 proposes tree canopy cover targets with the aim of achieving a net increase of at least 50,000 hectares of tree canopy cover with vegetation heights greater than 3 metres by 2050 for metropolitan Melbourne. Figure 2 shows canopy cover targets by Council. To achieve the *Living Melbourne* canopy targets, the largest net additions need to happen in the Southern, Northern and Western Melbourne regions of Melbourne.

Living Melbourne's principles to support the urban forest targets for Melbourne include that no more than 70% of the additional tree canopy and shrub cover planted to achieve targets should be on public land, and at least 30% should be on private land.

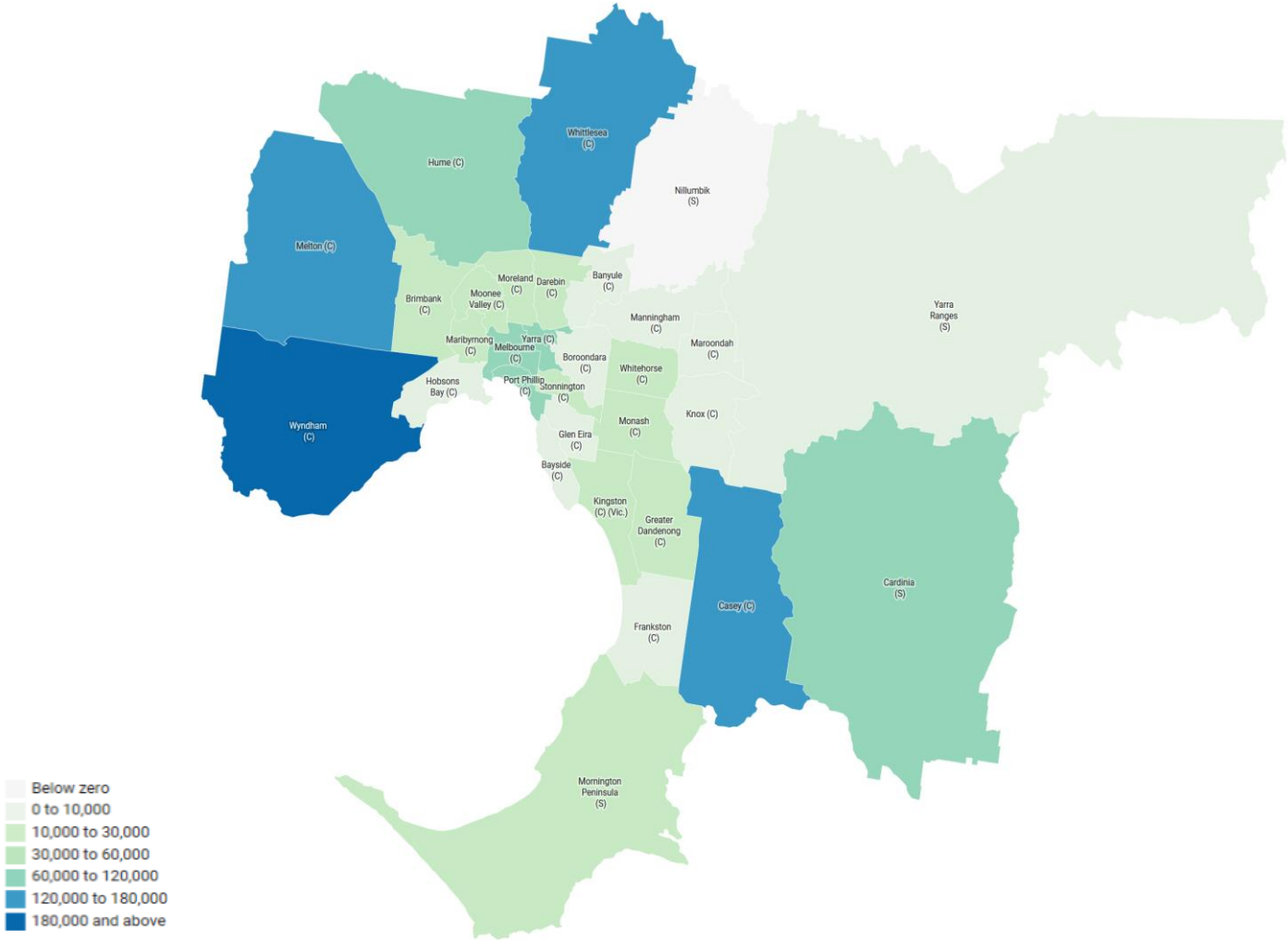
Figure 2 shows the land budget requirement assuming a 30% additional private land target, and additional 70% on open space and Crown Road Reserves. Figure 2 shows around 55% of tree canopy investment is needed in five Councils: Whittlesea, Wyndham, Casey, Melton, Hume, and Mitchell. In these areas there are significant canopy cover deficits on private land.

In sum, what Figure 2 highlights are that to reach tree canopy cover targets in the Councils that need them most we need more tree canopy cover on private land. Without trees on private land, we will not achieve the benefits being sought.

The overarching objective of this report is to help encourage canopy cover on private land through having a clear understanding and way of communicating the monetary value and benefits trees provide on private property. The specific objectives of this report are to communicate these values and benefits with private property owners, developers, and other key stakeholders in a common way, and using a consistent approach. This report will also start to identify innovative funding and financing mechanisms that can be introduced to support sustained investment that encourages tree planting and maintenance on private land in Greater Melbourne.

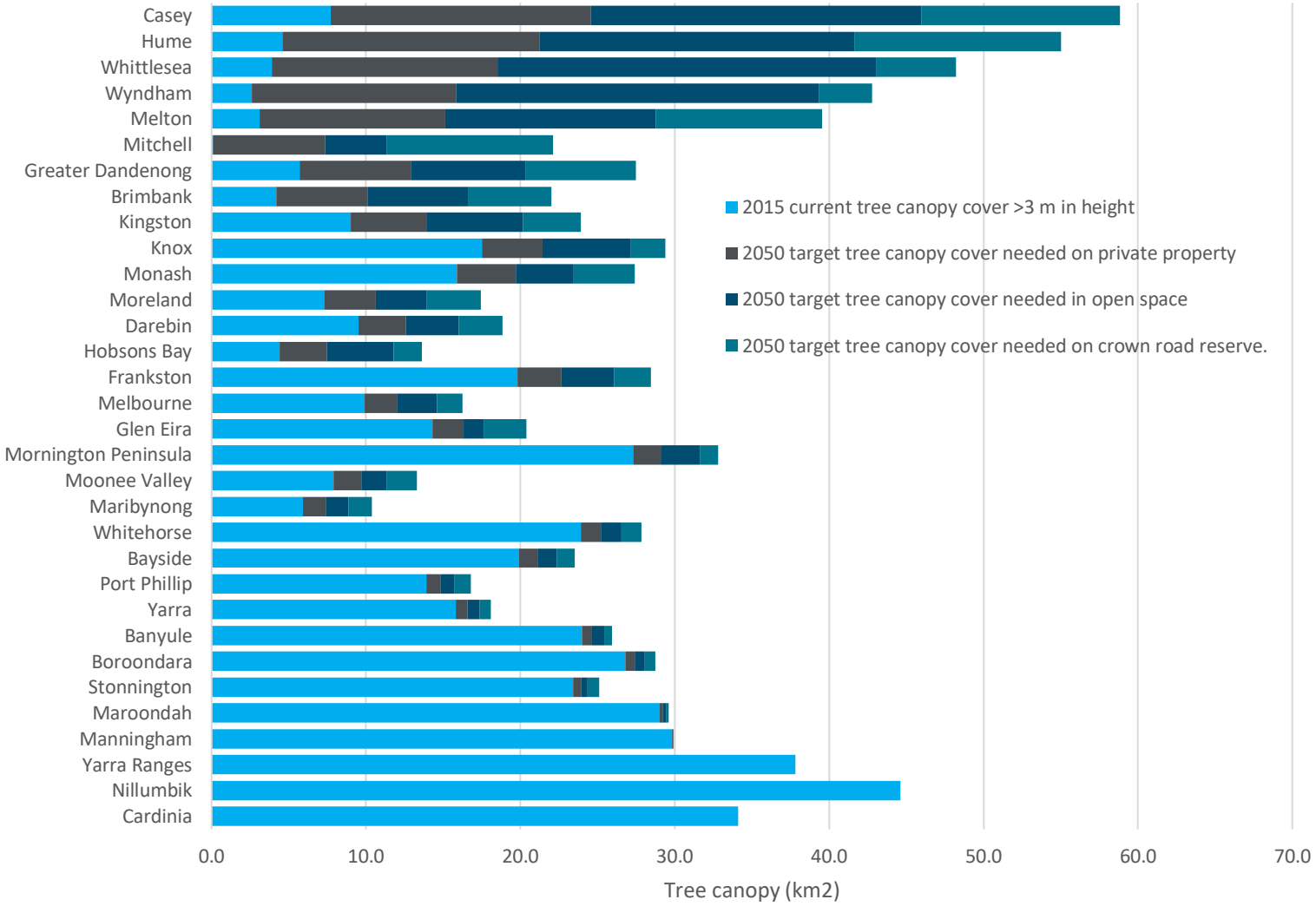
5.2Appendix 3 provides an example on application of benefits and cost values to determine the total lifetime benefits and costs of a tree to promote retention of mature trees. 5.2Appendix 4 includes two case studies from City of Melbourne and City of Marion that show how these Councils are using innovative approaches to encourage tree planting and retention on private land.

Figure 1: Metropolitan Melbourne urban forest area. Forecast population growth by local government area 2011-51



Source: Marsden Jacob analysis based on [1]

Figure 2: Baseline and target tree canopy cover to achieve Living Melbourne canopy targets by 2050



Source: Marsden Jacob analysis, based on [2]

2. Core concepts for monetary value analysis of trees on private land

Trees on private land deliver monetary benefits for the resident and for people living in the community. Some of these monetary benefits are observed through market transactions. Some monetary benefits are called economic benefits and others are financial benefits. What are these differences? Key concepts for understanding the monetary benefits of trees on private land are set out in this chapter.

2.1 Green infrastructure

Sectors within this report use the term green infrastructure in order to refer to the broader range of green spaces, not just trees

We use the CRC for Water Sensitive Cities definition of green infrastructure in this report. The term green infrastructure refers to "the public and private green spaces in our cities that can provide a range of benefits if they are managed as an integrated system. These green spaces range in scale: from single trees in a city street to golf courses, parks and waterway corridors that can shape the urban landscape. Some are natural, such as areas of remnant native vegetation, while others are more engineered, such as green roofs, green walls, biofilters and raingardens".

2.2 Private land

In this report when we talk about private land we mean any land that is not Government or Crown land. Private land can be residential, commercial, or industrial land, land owned by education institutions like universities, and all other land that is not Government or Crown land.

2.3 Monetary benefit values

This report is focussed on how trees on private land deliver monetary benefits. These monetary benefits can be in the form of cost savings to the private property owner or resident, for example from reduced heating costs or from being able to rent an investment property for more if it has a green outlook. Monetary benefits can also accrue to people who don't own the property. For example, a government may end up spending less on healthcare costs if enough people in an area maintain tree canopy which can reduce heat stress and lead to less hospitalisation on high temperature days.

All these types of benefit from green infrastructure are discussed in this report. At the outset it is important to make a couple of clear distinctions between different types of benefit value. This is because while these benefit values are all relevant and real, the values themselves are often not directly comparable.

Economic and financial monetary benefit values

Valuation involves measuring the value of goods and services in monetary terms. These monetary benefits vales can be either measured as economic or financial values

Economic monetary benefit values

In simple terms, the economic value of a good or service is measured by the maximum amount people willing to pay in money to have the good or service provided [3]. For example, the economic value of a cup of coffee or a house is measured by the maximum amount someone is willing to pay to purchase it. The same approach is used to value environmental goods and services, like tree canopy coverage and urban greening.

The difference between knowing the value of a cup of coffee or a house, when compared to the value of tree canopy coverage, is that cups of coffee and houses are traded in an open market every day. Many goods and services that have an associated environmental or social benefit, such as tree canopy coverage, are not traded like this. Without market observed prices for environmental and social goods and services we need other approaches to estimate these values. These approaches are known as quasi-market and non-market valuation approaches. Many of the benefit values in this report are estimated using these approaches.

Financial monetary benefit values

The financial value of a good or service is measured by how much people pay to have the good or service provided. Using the aforementioned coffee analogy, the financial value of a cup of coffee is how much someone must pay for a cup of coffee today. What someone pays for a cup of coffee in financial prices may be less or equal to its economic value to them – i.e., the maximum amount they would be willing to pay for that cup of coffee. For example, at 9:30 am in a boring meeting you may be willing to pay $10 for a cup of coffee (economic value), but if you leave the meeting and go and buy a cup of coffee you only have to pay the financial value of $4.50.

2.4 Ensuring monetary benefit values are comparable

Just like economic and financial values discussed above, when comparing monetary benefit values, we need to make sure we are assessing the values on a like with like valuation basis. In this report we differentiate between several types of benefit values. The key types of values we discuss in this report, include whether monetary values are at-source or at-site, long-term or short-term, total, marginal, or average values, and capitalised or per period values. These concepts are discussed further in [4]. In summary:

- Benefit values can be measured at source or at site: for example, the at-source value of a tree is the willingness to pay for the tree where it is being grown, for example, at a nursery. The value of the tree at site reflects the value of the tree at the property where it is planted, for example, private houses, parks, suburbs. The at-site value typically exceeds the cost of at-source values because they include the costs incurred in delivering and planting the tree.
- Benefit values can be measured over the long- or short-term. Short-term measures how the value of a tree's services change in a year. For example, the short-term urban cooling value of a tree is the benefit it provides for one year, whereas the long-term value of a tree is urban

cooling value the tree provides across its life. Long-term values are generally more appropriate for evaluating the benefits of long run green infrastructure capital investments. This is because as trees grow, they increase in size and so generally does the amount of value they provide over time.

- Benefit values are measured as total, average, or marginal value. The total value of a good or service is the amount someone is willing to pay in total. The marginal value is the willingness to pay for an additional quantity of a good or service, or a change in the quality of the good or service. For example, the total value of the trees on a property is the total amount someone would pay for all the trees. The marginal value is how much the person is willing to pay for an additional tree on the property. The average value is simply the total value divided by the number (of trees). Total, marginal, and average values can be very different from each other and can lead to different investment and risk management decisions.
- Benefit values can be Capitalised or measured as per period values. The per period values can be expressed per period (such as the annual energy savings from urban tree canopy) while others reflect the value of a capital asset (such as the asset value of trees on a property that is sold). In this report we differentiate between capitalised and per period values.

3. Monetary benefits of urban trees on private land

The monetary benefits of urban trees on private land are more complex than some might think. We discuss the monetary benefit values in this chapter.

Figure 3 summarises some of the headline benefits that urban trees on private land can provide. We also include some of the headline costs that tress on private land can create for their owners. The rest of this Chapter provides details on the benefits. The following Chapter provides details on the costs shown in Figure 3.

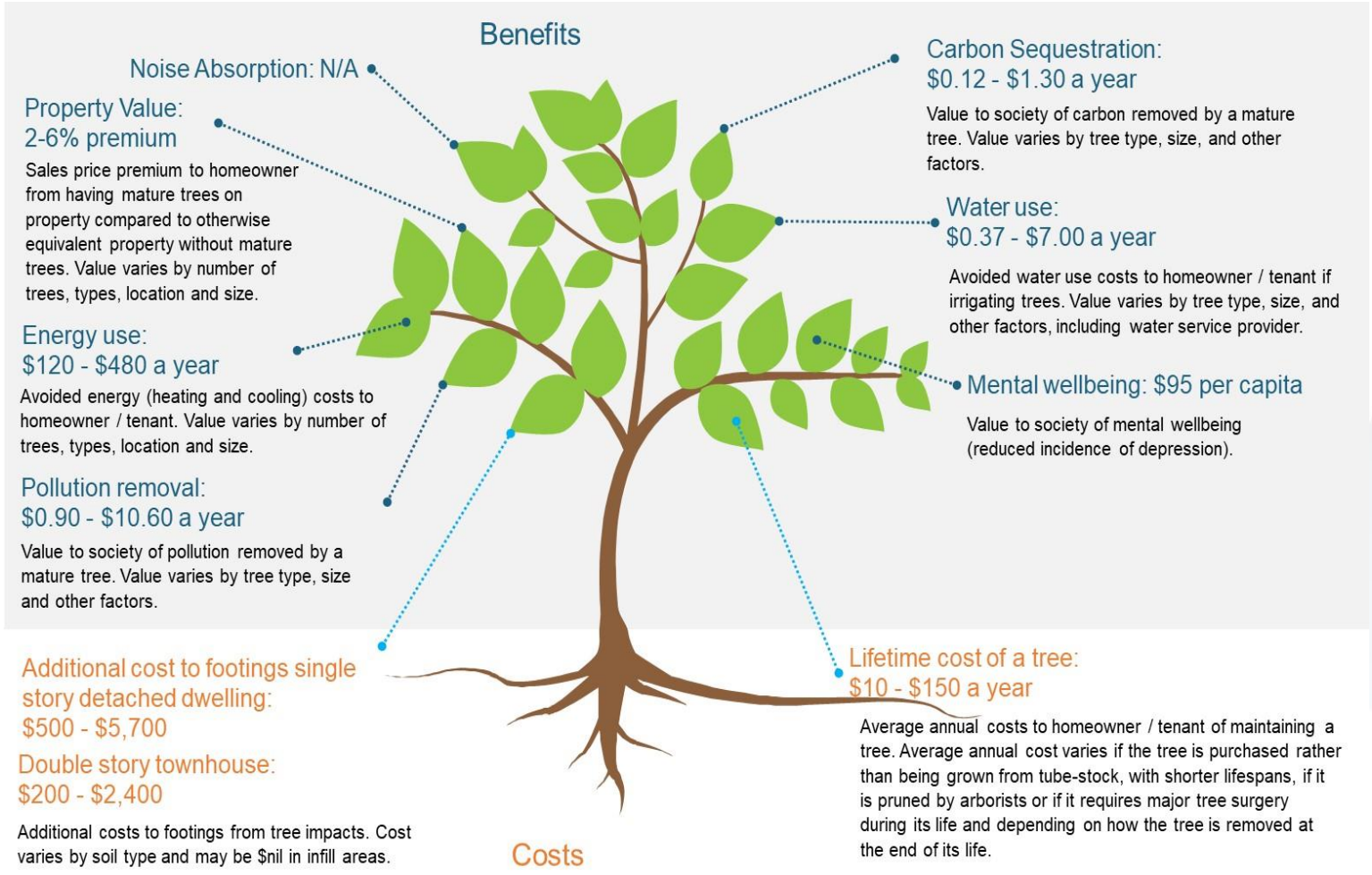
The material in this and the next Chapter aims to act as a detailed reference guide and evidence base to inform and guide the preparation of business cases and investment rational for initiatives and programs that increase and retain existing greening in the private realm. 5.2Appendix 3 provides an example of the application of benefits and costs during a tree's lifecycle.

3.1 Property values

There is a clear and well-established link between the 'greenness' and 'blueness' of a suburb and property prices in that suburb in Australia (see Table 14 in Appendix 1). The 'green and blue premium' reflects the benefit values that homeowners have for the amenity and recreational benefits of a green landscape and a near-water landscape. Assessments, including meta-analyses, have reported implicit property premiums associated with green infrastructure and urban amenity in the range of 0-10 percent. Key points are:

- **Australian and international studies show wide divergence in property premiums, despite generally controlling for the spatial location of other influences on property price** (e.g., access to schools, parks, and gardens, house, and lot size, year, and month of sale etcetera). Higher premiums are often associated with areas where there are mature slow growing broadleaf trees.
- **Most studies look at how urban greenness outside the property boundaries impact on property prices**. These studies generally find that greater greenness at the suburb scale results in greater property prices.
- **Across multiple studies, home-buyer preferences for trees on the property itself have varied from negative to positive and insignificant [5], depending on thresholds of canopy coverage of the site.** When trees on the property are less than 20% of the land area then the impact of trees is significant and positive. [6] For example, in Brisbane, tree cover on the property was found to have a significant negative effect on sale price, while controlling for the effects of house, land, and suburb variables. However, when tree cover on the property was less than 20%, the effect changed and became a significant and positive effect on sale price. These results are consistent with other studies from Australia and overseas.
- **A recent evaluation of people's preferences for trees and other forms of urban greening on private property using stated preference techniques found that having mature trees** together with other green features such as lawns, improved property values (owned and rented) by 3% to 8%in Melbourne. This was in comparison to properties whose private outdoor space was dominated by hard surfaces and no trees

Figure 3: Headline benefits (and costs) of urban trees on private land



[7]. Importantly, this study did not find that peoples' preferences were different depending on if the respondent was a university graduate or not or based on the number of income earners in the household. In other words, different types of households appear to have similar preferences for green features. We note however that the study did not include other important socioeconomic factors that may impact housing preferences, such as household income (as distinct from earners) and ethnicity.

What property values are appropriate to use?

Based on the literature review, the table below summarise outlines of some scenarios where the above values are applicable. Values in the table below are approximate and suitable for the early planning stage. When applying these values, we suggest you test the sensitivity of the project to low, medium, and high value assumptions (+/-50%). This means the low range would be 50% of the lower value (1%) and the high range would be 50% above the higher value range (i.e., 9%).

Table 1: Benefit of trees on property values

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Property price premium for mature trees on property	Economic	Capitalised	Marginal	2-6%	Only applicable when tree canopy is less than 20% of the property land area. When tree area is above 20% of the property land area then the impact of trees may be nil or negative on property value. Value is for mature trees only.

Factors to Consider

Double Counting. Double-counting benefits can be a significant risk. For example, property price uplift is valued using a hedonic regression model. This method infers the value properties have because of their closeness to green spaces, such as their front yard or a public park. However, property price uplift benefits might include benefits associated with green spaces, such as health and recreational benefits. Thus, double counting may occur. Care must be taken when undertaking an economic evaluation of the non-market values to ensure benefits are not double-counted, and assumptions need to be clearly stated.

Value is for mature trees and coverage up to 20% within a private property area. When trees are not mature it may be reasonable to assume that there is a linear relationship between tree maturity and property price premium. For example, if trees on a property are at 30% of maximum growth, then the property premium is 30% of 3-8%. It may also be reasonable to assume a linear relationship between the property price premium and canopy coverage up to 20%. For example, if mature canopy coverage is 10% of the property, then the property premium is around half of the mid-point of the value range, i.e., 2%.

3.2 Reduced energy space cooling

When planted in appropriate locations, urban trees reduce energy consumption through reducing heating of homes and cars on hot days, further reducing the need for use of air conditioning. Reduction of wind speed can also provide shelter from cold winds and reduce heating needs, thus reducing energy use and household financial costs.

There is sufficient evidence that urban heat impacts energy consumption and peak electricity demand in Australian cities. There is also good evidence that trees and canopy cover contribute towards reduced energy (heating and cooling) costs (see Table 15 in Appendix 1). These savings can be significant. For example, based on eight studies from Canada, Japan, Thailand, and United States [8] found that urban energy consumption per person per year increases by around 80 kWh per degree Celsius above 18 degrees, with greater increases depending on air-conditioning penetration and use.

Most studies evaluate the relationship between electricity use and temperatures at the regional and city scale (see Table 15 in Appendix 1). Fewer Australian studies have looked at how tree plantings on a private property impact that property's electricity use for cooling and heating, the so-called micro-scale (Table 2). Recent studies that do focus on the relationships between tree plantings on property and electricity use show [9, 10]:

- **In typical weather conditions (in Adelaide) optimal tree shading arrangements can lead to a maximum 40% of energy conservation from saving heating and cooling annual savings when trees are optimally placed**. Less optimal tree shading arrangements can lead to around 5-20% total heating and cooling annual savings.
- **The trees, their location and proximity to the residence are all key determinants of potential energy savings.** Key points here are:
    - Deciduous trees generally result in higher thermal energy conservation than evergreen trees, measured through tree providing shade cooling façade surface temperature and creating evaporative cooling.
    - Deciduous trees cause higher energy conservation overall if planted within 3 meters of the property. If landscapers prefer evergreen trees, planting trees within 5-meters provides better energy conservation. This is because evergreen trees do not drop their leaves during winter and create shade during winter which increases heating costs. Placing at five meters balances the benefits of shade for heating and cooling across the year.
    - In typical weather conditions, trees provide the greatest energy conservation benefits when planted to the west, east or north of the property, in that order. Trees planted south of the property provide little to no energy benefits.

What energy saving values are appropriate to use?

Based on the literature review, the table below summarise outlines of some scenarios where the above values are applicable. Values in the table below are approximate and suitable for the early planning stage. It important to test the sensitivity of the project to low, medium, and high value assumptions (+/-50%).

Table 2: Impact of trees on urban heat by scale

Scale	Description	Impact of trees
Micro	Refers to how individual things such as plants, buildings and gardens and streets impact on urban heat (from 0-100 metres)	Trees can provide an excellent means of reducing the thermal load received by building roofs, walls, and impervious ground surfaces. Similarly, trees can improve human thermal comfort along walkways where people may otherwise be exposed, and at critical positions in the urban landscape where people gather outside, such as bus/tram stops, children's playgrounds, inner-city plazas, and car parks.
Local	Refers to how contiguous private gardens, streetscapes, local public parks, and suburbs, covering horizontal areas of 100– 10,000 metres impact on urban heat.	The beneficial effects discussed at the micro- scale may be aggregated. However, it cannot be assumed that cooling at larger scales arises in a linear fashion from the cumulative effects of micro to local scale cooling within the urban canopy layer. Large parks with trees will achieve the greatest cooling benefits during the day. Large parks with fewer trees will achieve and provide the greatest cooling benefits within the park and downwind at night. All parks will achieve greatest cooling benefits with an adequate supply of water to maintain tree canopy health and maximise evapotranspiration.
Macro	Refers to contiguous private gardens, streetscapes, local public parks, and suburbs, covering horizontal areas of 10,000+ metres impact on urban heat.	The beneficial effects discussed at the micro- scale may be aggregated. However, it cannot be assumed that cooling at larger scales arises in a linear fashion from the cumulative effects of micro-to local scale cooling within the urban canopy layer. The temperature impact of planting more trees in streets may be considerably greater than planting more trees in parks.

Source: [11, 12]

Table 3: Benefit of trees on energy use

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Change in energy use costs from having one or more mature trees on residence.	Financial	Annual	Marginal	$120-480	Based on an assumed 12,000 kWh for heating and cooling[1] and an energy price of 20 cents per kWh. Assumes that the annual heating and cooling savings are 5-20%. Savings will increase when trees are: • mature • greater in number • planted on the west or east of the property • deciduous Trees on the south of the property have no energy saving value.
	Economic	Annual	Marginal	$40-60	Avoided GHG (scope 2) emissions based on National Greenhouse Account Factors for Victoria[2] (0.96), an assumed carbon price of $21 per tonne and converting CO2 to carbon through their atomic weight (12/44).

Factors to Consider

Double Counting. Double-counting benefits can be a significant risk. For example, energy savings may be factored into property prices as part of the green premium properties attract. Care must be taken when undertaking an economic evaluation of the non-market values to ensure benefits are not double-counted, and assumptions need to be clearly stated.

Types of trees, maturity, and their location. As noted above, not all trees are the same when it comes to energy savings. Savings will increase from nil to $120-480 when trees are mature, greater in number, planted on the west or east of the property and deciduous. Nil / low energy savings should be assumed during trees' establishment period.

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[1] https://renew.org.au/renew-magazine/efficient-homes/unravelling-home-energy-use-across-australia/

[2] https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors-2021

3.3 Climate regulation

In addition to providing energy savings from cooling, there is clear evidence that the addition of trees and other vegetation to the built environment provides benefit in mitigating the urban heat island effects in towns and cities in Australia and internationally [11-15] (see Table 15 in Appendix 1).

The mitigating impact of trees differs at micro, local and macro scales (Table 2). Greenery selection, plant configuration and urban morphology also impact on the mitigating impact of trees [12]. Cooling by evapotranspiration varies by climate, canopy physical and geometrical properties and season but is typically up to 2–3 °C at the local and macro scales, sometimes higher. In summer, this mechanism produces generally larger cooling (>2.0 °C). Cooling from vegetation is larger if canopies and ground cover are implemented in targeted configurations, e.g., private gardens and urban parks, rather than spread out over large areas [12].

Evidence shows that the extent of benefits due to local shading is location specific and (1) related to particular meteorological conditions and (2) the greenery maintenance regime and configuration [12]. Both these variables can compromise urban greenery mitigation effects at the micro, local and macro.

While most studies look at the impact of canopy at the local and macro scale and across public and private spaces, recent work in Adelaide, Australia has looked specifically at the local contribution (90 residential suburbs) of trees on private land to urban cooling during heat events [16].

This study showed that private gardens and yards with trees cooled areas of up to 30 m^2 around the tree during summer heatwaves. In this study, land surface temperature (LST) measured the peak of a heatwave event after three consecutive days with air temperature exceeding 40 ˚C. The tree canopy cover, and to a lesser extent grass cover, was found to decrease local LST by up to 6 ˚C in the treed area during the day on extreme heat days, but not at night, suggesting a moderate cooling effect of urban vegetation patches from private land.

What values are appropriate to use?

Based on the literature review, we do not recommend an economic or financial value for urban cooling from private property. This is because:

- The benefit of climate regulation and cooling is normally measured through impacts on heat stress related morbidity and mortality, and associated impacts on productivity. Collectively, this body of work finds extreme forms of urban heat do increase the financial cost burden placed on the healthcare system and on productivity. This conclusion is consistent with international literature on the relationships between heat, heat stress, health conditions, health cost measures and productivity. This evidence base is comprehensively reviewed in [17]. While these studies establish clear linkages, they do so by looking at how health conditions change as temperatures change at the macro / city level, rather than at the individual property level. This means we cannot say that changing outdoor temperatures at a property scale will impact on health outcomes at the property scale, or within the property buffer zone.
- Changing property level outdoor temperatures may not impact indoor temperatures, particularly at night. To date, so far as we are aware, only a few Australian studies [18, 19] have explicitly looked at where, when and how heat stress events have occurred. This is an important area that has received less than needed consideration in Australian studies to date. There is some evidence that heat stress may occur more indoors than outdoors. [18] notes, based on evidence in a Victorian Department of Health report, that most health impacts in Melbourne in 2012 occurred to people within their own residence, not outdoors. Similarly, [20, 21] identify that the effects of urban heat can be more pronounced overnight when heat stored in buildings and hard surfaces during the day is released, which means heat stress may occur more at home, at night. [16] found that trees on private land did not result in cooler LST night temperatures. This means there may not be an evidence base for attributing urban cooling benefits to trees on private land

Table 4: Benefit of trees on urban cooling

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Urban cooling morbidity and mortality.	NA	NA	NA	NA	NA

3.4 Tree uptake of gas and particulate pollution

Trees play an important role in filtering and cleaning the air of harmful gaseous and particulate pollutants, via uptake through leaves and interception and accumulation of particles on the plant surface.

We have estimated the carbon and air quality benefit values of urban trees using i-Tree Eco Australia (version 5). i-Tree is a peer-reviewed software program developed by the USDA Forest Service. i-Tree Eco (Australia) is currently designed to provide accurate estimates in Greater Melbourne of tree services for air pollution (ozone, nitrogen dioxide, particulate matter less than 2.5 microns (PM2.5), sulphur dioxide and carbon monoxide) and carbon storage and sequestration.

i-Tree Eco was setup using i-Tree's 2019 pollution dataset for Altona North weather station as the reference station. The 2019 dataset is the latest containing weather and pollution data for Altona North.

The representative sample of trees used to obtain unit values is calculated from sample species include Yellow and Red Box, Pink Flowering and Yellow Gum, and Smooth-barked Apple Myrtle, with the balance of the tree species being less typical, including a mix of native and exotic species. Examples include English Oak, Golden-rain Tree, Judas Tree and Kanooka. These species have been selected to meet desired outcomes of improved liveability by increasing shade canopy, leaf area and biomass, evapotranspiration, and amenity etc. Trees were chosen based on previous experience in locations like Western Melbourne and evidence of their urban cooling, air pollution and carbon storage capacities. Trees chosen were primarily fast to moderate growing. A mix of evergreen and deciduous trees were chosen.

The value of pollution removal was set at $22 per metric tonne for carbon monoxide, $4,300 per metric tonne of ozone, $641 per metric tonne of nitrogen dioxide, $234 per metric tonne of sulphur dioxide and $149,365 per metric tonne of (PM2.5). These values are based on international estimates of the health impacts of urban pollution and carbon [22].

What values are appropriate to use?

Based on the i-Tree Eco simulations the table below summarises appropriate values by tree type. All values in the table below are average economic values. Values in the table below are approximate and suitable for the early planning stage. It important to test the sensitivity of the project to low, medium, and high value assumptions (+/-50%).

Table 5: i-Tree economic value of carbon and pollution removal per mature tree

Botanical Name	Years to max height (approx.)	Height at maturity	Gross Carbon Sequestration		Pollution removal	
			(ton/yr)	(A$/yr)	(ton/yr)	(A$/yr)
Acacia implexa (Lightwood)	10	7.5	0.01	0.24	0.00	3.16
Corymbia ficifolia 'Fairy Floss' (Pink Flowering Gum)	8	6	0.01	0.24	0.00	1.24
Eucalyptus leucoxylon 'Wildire' (Yellow Gum)	13	10	0.02	0.47	0.00	4.78
Acer truncatum 'Norwegian Sunset' (Norwegian Sunset Maple)	24	11	0.02	0.44	0.00	7.19
Lagerstroemia 'Natchez' (Crepe Myrtle Hybrid Cultivar)	11	5	0.01	0.12	0.00	0.91
Melia azederach (White Cedar)	16	9	0.02	0.39	0.00	5.65
Angophora costata (Smooth-barked Apple Myrtle)	27	20	0.04	0.85	0.00	9.75
Eucalyptus melliodora (Yellow Box)	40	10	0.05	1.03	0.00	10.59
Eucalyptus polyanthemos (Red Box)	37	17	0.04	0.85	0.00	9.76
Ulmus parvifolia (Chinese Elm)	22	9	0.02	0.39	0.00	6.95
Quercus canariensis (Algerian Oak)	39	18	0.06	1.29	0.00	9.58
Cupaniopsis anacardiodes (Tuckeroo)	17	10	0.02	0.38	0.00	5.10
Lophostemon confertus (Brush Box)	26	10	0.02	0.39	0.00	4.22
Tristaniopsis laurina (Kanooka)	17	8	0.01	0.24	0.00	1.49
Cercis siliquastrum (Judas Tree)	48	12	0.01	0.25	0.00	3.16
Koelreuteria paniculata (Golden-rain Tree)	32	10	0.02	0.38	0.00	4.54
Ficus rubiginosa (Port Jackson Fig)	26	12	0.04	0.83	0.00	6.35
Fraxinus pennsylvanica 'Urbdell' (Urbanite Ash)	32	15	0.01	0.28	0.00	6.57
Quercus robur (English Oak)	39	18	0.05	1.03	0.00	8.85
Quercus rubra (Red Oak)	35	16	0.04	0.93	0.00	8.24
Zelkova serrata 'Green Vase' (Japanese Zelkova)	39	18	0.05	1.05	0.00	9.21

Factors to Consider

Double Counting. Double-counting benefits can be a significant risk. For example, pollution removal benefits may be factored into property prices as part of the green premium properties attract. Care must be taken when undertaking an economic evaluation of the non-market values to ensure benefits are not double-counted, and assumptions need to be clearly stated.

Types of trees, maturity, and their location. Benefits will increase when trees are mature, healthy, close to pollution emitting sources, and larger population densities. When trees are not mature it is reasonable to assume that there is a linear relationship between tree maturity carbon and pollution benefits. For example, if trees on a property are at 30% of maximum growth, then the carbon and pollution benefit is 30% of the values in Table 5.

3.5 Reduced potable water use and avoided stormwater runoff

Impervious surfaces in urban areas generate substantial volumes of polluted surface runoff. In Melbourne, this runoff results in degradation of our waterways, Port Philip and Westernport Bays, and flooding. Urban trees can help to mitigate the impacts of runoff by restoring key hydrological processes, including canopy interception, throughfall, stemflow, and transpiration [23].

In Melbourne, recent work has shown that redirecting stormwater to established Brush Box trees in the grassed verges of a typical suburban streets resulted in these trees using large volumes of water (up to 96 L d−1), corresponding to 3.4 mm a day. Annually, stormwater retention was 24% of runoff and tree transpiration was equivalent to 17% of runoff. These results suggest that landscapes fitted with tree-based stormwater control measures could increase the volumetric reduction of stormwater runoff by increasing the proportion of evapotranspiration in the water balance [24]. Similarly, species including Red Box, Brush Box), Willow Bottlebrush and Oriental Plane have all been found to contribute to significant reductions in nitrogen and phosphorus concentrations of the stormwater in biofiltration systems in Melbourne [25].

We are not aware of previous literature that has attempted to place a monetary value on the stormwater removal function of trees on private land in Melbourne, or Australia. To estimate transferrable values, we have used i-Tree Eco Australia (version 5) and the same trees as shown in Table 5 to estimate stormwater retention functions and values. In i-Tree, the annual avoided stormwater run-off attributable to trees is calculated by comparing hourly precipitation (Essendon Airport rainfall observed in 2019) and total annual surface run-off volume with and without trees based on the i-Tree sub-model.

We have calculated the average avoided runoff value assuming an average cost of $7.35 per square meter of (equivalent to $3,500 per kg TN). This estimate is based on previous experience estimating the cost of mitigating stormwater impacts using assets on private and public land and the observed relationship for nitrogen composition for baseflows and stormflows in Melbourne in [26]. As such, this value is a proxy replacement value for stormwater retention services provided by mature trees. This cost estimate does not include land value.

For avoided potable water costs we have assumed that reticulated water would be used instead of stormwater runoff, and a price of $2.70 per kL.

What values are appropriate to use?

Based on the i-Tree Eco simulations the table below summarises appropriate values by tree type. All values in the table below are average economic values. Values in the table below are approximate and suitable for the early planning stage. It important to test the sensitivity of the project to low, medium, and high value assumptions (+/-50%).

Table 6: i-Tree economic value of stormwater mitigation per mature tree

Species Name	Avoided Runoff (m3/yr)	Avoided Runoff Value (A$ per annum)	Avoided potable water use (A$ per annum)
Acacia implexa (Lightwood)	0.23	1.69	0.62
Corymbia ficifolia 'Fairy Floss' (Pink Flowering Gum)	0.14	1.03	0.37
Eucalyptus leucoxylon 'Wildire' (Yellow Gum)	0.5	3.68	1.35
Acer truncatum 'Norwegian Sunset' (Norwegian Sunset Maple)	0.38	2.79	1.03
Lagerstroemia 'Natchez' (Crepe Myrtle Hybrid Cultivar)	0.29	2.13	0.78
Melia azederach (White Cedar)	0.38	2.79	1.03
Angophora costata (Smooth-barked Apple Myrtle)	2.65	19.48	7.16
Eucalyptus melliodora (Yellow Box)	2.01	14.77	5.43
Eucalyptus polyanthemos (Red Box)	0.85	6.25	2.30
Ulmus parvifolia (Chinese Elm)	0.38	2.79	1.02
Quercus canariensis (Algerian Oak)	1.34	9.85	3.62
Cupaniopsis anacardiodes (Tuckeroo)	0.36	2.65	0.97
Lophostemon confertus (Brush Box)	1.13	8.31	3.05
Tristaniopsis laurina (Kanooka)	0.46	3.38	1.24
Cercis siliquastrum (Judas Tree)	0.87	6.39	2.35
Koelreuteria paniculata (Golden-rain Tree)	0.63	4.63	1.70
Ficus rubiginosa (Port Jackson Fig)	1.04	7.64	2.81
Fraxinus pennsylvanica 'Urbdell' (Urbanite Ash)	1.57	11.54	4.24
Quercus robur (English Oak)	1.6	11.76	4.32
Quercus rubra (Red Oak)	0.74	5.44	1.99
Zelkova serrata 'Green Vase' (Japanese Zelkova)	1.47	10.80	3.97

Factors to Consider

Double Counting. Double-counting benefits can be a significant risk. For example, stormwater removal benefits may be factored into property prices as part of the green premium properties attract. Care must be taken when undertaking an economic evaluation of the non-market values to ensure benefits are not double-counted, and assumptions need to be clearly stated.

Types of trees, maturity, and their location. Benefits will increase when trees are mature, are healthy, are when trees are on land that drains to the stormwater system and / or waterways and are in areas with higher impervious areas. When trees are not mature it may be reasonable to assume that there is a linear relationship between tree maturity and stormwater detention benefits. For example, if trees on a property are at 30% of maximum growth, then the stormwater benefit is 30% of the values in Table 5.

3.6 Reducing Noise pollution

Noise in urban environments can be a substantial problem, especially when an area has a lot of hard surfaces that reflect noise. Emerging research is identifying that in areas with increased tree canopy cover, human and weather produced sounds such as traffic and wind noise is reduced [27].

What values are appropriate to use?

Based on the literature review, we do not recommend an economic or financial value for noise absorption at this time. This is because:

- Understanding of the benefits of noise absorption is an emerging area of research
- The private benefit of noise absorption from trees is likely already captured in property price premium values.

Table 7: Benefit of trees on noise absorption

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Noise absorption	NA	NA	NA	NA	NA

3.7 Mental wellbeing of having trees and a green backyard

A number of Australian studies suggest that neighbourhood 'greenness' contributes positively towards mental health outcomes [28].

Of note, a recent Australian study found associations between the duration, frequency, and intensity of exposure to nature and health in urban Australian populations [29]. A dose-response analysis for depression and high blood pressure suggests that visits to outdoor green spaces of 30 minutes or more during a week could reduce the population prevalence of these illnesses by up to 7% and 9% respectively. Importantly, while this study found a relationship between greenness exposure duration and mental wellbeing, it found no association between the measure of nature

intensity (vegetation complexity) and any of the health outcomes measured. What this result may indicate is that beyond some minimum requirements for greenness, the quality and physical extent of exposure to greenness is less important than the duration of exposure. In simple terms, people may achieve the same amounts of mental health benefits from spending 30 minutes or more in their back-garden with trees and lower vegetation complexity as they would in a national park with higher vegetation complexity. This issue deserves further study.

An estimate of the impact of greenspace can be achieved by applying the 7% figure from [29] to the burden of disease estimate for depression published by the AIHW (measured in per capita expenditure for Victoria in 2019-20 for healthcare costs of depression) enables an estimate of the impact of more amenable an accessible greenspace on mental health outcomes, consistent with the approach in [30].

What values are appropriate to use?

Based on the literature review, the table below summarise outlines of some scenarios where the above values are applicable. Values in the table below are approximate and suitable for the early planning stage. It important to test the sensitivity of the project to low, medium, and high value assumptions (+/-50%).

Table 8: Benefit of trees on energy use

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Benefit value of mental wellbeing (reduced incidence of depression)	Financial	Annual	Marginal	$95 per capita	Measures the approximate annual per capita expenditure in Victoria for treating depression, including Medicare-subsidised mental health-specific services and prescriptions. Does not include other avoided costs such as loss of workplace productivity, or DALYs. To calculate the benefit of green space: • Estimate the population accessing benefits from spending 30 minutes or more in their back-garden with trees and lower vegetation complexity • Multiply 7% of the population by $95 per capita to calculate the annual impact of exposure to greenness for reducing financial burden of depression.

Factors to Consider

Double Counting. Double-counting benefits can be a significant risk. For example, mental health and other benefits may be factored into property prices as part of the green premium properties attract. Care must be taken when undertaking an economic evaluation of the non-market values to ensure benefits are not double-counted, and assumptions need to be clearly stated.

Other forms of greenness may provide benefits, not just trees. [29] measured vegetation complexity using LiDAR-derived maps of vegetation cover at a 5 × 5 m resolution (details provided in the Supplementary material). The measures included multiple forms of vegetation strata that have relevance to the human experience of nature, not just the presence of trees. This means the benefits of trees may also be achieved with other vegetation arrangements, such as shrubs or grasslands. As such, benefits are attributable to greenness, not trees per se.

4. Understanding the costs and barriers to growing trees on private land

Despite their benefits, the lack of trees on many properties in Greater Melbourne suggests people may not want trees on their properties. Understanding costs and barriers to having trees on private property is key part of encouraging tree investments on urban private property.

In this section we focus on two key barriers to getting more trees planted on private property in Greater Melbourne – the costs of trees on private land, and peoples' perceived barriers and preferences for not having trees.

4.1 The costs of trees on private land

For all their benefits, trees can and do impose costs on private landowners when they are on their property. For example, tree root growth can cause damage to pipes and paving and disrupt foundations. Falling branches can cause damage to people and property. Leaf litter can fill gutters and create fire and flooding risks if not managed. In many cases the impacts of poor tree selection or placement can be avoided with proper planning.

Lifetime costs

The lifetime cost of maintaining trees include costs of establishment, maintenance, and eventual removal when the tree is in decline nearing the end of its lifetime. The maintenance cost of a urban trees is generally considered to be low when compared to other vegetation types, such as turf or annuals, except in the establishment and decline phase [32].

The lifetime costs of trees vary depending on how costs are thought about and what costs are included in the calculation. [32, 33] show that upfront costs. Costs include planting, pruning, pest management, irrigation, removal, administration, inspection, infrastructure repairs, litter cleaning and liability claims, mulching, tree support and protection systems and soil management. [32] shows that with proper maintenance urban trees can have longer lifespans, and that this can reduce the average annual lifetime cost.

Horticulture Innovation Australia's urban tree costing tool is an easy to use resource that people can use to calculate the costs of establishing and maintaining trees through their lifetime. The tool includes standard rates and allows users to input their own assumptions.

What values are appropriate to use?

Based on the literature review, the table below summarise outlines indicative lifetime costs for urban trees. Values in the table below are approximate and suitable for the early planning stage. It important to test the sensitivity of the project to low, medium, and high value assumptions (+/-50%).

Table 9: Lifetime cost of urban trees

Value	Economic or financial value	Annualised or capitalised value (short run or long run)	Total Average or Marginal	Value range	Notes on application
Lifetime cost of urban tree	Financial	Annual	Average	$10-150 per tree a year	Measures the approximate average annual expenditure on maintaining urban trees. Does not include structural costs that may arise from tree planting. This is covered below. Average annual costs will be higher if the tree is purchased rather than being grown from tube-stock, with shorter lifespans, if it is pruned by arborists during its life, if it requires major tree surgery during its life, and depending on how the tree is removed at the end of its life [32, 33].

Building structural costs

This section is largely based on a comprehensive recent review of the cost of trees on private and public land for the South Australian Attorney-General's Department as part of the review of the Infill Planning and Design code [31].

Developers have raised the impact of tree planting on housing affordability due to higher costs associated with footings. As part of the review of the Infill Code, specialist advice was commissioned on this issue. The key points from the advice were that:

- **Structural engineers will design house footings to factor in a 'single tree effect' if the distance between the dwelling and the tree is 1x the mature height of a single tree (in the case of one or two trees).** They will also factor in a 'group tree effect' if the distance between the dwelling and the trees is 1.5x the mature height of a group of trees (in the case of three trees close together). This reflects requirements in AS2870-2011 Residential Slabs and Footings.
- **However, if a tree is within the tree effect zone, the required footing depth can be influenced by other factors such as the soil type, construction method, the height of the tree at maturity, the number of other trees present, and the type and shape of footing.** This means the cost impact of trees on footings is highly variable.

- **Costs will depend in part on soil type.** For less reactive sandy soils, a tree (even planted quite close to a house) would have only a low impact on footing thickness (and therefore cost). For more reactive soils such as clay, the cost may be much greater.
- **In an established urban area, house footings often will already have to be designed to accommodate the impact of nearby offsite trees, regardless of the tree policy.** In areas with established trees, new houses and renovations are normally designed to consider the 'tree effect' zone on the new dwelling. This means adding new trees does not impose additional costs as the new build already needs to accommodate for existing trees.

Table 10 summarises estimated additional costs to footings from single tree effects by soil type in metropolitan Adelaide. As noted above, these additional costs will generally only be incurred when there are no existing trees on or near the dwelling.

Table 10: Additional costs to footings from single tree effects by soil type (2020)[3]

Soil type	Case study 1: 200sqm single story detached dwelling			Case study 2: 90sqm double story townhouse
	Estimate 1	Estimate 2	Estimate 3	
Sandy	$500	$1,500	$1,000	$600
M-D[4]	$500	$700	$600	$600
H1-D	$3,500	$1,700	$2,600	$200
H2-D	$3,800	$3,500	$3,700	$2,400
ED	$5,700	$1,500	$3,600	$1,100

Source: [31].

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[4] M-D: Moderately reactive clay or silt sites, which may experience moderate ground movement (21-40 mm) from deep-seated moisture changes.

H1-D: Highly reactive clay sites, which may experience high ground movement (41-60 mm) from deep-seated moisture changes.

H2:D: Highly reactive clay sites, which may experience very high ground movement (61-75 mm) from deep-seated moisture changes.

E-D: Extremely reactive sites, which may experience extreme ground movement (>75 mm) from deep- seated moisture changes

4.2 Other barriers: attitudes and opportunities

Beyond costs there are a range of other reasons people choose not to plant trees, or not to plant more trees, on their properties. Reasons include negative attitudes towards trees because of:

- **Perceived risks, allergies, encroachment on solar access or views and disservices such as the maintenance burden of trees in close proximity to houses**, are all reasons for not wanting trees on private property that have been reported within and outside of Australia [6, 34].
- **Physical and practical limitations as barriers to planting trees.** Barriers to tree planting include lack of space and professional advice in private gardens, and timing and physical limitations for participating in tree programs [34].
- **Land use preferences:** retaining or growing large trees on a private property can leads to a lost opportunity cost for development into higher sale value of strata title. Property owners may choose not to plant trees for this reason.
- **Household specific effects. Otherwise called 'the luxury effect'.** Some studies have suggested that factors such as higher education and income are positively related to preferences for trees. A recent evaluation from Melbourne [35] suggest that household socioeconomic factors are associated with street tree density and diversity across a number of municipalities of Melbourne, Australia. When controlling for other measures, education and English proficiency were positively correlated with tree density, consistent with studies in other Australian cities. Income and rental status were a negative predictor of tree distribution. These results suggest that household specific effects alone do not adequately explain the distribution of trees across Melbourne.
- **Councils and other structural factors.** [35] find that Council requirements and support for trees impacts on the diversity and density of trees in Melbourne. Councils that have public tree policies and that encourage trees on private land may be contributing to changing patterns of tree density and diversity within their area over time. Similarly, [35] suggests that by focussing on residents in more advantaged areas and managing trees through business as usual routines and maintenance plans other Councils may be contributing to tree diversity and density remaining in Greater Melbourne's 'leafier east'.

5. Incentivising trees on private property. A shortlist of examples currently adopted in Australia

Many urban places around the world and in Australia have initiatives in place aimed at establishing and retaining trees on private land. Most use regulations and legal and planning means (such as overlays and fines for removing trees) as a basis for establishing and retaining trees, instead of incentives.

In this Chapter we focus on incentive approaches other than regulation and fines that are currently adopted in Australia to motivate establishment and retention of trees on private property in the urban landscape. We do this by providing a shortlist of examples currently adopted in Australia. Most of the material in this Chapter is derived from three recent reviews of controls and incentives for establishing and maintaining trees on private property in Greater Melbourne, Australia and internationally: [36-41].

Regulatory, planning and legal mechanisms for establishing and retaining trees on private land in Australia are comprehensively reviewed in [36, 39, 40], with [36] including penalty rates as of 2011. [42] provides a contemporary evaluation of how urban forest managers in Victoria evaluate and navigate management and governance opportunities and challenges for establishing and maintaining trees on private land.

5.1 Incentive based approaches

Incentive based approaches for establishing and maintaining trees on private land are programs that encourage the voluntary action by private landholders beyond regulated requirements. Incentive based approaches vary widely, and are influenced by legal frameworks, governance structures, cultural norms, and land ownership laws [41].

Table 11 summarises approaches for establishing and maintaining trees on private land, extending on [41] to include education and support incentives. [39, 41] applied this framework to characterise the types of mechanisms that are currently adopted by local governments to protect and retain trees on private urban lands in Australia and Victoria, and internationally.

Table 12 provides a shortlist of incentive examples currently adopted in Australia to establish and retain trees on private land. To support identification of opportunities for innovation, Table 13 provides a shortlist of incentive examples currently adopted internationally to establish and retain trees on private land.

Headline observations from these resources and examples (Table 12 and Table 13) are:

- **Incentive based approaches for establishing and maintaining trees on private land in Australia are very limited compared to international approaches and experience.** Another way of saying this is that Australia lags behind more innovative cities in the US, and some European and Scandinavian counterparts in the way we approach incentives on private land.

- **Australian approaches for incentivising tree establishment and maintenance on private land** is largely limited to direct incentives (such as free tree programs), education and information campaigns, and 'negative incentives' in the form of tree bonds and tree compensation.

  Tree bonds require land developers to deposit a money guarantee with the local authority before starting development. If trees are damaged the bond is forfeited. These bonds only apply to significant trees. The size of the bond reflects an estimated tree valuation, typically calculated using the i-Tree tool. The City of Stonnington in metropolitan Melbourne is implementing tree bonds on private land as a mechanism for protection. Tree bonds are used by many Australian cities, including Bendigo, Stirling, and Sydney, but only Stonnington applies them to private urban land [35].

  Tree compensation operates in a similar way to tree bonds, with the difference being that the payment does not occur up front. Rather, compensation is paid if a tree is damaged or removed during property development. Compensation usually only for significant trees.

- **International approaches for incentivising tree establishment and maintenance on private land provide transferrable lessons and examples.** Tax rebates and direct payments for maintaining trees that deliver benefits like avoided stormwater runoff are clear transferrable case studies.

  Cities like Seattle, Portland, Washington DC, Berlin, Helsinki, and Malmö have all implemented tax rebate schemes for creating or retaining trees on private land, based on the amount of greening that is being generated on the site. These programs often provide annual tax credits, so that the credit only occurs when the greening is being provided and ends if trees are removed. Hawaii's tree-retention incentive provides a tax rebate of up to $3,000 per tree every year when they have a significant tree on their property. To apply for this tax rebate, residents need to be able to demonstrate that they have spent money on tree maintenance, ranging from pruning or lopping the tree, to mulching it [41].

  Several cities operate schemes that compensate landowners for positive community benefits, including carbon abatement and avoided stormwater runoff.

- **The efficacy and efficiency of incentive mechanisms can be difficult to evaluate.** In part this is because monitoring and evaluation of programs is incomplete, and there isn't a consistent framework for evaluating outcomes.

In Melbourne, more innovative incentive mechanisms such as tax credits, carbon and stormwater runoff payments could compliment Council run schemes and progress Council initiatives. For example:

- **More than 15 Greater Melbourne Councils have declared climate emergencies and submitted Council Pledges under Victoria's Climate Change Act 2017, to demonstrate their significant contributions to reducing the state's emissions.** Incentivising private landholders to retain or grow trees on private land by pooling carbon credits for trees on private land and then distributing payments would be one direct way that action could be taken. This is already happening in some cases in Australia at the localised scale – for example GreenFleet is earning carbon credits by investing in urban trees in Western Melbourne as part of the Greening the Pipeline initiative.

- **The introduction of VC154 now requires all private residential, commercial and industrial developments to achieve stormwater quality compliance requirements in Victoria** by developers undertaking stormwater compliance on site. By meeting these requirements developers reduce the impact of stormwater runoff entering Melbourne's waterways and bays. Developers could be incentivised to go above and beyond the VC154 compliance requirements through financial incentives that compensate them, and the subsequent landholders, for having trees on their site that result in properties exceeding compliance requirements.

- **We could also follow the lead of places like London and create financial incentives for Urban Greening Factors (UFG).** UFGs could work as stacked financial incentives and credits – combining carbon offsetting, stormwater runoff mitigation, biodiversity and amenity benefits into a

single incentive payment. By stacking incentives, we can create scaled up compensation for trees, which may make them more attractive to landholders than smaller individual payments for things like carbon or stormwater retention separately.

Opportunities for incentives need to be tempered against understanding that these schemes can be complex to run and can be costly when site inspections are needed. Also, because they are innovative, some Councils may be averse to perceived risks of running these types of schemes. For incentive schemes to be effective, local governments will need to establish policies to support them, will need to fund them, and will need to establish long term monitoring programs based on baselines. This will require political will and coordination within and across Councils.

Table 11: Approaches for establishing and maintaining trees on private land

Mechanism	Details	Business-as usual (BAU) approach	Innovative approach
Incentives			
Voluntary standard or certification	Standard or certification schemes that specify tree management recommendations for developments	Incentive encouraging retention or discouraging removal of vegetation in a development context; not specific about trees; and triggered by vegetation size (e.g., height, DBH) or species (e.g., threatened species)	Incentive as BAU approach that codifies the type of vegetation to be retained or added, with trees having a higher value than other vegetation; and does not discriminate by tree size or species
Voluntary financial incentive	Financial incentive for tree retention in new developments or private residences	Incentive that specifies a financial tax rebate for vegetation retention; is not specific to trees; and may be of a fixed value	Incentive as BAU approach that codifies the vegetation type retained or added, with trees having a higher value than other vegetation; does not discriminate by tree size or species; rebate or grant calculated via compensatory tree valuation formulas
Other support and education incentives	Free resources for tree establishment and retention on private residences.	Free tree seedlings for plantings, free arboriculture maintenance work, free resources for establishing and retaining trees on private land, tree awareness programs.	Free tree seedlings for plantings and free arboriculture maintenance work, with a minimum retention time on property.
Regulations			
Land use planning scheme	Zoning and overlay mechanisms specified in environmental and planning laws, that apply to a specific area of the city	Zoning or overlay for natural or vegetative features that are not specific to trees; encourages retention of mature or high-quality trees; requires permit approvals for trees that are to be removed or altered (e.g., pruned) as part of new developments	Zoning or overlay as BAU approach that is specific to trees; requires all trees to be retained; requires a specific number of trees to be planted and/or retained as part of new developments
Tree listings	Significant tree registry (as either a planning scheme through zonings or overlays, or local law)	Protection for trees of special aesthetic or cultural value; is not specific to private land; is triggered by the size of the tree (e.g., DBH, height, or canopy cover); specifies fines for	Protection as BAU approach but that applies specifically to private land; does not discriminate based on tree size or species; and uses compensatory tree valuation formulas*

Mechanism	Details	Business-as usual (BAU) approach	Innovative approach
		removal without permit, calculated via compensatory tree valuation formulas*	
Local laws for tree protection	Local tree protection against removal or alteration	Protection triggering permits removing or altering (e.g., pruning) trees; specifies fines for illegal removals, calculated via compensatory tree valuation formulas* based on tree size; and is not specific to private land	Protection as BAU approach that applies specifically to private land; does not discriminate based on tree size or species; requires payment in advance as an investment or bond; and uses compensatory tree valuation formulas*

Source: [41]

Table 12: A shortlist of an incentive examples currently adopted in Australia

City	State	Type	Description of innovation or details of mechanism	Source (see References for academic sources)
Bendigo	Victoria	Penalty (negative incentive)	Tree bonds	City of Bendigo (2017) Urban Tree Management Policy. Retrieved from: https://www.bendigo.vic.gov.au/About/Document-Library/urban-tree-management-policy, Oct 2019
Melbourne	Victoria	Penalty	Tree replacement standards: advanced tree valuation compensatory formula	City of Melbourne (2018) Tree Retention and Removal policy. Melbourne, VIC, Australia. Retrieved from https://www.melbourne.vic.gov.au/community/greening-the-city/tree-protection-management/Pages/tree-protection-policy.aspx, Oct 2019
Stirling	Western Australia	Penalty	Tree bonds	City of Stirling (2019) Trees and Development. Retrieved from https://www.stirling.wa.gov.au/waste-and-environment/trees/trees-and-development, Oct 2019
Stonnington	Victoria	Penalty	Tree bonds	City of Stonnington (2019) Council Tree Maintenance. Retrieved from: https://www.stonnington.vic.gov.au/Live/Trees-in-Stonnington/Trees-on-public-land/Council-Tree-Maintenance, Oct 2019
Sydney	New South Wales	Penalty	Tree replacement standards: advanced tree valuation compensatory formula	City of Sydney (2017). Tree Valuation formulas. Retrieved from http://peterthyer.com/City%20of%20Sydney%20Tree%20Valuation%20Dec%202003%20%20Peter%20Thyer.pdf, Oct 2019.

Source: [41]

Table 13: A shortlist of incentive examples currently adopted internationally

City	Country	Code	Description of innovation or details of mechanism	More information available at
Austin, TX	USA	Financial incentive	Tree planting program on private and public urban land to obtain carbon credits for the city to meet carbon goals.	City of Austin (2017) State of our Environment Report. Austin, TX, USA. Retrieved from https://data.austintexas.gov/stories/s/2017-State-of-Our-Environment-Report-Urban-Forest-/mquz-kyrj/, Oct 2019. Lavy, B.L.; Hagelman III, R.R. (2017). Spatial and temporal patterns associated with permitted tree removal in Austin, texas, 2002–2011. The Professional Geographer 69 (4), 539-552. https://doi.org/10.1080/00330124.2016.1266953
Baltimore, MD	USA	Direct investment	Tree-planting programs on private land	Nguyen, V.D., Roman, L.A., Locke, D.H., Mincey, S., Sanders, J.R., Fichman, E.S., Duran-Mitchell, M.; Tobing, S.L. (2017). Branching out to residential lands: Missions and strategies of five tree distribution programs in the U.S. Urban Forestry & Urban Greening 22, 24-35. https://doi.org/10.1016/j.ufug.2017.01.007
Boone, NC	USA	Financial incentives	Tax credits defined by size of tree to preserve trees in local properties	Bardon, R.; King, B. (2019). Protecting and retaining trees - A guide for municipalities and counties in North Carolina. North Carolina State University, Raleigh, NC, US. Retrieved from https://content.ces.ncsu.edu/protecting-and-retaining-trees-a-guide-for-municipalities-and-counties-in-north-carolina, Oct 2019.
Hawaii	USA	Financial incentives	Tree-retention incentive: tax cut for private residents to maintain their exceptional trees. Maximum of $3,000 per tree per year for maintenance (pruning, mulching, etc.)	The Tax Foundation (2006) Exceptional tree deductions. Hawaii, US. Retrieved from https://taxfoundation.org/exceptional-tree-deduction/, Oct 2019 City and County of Honolulu. (2020). Article 13. Protective Regulations for Exceptional Trees. Retrieved from https://www.honolulu.gov/rep/site/ocs/roh/ROH_Chapter_41a1-25_.pdf, Jan 2020
Helsinki	Finland	Financial incentives	Green factors index financial incentives	Juhola, S. (2018). Planning for a green city: The green factor tool. Urban Forestry & Urban Greening 34, 254-258. https://doi.org/10.1016/j.ufug.2018.07.019
London	UK	Certification	Urban greening factor as an incentive to retain trees via tree valuation. Calculates the potential of greening of a new development area. Existing trees get a higher score than simply grass.	Greater London Authorioty (2017) Green Infrastructure. London, UK. Retrieved from https://www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan/draft-new-london-plan/chapter-8-green-infrastructure-and-natural-environment/policy-g5, Oct 2019 City of London (2018) Urban greening factor study. London, UK. https://www.london.gov.uk/sites/default/files/urban_greening_factor_for_london_final_report.pdf, Oct 2019

City	Country	Code	Description of innovation or details of mechanism	More information available at
Philadelphia, PA	USA	Other incentive	Tree retention index calculated via water runoff benefits for new developments, based on reduction of impervious surface or volume	City of Philadelphia (2013). Stormwater Management Incentives Program Grant Fact Sheet. Philadelphia, PA, US. Retrieved from http://www.phillywatersheds.org/doc/SMIP_Grant_Factsheet_FY13.pdf, Oct 2019; Fitzko, D. (2014). Tree credit systems and incentives at the site scale. Urban and Community Forestry, Vermont Dept. of Forests, Parks & Rec. Stone Environmental, Inc., Montpelier, VT, US, pp. 24. https://vtcommunityforestry.org/sites/default/files/pictures/site_scale_tree_credits_2014_02_28_final.pdf, Oct 2019. Nguyen, V.D., Roman, L.A., Locke, D.H., Mincey, S., Sanders, J.R., Fichman, E.S., Duran-Mitchell, M.; Tobing, S.L. (2017). Branching out to residential lands: Missions and strategies of five tree distribution programs in the U.S. Urban Forestry & Urban Greening 22, 24-35. https://doi.org/10.1016/j.ufug.2017.01.007
		Direct investment	Tree planting programs on private land by City	
		Other incentive	Community stewardship programs "Cool streets" contest.	
Seattle	USA	Other incentive	Tree retention index calculated via water runoff benefits for new developments, based on reduction of impervious surface or volume	City of Seattle (2018). Tree protection regulation review. Seattle, WA, US. Retrieved from https://www.seattle.gov/Documents/Departments/UrbanForestryCommission/Resources/Final%20Report_Tree%20Regulation%20Research%20ProjectPahseII_31MAR2017_final.pdf, Oct 2019 City of Seattle (2015) Seattle Green Factor. Seattle, WA, US. Retrieved from http://www.seattle.gov/sdci/codes/codes-we-enforce-(a-z)/seattle-green-factor, Oct 2019. City of Seattle (2019) Trees for Neighbourhoods program. Retrieved from https://www.seattle.gov/ trees/planting-and-care/trees-for-neighborhoods
		Direct investment	Tree planting programs on private land by City	

Source: [41]

5.2 Other incentive-based approaches

Beyond those incentive mechanisms mentioned in the last section, there are other incentive approaches that local and state Governments can use to encourage the establishment and retention of trees on private land in Greater Melbourne. These include:

- **Governments as a buyer of trees on private land:** Governments (Federal, State, Local) are significant purchasers of private sector goods and services. Governments can underwrite investments in trees by targeting their investments and stating tree canopy requirements for developers for things like public housing. Beyond Value for Money: support Local Government to drive through Social Procurement for Victorian Local Government policies is one example of this in action. As another example, Governments can adopt preferential sourcing of developers for Government developments so that tree requirements on private lots are a condition of purchase, and hence financing. Victoria will require

almost 70,000 more social housing homes over the next 20 years to meet the needs of lower income households now facing severe housing stress in the private rental market (ref). Requiring that these developments meet tree canopy targets as well as other targets for things like carbon, integrated water, liveability, and waste would have the effect of driving tree investments through 8% of Victoria's developed housing stock.

- **Government also acting as a co-buyer for trees by providing low or zero interest loans.** For example, the ACT Sustainable Household Scheme provides financing to eligible households for products that reduce household emissions including rooftop solar panels, household battery storage, and electric vehicles. Similar schemes could be developed to encourage people establishing trees on private land.

Appendix 1 Tables of studies

This Appendix includes summaries of the studies referenced in this report.

Table 14: Hedonic price impacts of green and blue infrastructure on Australian urban property values

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
Property premium for urban trees in 23 suburbs of Perth Metropolitan Area in Western Australia. A broad-leaved tree on the street verge is estimated to increase the median property price in the suburb by about AU$16,800. Neither broad-leaved trees on the property or on neighbouring properties nor palm trees irrespective of the locations contributed significantly to sale price.	Green	0.3% per property on average	Perth	[43]
One standard deviation increase in the Enhanced Vegetation Index (EVI) leads to increases in housing prices of 8.62% across whole suburbs. A one standard deviation increase in EVI is equivalent to adding a thinly canopied parkland to approximately 20% of a suburb [44]. A one standard deviation change approximately equates to 0.01% increase in house prices per acre of additional green area. Note the green index is a measure of greeness, not tree canopy specifically.	Green	0.01% per additional acre of high green area within suburb, on average	National	[44]
Tree canopy cover increases the property value when located on adjacent public space, but decreases the value when it is on own property and on the adjacent property within 20 m of property boundary	Green and blue	0.9% for a 1% increase in TCC on adjacent public space	Perth	[5]
		0.3% decrease for 1% increase on adjacent private space.	Perth	[5]
Based on 2,300 house sales across 80 sample sites in 52 residential Brisbane suburbs.	Green	3.73% for street trees with 50% tree canopy coverage of the footpath zone by 2031 within 100m.	Brisbane	[6]

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
Tree cover on the property was found to have a significant negative effect on sale price, while controlling for the effects of house, land, and suburb variables. However, when tree cover on the property was less than 20% of total lot, the effect changed to be significant and positive.	Green	Tree coverage on <20% property increased property value by around 4.8%.	Brisbane	
Compared willingness to pay for household features, using a choice modelling approach. Respondents from Melbourne included 8,200 owners and 5,000+ renters. The study differentiated between three levels of private outdoor area: • Minimal: an outdoor area that was primarily hard surface, poorly shaded, poorly connected to the indoor space, had no garden, and no water management in place. • Some: quality space, the outdoor area was still dominated by hard surfaces, but with more lawn and a small garden. With a couple of large trees present, water could flow to the deep root zone, and a majority of the outdoor surface was permeable for water infiltration. For an apartment, this meant a balcony with some potted plants. • High: highest level included an even breakdown of garden, lawn, and hard surface area, ideal shading, ideal connectivity with the indoor space, a waterwise garden design with irrigation, larger trees for water infiltration, and nearly all the outdoor space permeable for water. For an apartment, this meant a balcony with a water-wise potted garden and green wall.	Green	Difference between minimal and some accounts for 3-8% of property value.	Melbourne	[7]

Table 15: Urban cooling impacts

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
A study in the City of Melbourne reported that every 10% increase in tree cover at the precinct scale results in a 0.5-1ºC cooling of	Green		Melbourne	[45, 46]

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
land surface temperatures; and other studies have shown that tree shading can cool air temperatures up to 4ºC (compared to unshaded areas), and cool soil surface temperatures by between 3-12ºC.				
A study in 2021, over 90 Australian residential suburbs in Greater Adelaide, shows tree-inclusive gardens and yards provide up to 30m2 enhancement area (buffer zone) on land surface temperatures (LST) during summer heatwaves. LST was measured at the peak of a heatwave event, after three consecutive days with air temperature exceeding 40 ˚C. At the land unit scale (approx. 400 sqm), tree canopy cover, and to a lesser extent grass cover, decreased local land surface temperature by up to 6 ˚C during the day on extreme heat days, but not at night.	Green		Adelaide	[16]
Coolstreets estimated that a neighbourhood of 40 houses on a street with trees reduced their electricity use (through less use of air-conditioning in summer) by 10,651 kWh per year, compared to a similar street without street trees. Medium-sized Street trees in the study were approximately 20 years old, and assuming a one-year-old tree would have a negligible effect on cooling, a tree age by energy saving profile was derived.	Green	260kWh per household, on average. Average tariff is around 20 cents per kWh[5] Equates to $52 per household.	Sydney	[47]
A recent study in Western Adelaide assessed the effects of trees and other vegetation in people's yards at reducing daytime and night-time heat during an extreme heatwave event. Despite covering about 20% of urban land, people's yards contained more than 40% of the total tree cover. The number of private gardens, as well as the percentage of vegetation cover within these gardens, both contributed significantly to providing widespread cooling benefits across the Western Adelaide	Green		Adelaide	[16]

[5] https://www.canstarblue.com.au/electricity/electricity-costs-kwh/

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
region with localised reductions in land surface temperatures of up to 5-6°C during the day compared to non-vegetated areas and land parcels, but not at night. Moving inland from the coast, small vegetation patches, mostly contained in yards and gardens, was associated with the greatest localised LST reductions in the hotter inland suburbs. LST within land units was further decreased during the day when vegetation was present within 30 m buffers around each land unit, suggesting a moderate landscape cooling effect on LST. Results suggest that even small urban vegetation patches can be managed to provide substantial heat mitigation during increasingly frequent summer heatwaves, particularly around the residential environments where people live.				
Quantified the energy saving provided by shade trees in California, by reducing the need for air conditioning, to be approximately 107kWh (kilowatt hours) per year with each tree reducing the cost of air conditioning required by about 80kWh per year. Melbourne has areas of climate that are similar and similar impacts could be expected in Melbourne where trees are planted on the northern and western sides of houses			California	Ko et al. (2015)
Urban energy consumption per person-year increases by 0.73 _ 0.64 kWh/m2/_C, or 78 _ 47 kWh/_C, while peak electricity demand increases by 0.45–12.3%/_C, depending on AC penetration and setpoint temperature. The average increase of the cooling demand is 23% while the corresponding average reduction of the heating is 19%. In total, the average energy consumption of typical buildings for heating and cooling purposes increased by 11% for the same period.	Green		Greater Sydney	[8]
Urban overheating can increase indoor overheating levels by56% and cooling energy demand by 16% per year. The cooling penalties of residential and commercial buildings were 6.4% and 15.6% per year, respectively, or about 1.8 kWh/m2/_C and 6.7 kWh/m2/_C per year, respectively.	Green		Greater Sydney	[48]
Evaluates dwellings' response to residential tree planting parameters to assess the building–surround relationship in Australia. These		5-25%	Greater Adelaide	[49]

Likely benefits for developments	Green or blue infrastructure	Unit value	Location	Source
parameters include tree type (evergreen or deciduous), volume (1–3 trees), Tree–Building distance (3 m or 5 m) in each cardinal and inter–cardinal azimuth. These planting configurations highlight dominant Australian urban planning policy. This study quantifies tree planting configuration models, utilising both typical and extreme weather data and a bi–seasonal approach, to arrive at an Optimal Residential Tree arrangement (ORTa). The result demonstrates a high probability that deciduous trees save energy bi–seasonally. Shows: • Planting deciduous trees (Deci), in different cardinal aspects, results in higher thermal energy conservation than evergreen trees, measured through tree providing shade cooling façade surface temperature and creating evaporative cooling • Deciduous trees cause higher energy conservation overall if planted within 3 meters of the property. If landscapers prefer evergreen trees, planting at a 5 m Tree-Building distance is better than a 3-meter Tree–Building distance. Beyond 5 metres the impacts are negligible. • In typical weather conditions, two deciduous tree arrangements lead to maximum 40% heating energy conservation from any potential ORTa in east, west or north. In addition, it provides 15% east or west cooling energy saving and 7% north. In extreme weather conditions, two tree arrangements provide 25% thermal heating conservation, in any aspect. During heatwaves easterly deciduous tree planting is optimal (18% energy conservation), followed by westerly (7%) and northerly (1%).				

Appendix 2 I-Tree full method for carbon and air quality per tree

This Appendix sets out approach for per tree values for air quality and carbon. It is the same method used to calculate carbon and air pollution values in SEVT.

We have measured economic values for the following tree biomass benefits for Greater Melbourne, using western Melbourne:

- **Air pollution removed by urban forest**, and associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns).
- **Urban forest volatile organic compound emissions** and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year.
- Total carbon stored and net carbon annually sequestered within the urban forest.

Approach

Benefits have been estimated with i-Tree Eco Australia (version 5). i-Tree is a peer-reviewed software program developed by the USDA Forest Service[6]. i-Tree Eco (Australia) is currently designed to provide accurate estimates in Greater Melbourne of tree services for air pollution, volatile organic compound emissions and carbon storage and sequestration.

I-Tree has been parameterised for Victoria and uses Victorian data. You can read more about the Victorian model here https://www.itreetools.org/eco/international.php. The Victorian model of the human health impacts of air pollution removal are based on BenMAP a US specific model created by the Environmental Protection Agency, parameterised for Australia (read more here). i-Tree Eco (Australia) is currently designed to provide accurate estimates in Victoria of:

- Urban forest structure (e.g., species composition, number of trees, tree density, tree health etc.) analysed by land-use type.
- Hourly amount of pollution removed by the urban forest, and associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns).

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[6] http://www.itreetools.org/

- Hourly urban forest volatile organic compound emissions and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year.
- Public health incidence reduction and economic benefit based on the effect of trees on air quality improvement.
- Total carbon stored and net carbon annually sequestered within the urban forest.
- Yearly tree canopy rainfall interception summarized by tree species or land use.
- Compensatory (amenity) value of the forest, as well as the value of air pollution removal and carbon storage and sequestration.

Calculation methods for functional structure and ecosystem services are detailed in [50].

What the economic benefit values are based on.

Different trees remove different amounts of air pollution and sequester different amounts of carbon. As a result, different trees have different economic benefits of air pollution removal and carbon sequestration.

For the SEVT, the $/tree/year values are the average pollution removal and carbon sequestration economic value based on a representative mix of tree species that would perform well in Melbourne. Pollution data is referenced on RAAF-Laverton weather station.

The representative sample of trees used to obtain unit values is calculated from sample species include Yellow and Red Box, Pink Flowering and Yellow Gum, and Smooth-barked Apple Myrtle, with the balance of the tree species being less typical, including a mix of native and exotic species. Examples include English Oak, Golden-rain Tree, Judas Tree and Kanooka. These species have been selected to meet desired outcomes of improved liveability by increasing shade canopy, leaf area and biomass, evapotranspiration, and amenity etc.

Carbon economic values

Carbon dioxide sequestration values are derived from species-based biomass equations. Carbon dioxide avoided values are estimated by converting the savings to tonne of avoided carbon emissions. Values (kWh and Mbtu) are converted to carbon dioxide using state-based EPA E-grid conversion values.

The low-end carbon sequestration dollar value is $17 per metric ton. This per tonne value is the current Australian Carbon Credit Unit price, as at December 2020. It is the price someone seeking to offset carbon emissions would pay to offset under the Australian Carbon Credit scheme. Carbon Credits have traded in the $15-18 range per metric tonne since 2015.

The high-end carbon sequestration value reflects the potential social cost of carbon, based on avoided health costs and morbidity. The social cost of carbon is based on [insert ref]

Air pollution economic values

Air pollutant deposition resource unit values are based on methods and models derived from the i-Tree Streets application. Air pollutant removal resource units and monetary values for air quality benefits are estimated based on avoided health costs and morbidity. We use the

following parameters based on Australian estimates and previous work by Marsden Jacob Associates: NO2 $673 per metric ton; PM10 $185 per metric ton; SO2 $471 per metric ton ($2019).

Table 16: i-Tree economic value of carbon and pollution removal per mature tree

Botanical Name	Years to max height (approx.)	Carbon Storage		Gross Carbon Sequestration		Pollution Removal	
		(ton)	(A$)	(ton/yr)	(A$/yr)	(ton/yr)	(A$/yr)
Acacia implexa (Lightwood)	10	0.18	3.81	0.01	0.24	0.00	3.16
Corymbia ficifolia 'Fairy Floss' (Pink Flowering Gum)	8	0.16	3.33	0.01	0.24	0.00	1.24
Eucalyptus leucoxylon 'Wildire' (Yellow Gum)	13	0.52	10.79	0.02	0.47	0.00	4.78
Acer truncatum 'Norwegian Sunset' (Norwegian Sunset Maple)	24	0.51	10.49	0.02	0.44	0.00	7.19
Lagerstroemia 'Natchez' (Crepe Myrtle Hybrid Cultivar)	11	0.05	0.97	0.01	0.12	0.00	0.91
Melia azederach (White Cedar)	16	0.37	7.65	0.02	0.39	0.00	5.65
Angophora costata (Smooth-barked Apple Myrtle)	27	1.42	29.29	0.04	0.85	0.00	9.75
Eucalyptus melliodora (Yellow Box)	40	1.97	40.80	0.05	1.03	0.00	10.59
Eucalyptus polyanthemos (Red Box)	37	1.41	29.25	0.04	0.85	0.00	9.76
Ulmus parvifolia (Chinese Elm)	22	0.43	8.82	0.02	0.39	0.00	6.95
Quercus canariensis (Algerian Oak)	39	2.36	48.88	0.06	1.29	0.00	9.58
Cupaniopsis anacardiodes (Tuckeroo)	17	0.37	7.69	0.02	0.38	0.00	5.10
Lophostemon confertus (Brush Box)	26	0.38	7.85	0.02	0.39	0.00	4.22
Tristaniopsis laurina (Kanooka)	17	0.16	3.40	0.01	0.24	0.00	1.49
Cercis siliquastrum (Judas Tree)	48	0.17	3.44	0.01	0.25	0.00	3.16
Koelreuteria paniculata (Golden-rain Tree)	32	0.36	7.44	0.02	0.38	0.00	4.54
Ficus rubiginosa (Port Jackson Fig)	26	1.36	28.09	0.04	0.83	0.00	6.35
Fraxinus pennsylvanica 'Urbdell' (Urbanite Ash)	32	0.46	9.52	0.01	0.28	0.00	6.57

Botanical Name	Years to max height (approx.)	Carbon Storage		Gross Carbon Sequestration		Pollution Removal	
		(ton)	(A$)	(ton/yr)	(A$/yr)	(ton/yr)	(A$/yr)
Quercus robur (English Oak)	39	1.62	33.49	0.05	1.03	0.00	8.85
Quercus rubra (Red Oak)	35	1.50	31.08	0.04	0.93	0.00	8.24
Zelkova serrata 'Green Vase' (Japanese Zelkova)	39	2.00	41.29	0.05	1.05	0.00	9.21

Appendix 3 Application of benefit and cost values

This Appendix provides a worked example showing how to apply the benefit and cost values in this report. The worked example in this Appendix evaluates the total lifetime benefits and costs of urban trees, and the differences in benefits and costs of newly established versus mature trees.

A3.1 Context

Planting and retention of trees on private land when done by the landowners can be a costly activity. The benefits and costs can be very different for planting a new tree versus retention of a mature tree on private land. These can accrue to the private landowners but also the community depending on their location and proximity to the residence.

Understanding the benefits and costs associated with each stage of the tree lifecycle is also important to different stakeholders including arborists, council members, planners, accountants, private landowners, and community members to make sound decisions regarding management and protection of urban trees. Innovative incentive or penalty schemes can be implemented to protect and promote new tree planting and/or retention of mature trees on private land (Appendix 4).

A3.2 Approach

We have looked at two scenarios (high and low) to assess the indicative lifecycle benefits and costs associated with a tree on private land in Australian cities and major regional centres across Australia.

The monetary benefits included the property value premium of mature trees on private land, energy use, pollution removal, carbon sequestration and water use, with these values drawn from the above-mentioned Monetary benefits and Costs. Costs are associated with planting, establishment, and maintenance of a tree, based on the Hort Innovation urban tree budgeting tool.

The data are presented in a form that looks at both annual and cumulative benefits and costs over a projected 30-year lifespan of an urban tree. The high scenario assumes higher and more extensive maintenance and costs per urban tree. This translates into higher benefits due to the tree being in better health, plus these benefits are longer lasting because the tree lives longer. The low scenario assumes lower maintenance and costs per urban tree, resulting in a shorter lived and less productive tree. The installation costs are assumed constant under both scenarios.

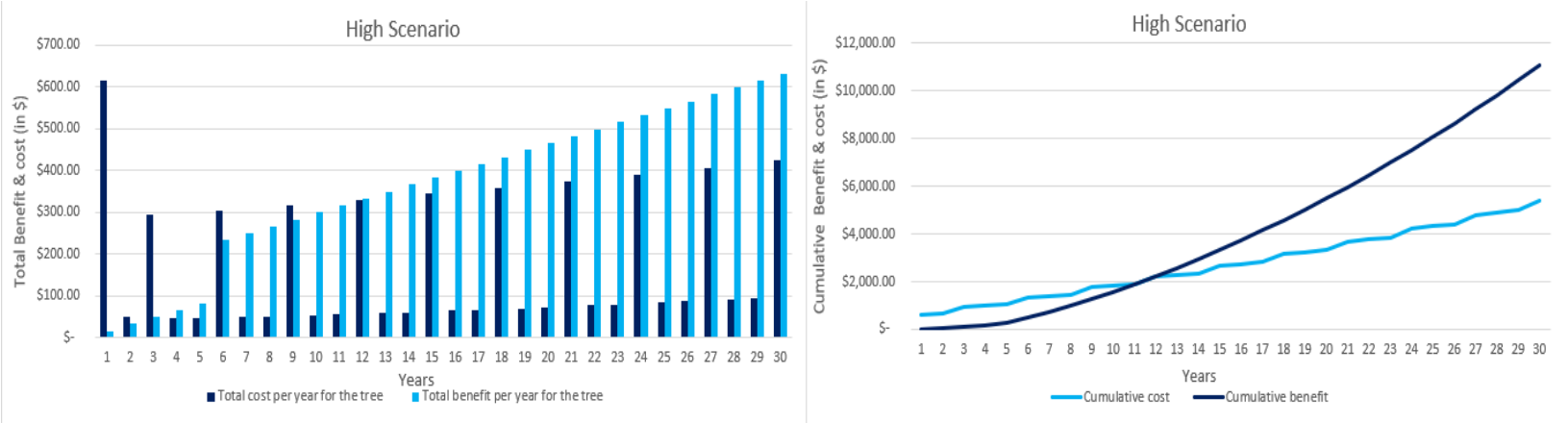
A3.3 Results

Table shows the breakdown of benefits and costs estimated at years 1, 5, 10, 20, and 30 years. Our evaluation shows the following:

- **High scenario –** New planting incurs high establishment cost and there are frequent costs incurred with tree maintenance (you can see these cost items we have assumed in Table 15). The cumulative benefits of the tree start to exceed costs from around year 11 as the tree grows and supplies cooling, pollution removal, energy use and other benefits. The cumulative benefits gained by the mature tree at the end of 30 years is around $11,000 compared to around $5,400 in costs in constant prices – i.e., a net benefit of around $5,600. Adjusting for inflation (assumed to be 5%) the net benefit is around $1,800 in real terms (i.e., measured in today's dollars).
- **Low scenario –**The tree is lower maintenance and therefore has lower maintenance costs, but this curtails the benefits through slower growth and the tree being less healthy. The cumulative benefits gained by the tree at the end of 30 years is around $3,500 compared to around $1,000 in costs, in constant terms. Adjusting for inflation (assumed to be 5%) the net benefit is around $960 in real terms (i.e., measured in today's dollars).

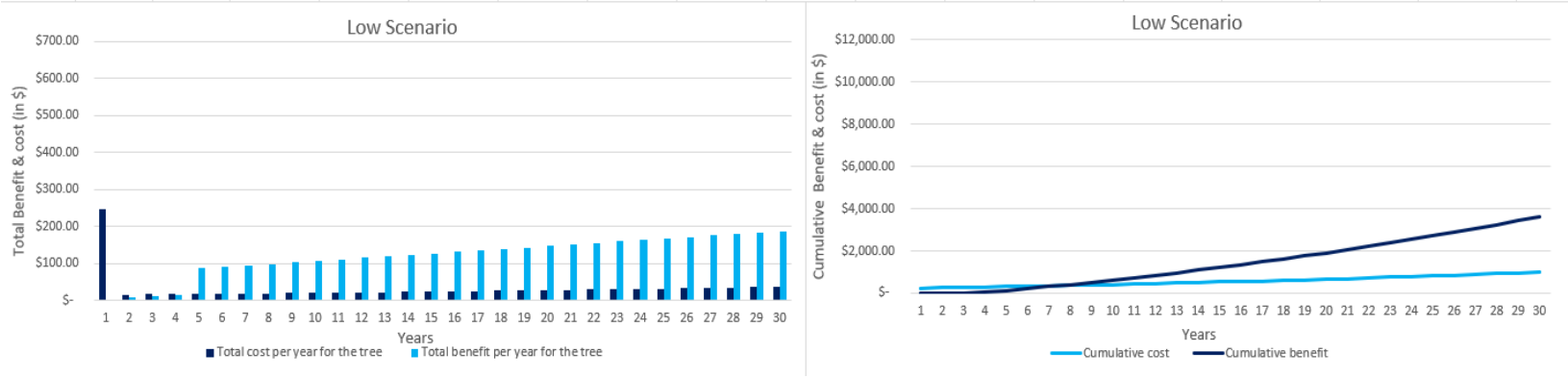
The types of costs and benefits provided by urban trees on private land will vary because of many things, including where the tree is planted, the tree species, the soil conditions, and other factors. While illustrative, what the results in this example show is that by using realistic assumptions and easily accessible resources it is easy to show that there can be **high benefits from well-maintained and mature trees.** The benefits of well-maintained trees can be several multiples of the financial cost. It also shows that there are more benefits to be had by retaining existing mature trees compared to establishing new trees. This is because many of the benefits of trees occur towards the second half of a tree's life, but many of the costs occur upfront.

Figure 4: High Scenario (values in $AUD) – annual benefit and cost (left), cumulative benefit and cost (right), constant prices.



Source: Marsden Jacob Analysis

Figure 5: Low scenario (values in AUD) – annual benefit and cost (left), cumulative benefit and cost (right), constant prices.



Source: Marsden Jacob Analysis

Table 15: Annual benefits and costs for high and low scenarios at years 1, 5, 10, 20, and 30, constant prices.

	Year 1	Year 5	Year 10	Year 20	Year 30
Benefits (High, Low)					
Property value premium	$0, $0	$133, $67	$133, $67	$133, $67	$133, $67
Energy use	$16, $4	$80, $20	$160, $40	$320, $80	$480, $120
Pollution removal[7]	$0.35, $0.03	$1.77, $0.15	$4, $0.30	$7, $0.60	$11, $0.90
Carbon sequestration	$0.04, $0.00	$0.22, $0.02	$0.43, $0.04	$0.87, $0.08	$1, $0.12
Water use	$0.23, $0.01	$1.17, $0.06	$2, $0.12	$5, $0.25	$7, $0.37
Costs (High, Low)					
Supply ($)	$150	-	-	-	-
Unbundled installation	$24	-	-	-	-
Mulch cost ($/m3)	$5	-	-	-	-
Stakes and ties ($)	$5	-	-	-	-
Soil cost ($/m3)	$15	-	-	-	-
Irrigation	$48	$18, $0	$21, $0	$28, $0	$38, $0
Maintenance	$114, $0	$25, $0	$29, $0	$39, $0	$53, $0
Tree protection fencing ($)	$250, $0	$3, $0	$4, $0	$5, $0	$326, $0
Visual tree inspection ($)	$3, $0	-	-	-	$7, $0
GIS mapping and inventory assessment ($)	$2, $0	-	-	-	-

[1] Ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter (PM10).

Appendix 4 Case Studies

The case studies from City of Melbourne and City of Marion in this Appendix show how these Councils are using innovative approaches to encourage tree planting and retention on private land.

A4.1 City of Melbourne's Exceptional Tree Register

Identifying exceptional trees as part of the vision for City of Melbourne's urban forest.

Insight

A register that recognises and protects, promotes, and celebrates exceptional trees on private properties in the City of Melbourne.

Project description

The City of Melbourne Exceptional Tree Register recognises, celebrates and protects trees growing on non-City of Melbourne owned or managed land. The register is typically updated every five years. Trees on the register are protected by an Environmental Significance Overlay through the Melbourne Planning Scheme.

Anyone can nominate to have a tree included on the register. However, for the nomination to proceed, the property owner needs to provide consent for an Arborist to access their property to undertake a tree assessment. Once a tree is listed on the register, current or future property owners must apply for a permit from the City of Melbourne Planning Department for any activity that will impact the tree or its Tree Protection Zone (TPZ).

The Exceptional Tree Register protects the listed nominated trees and promotes tree planting on private properties to increase urban canopy cover. It recognises that these trees promote a wide range of benefits, including habitat value, environmental services, and historical, social, and cultural values for people living in and visiting the City of Melbourne.

What does this case study demonstrate?

The case study has been selected to demonstrate specific solutions or benefits that support tree retention and new planting on private properties. This case study focuses on:

Innovative financing & funding | **Urban canopy cover** | **Behavioural change**

Drivers

The Exceptional Tree drivers are to:

Protect trees on private land – The register provides tree protection against activities that are potentially harmful to the tree.

Provide substantial environment and community benefits – protecting urban trees provide environmental benefits, reduce energy costs, increase property value, and provide aesthetic and amenity value.

Minimize the loss of trees on private land – infrastructure development in the city is a significant issue that contributes to tree loss. There is growing concerns about the loss of environmental and community benefits when trees are cut down. The register aims to protect the exceptional trees through the Melbourne Planning Scheme.

Enforce through the planning scheme – Exceptional Trees on the register are protected using as Environmental Significance Overlay (ESO). As part of this, people need a planning permit to build or carry out works within the TPZ, or when they want to significantly prune, lop, or remove the exceptional tree.

Innovations

An Interactive map provides details of the exceptional trees protected under the register. You can find out information about the trees, including location, statement of tree significance and the TPZ area.

Tree protection zone – Each exceptional tree has its own tree protection zone (TPZ). The TPZ is an area above, around and below the tree. The TPZ is used in Arboriculture to determine the area, where a tree's root system could be detrimentally damaged by development. TPZ is calculated in accordance with AS 4970-2009, Protection of Trees on Development Sites, using trunk diameter measurement and varies depending on the size of the tree.

Juvenile trees have a predicted TPZ - Juvenile exceptional trees' TPZ, which is particularly relevant for avenues or groups of trees, is based on the expected TPZ for that tree species in its location once it reaches maturity. This allows for the tree to grow to its full mature scale, and not be impacted during establishment by development that could detrimentally damage the trees growth.

Outcomes

The City of Melbourne currently protects 160 exceptional trees on privately owned or managed land around the city from being removed or significantly pruned. In early 2019, the City of Melbourne called for public nominations to expand the list of protected exceptional trees. A panel of experts reviewed all the nominated trees and associated Arboriculture reports and recommended that a further 119 trees to be added to the list. Interim planning controls protecting the recommended 119 exceptional trees until 27 April 2023 are currently in place, and a planning scheme amendment to for permanent protection controls (Amendment C379) is currently underway.

Each mature tree on the register provides property owners and people living and visiting City of Melbourne with monetary and non-monetary benefits. The type and amount of benefit will vary by tree. Some indicative values of mature trees are shown in the figure below. Based on the indicative values of trees shown below, with a median sale price of $1.2 million, mature exceptional trees could add up to $72,000 to the sale value of a median residential house.

Lessons

Seeking interim protection while undergoing the Amendments – Planning Scheme Amendments to protect exceptional trees on the register via an ESO is a multi-staged and time-consuming process. An interim protection measure can help avoid any perverse outcomes for trees during the tree register's amendment cycle.

Incentives to provide financial support - Innovative financing and funding scheme like grants or financial assistance can help with increasing private landholders' acceptance for retaining exceptional trees and promote new tree planting on private land. City of Melbourne is currently exploring financial incentives and funding schemes to help landowners tree maintenance and retention. City of Melbourne is also exploring ways to celebrate people who chose to nominate trees on their property for protection through the register.

Transferability

The register approach is very transferrable. Many Councils use the approach under different names. To develop your own exceptional tree register you need to consider the following:

Involvement of other key stakeholders in the area to increase tree nominations – The key stakeholders beyond residential property owners include large landowners such as Universities and school, local community groups, students, property managers and commercial businesses.

Well considered exceptional tree criteria – Make sure there is a clear process and criteria in place for nominating and evaluating exceptional tree applications. For the City of Melbourne's Exceptional Tree Register; trees on the register were assessed by a qualified Arborist, peer reviewed and presented to an expert assessment panel to ensure accuracy, robustness, and transparency to confirm they meet the criteria for the register. The criteria for determining exceptional trees in the City of Melbourne were informed by those used in:

The National Trust of Australia (Victoria) criteria for identification and classification of significant trees in Victoria

Heritage Victoria criteria for Assessment of Cultural Heritage Significance

The Australian International Charter for the Conservation of Monuments and Sites (ICOMOS)

Burra Charter criteria

City of Melbourne's Urban Forest Strategy

Recognising urban forest as a dynamic system – The register needs to consider the natural cycle of tree growth, maturation and death through ongoing revisions, updates, and improvements.

Good communication and education about tree protection requirements - For tree protection through the Melbourne Planning Scheme, ensure that planners are well educated about the tree protection requirements and facilitate good communications with Council's Urban Foresters/Arborists for advice.

A4.2 City of Marion's Regulated Tree Maintenance Fund

Creating incentives for property owners to adequately maintain trees in the City of Marion.

Insight

A program that showcases an innovative financing and funding scheme to promote tree retention on private properties in City of Marion.

Project description

The City of Marion Regulated Tree Maintenance Fund is an incentive-based program to assist and encourage property owners to adequately maintain regulated and significant trees on their private property.

The program provides financial assistance to private property owners to promote tree preservation on private land. Financial assistance is available to property owners for maintenance and management of regulated and significant trees, including things like tree pruning, pest, disease control, and for arborist reports when works are undertaken.

Funding is in the form of reimbursement. Property owners are eligible for reimbursement of up to half of maintenance and management costs of the tree, and up to $1,750 per tree for a single application. Repeat applications may be considered if landowners clearly demonstrate that the work being undertaken is required maintenance outlines in the tree management plan. Funding is not available for tree removal, repairs to infrastructure caused or suspected to be caused by the tree, works undertaken by landowner without planning consent, and arborist report where no subsequent maintenance work on the tree is undertaken.

Drivers

The Regulated Tree Maintenance Fund drivers are:

Retention of trees on private land - The diverse landform areas throughout the City of Marion have resulted in a large population of mature trees situated on land under private ownership. Retaining trees that have a high amenity value or special botanic interest is for the benefit of the local community and residents within the city.

Management of urban consolidation - The impacts of urban consolidation have placed significant pressures on the retention of trees in private ownership as development increases in the City of Marion. The management of urban consolidation needs to be balanced with appropriate tree retention where they provide landscape and amenity value.

Necessary property development requirements - The inclusion of regulated trees within the Planning, Development and Infrastructure Act 2016 and Development Regulations 2008 has placed a development requirement on landholders where they have large trees on their property in South Australia. Because of this, the City of Marion is developing and implementing incentive-based strategies and actions to retain trees that have high amenity value, good health, and structure.

Tree management framework – Elected council members were proactive in the urban greening space, and conscious of large canopy trees disappearing from private land. The City of Marion developed a foundation document outlining the tree management framework in 2018, the key action included development of new ways to protect greater number of trees on private property.

Provide large tree management in backyards – Managing large trees in backyards is challenging and costly. Moreover, some people can perceive trees to be bothersome with leaves and roots blocking and/or breaking pipes on private land. The regulated tree maintenance fund aims to provide financial assistance that covers arborist report, tree pruning, pest, and disease control to make tree maintenance on private property easier.

Innovations

Forestree - City of Marion started working with Forestree, which is a tree management tool that records all the information across the urban forest in a database platform. It focuses on Local Governments and make tree inspections, works and risk management simple and easy.

Increased media reach – City of Marion worked on expanding media reach to get public interest and support for tree retention and planting on private property. This was achieved through media campaigns, like the mayor supporting the regulated tree maintenance fund on ABC radio, and elected members handing out flyers.

Outcomes

The City of Marion successfully completed the 12-month trial of the Regulated Tree Maintenance Fund and got approval to continue with a $20,000 budget for the Fund every year. For the first 12-month trial, there were 10 successful applications out of 12 and an average funding of $1,750 each was provided.

Lessons

Early stage in the process - The Regulated Tree Maintenance Fund is early in the implementation process. Ensuring ongoing support from Council members and the community to progress and successfully benefit from the funding scheme is integral for the scheme.

Easy access to arborists – People needs to participate for the program to be successful. Given an arborist review is needed, one way this can be done is by having a publicly available register of arborists who are available to undertake assessments. This makes it easier for people to find and engage an arborist.

Transferability

The Regulated Tree Maintenance Fund approach was adopted from the "Tree Assistance Fund" of City of Burnside. The Regulated Tree Maintenance Fund approach is easy to pick up and transfer the grant guidelines. Many councils use the approach under different names.

To develop your own regulated tree maintenance fund, you need to consider the following:

Setting up the significant/regulated tree register – A register that outlines what regulated and significant trees are, key stakeholders that can nominate trees to be regulated and what special requirements may apply if a regulated/significant tree exists on your property or a neighbouring property.

Well considered guidelines for providing financial assistance – Provide detailed guidelines for financial assistance available, who can apply, what funding is available and how to make an application. The City of Marion's Regulated Tree maintenance fund involves the following steps:

Contact the council to discuss the application – property owner should contact council to discuss the eligibility and all relevant information

Expert assessment of the tree – Property owners should arrange for an expert Arborist to inspect the tree and provide a detailed tree report

Complete application form – property owners should seek quotes from qualified arborist/tree-maintenance specialist capable of undertaking the maintenance work. The grant application must be submitted with a copy of the tree report and quotation for the works

Application assessment – the applications are reviewed by council's staff consisting of the Arboriculture Coordinator and Open space Operations Unit Manager. The decision for approval is at the discretion of the staff and is final with no right of appeal

Assessment outcome – Applicants are notified of the outcome in writing and maintenance and/or management work for successful application can commence after received the notification and any Planning consent.

Good communication and education about tree protection requirements and funding application – For tree protection under Planning, Development, and Infrastructure Act 2016, ensure that planners and stakeholders are well educated about the tree protection requirements and grant approval conditions. Also, facilitate good communication between Council's staff and Arborists for advice.

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